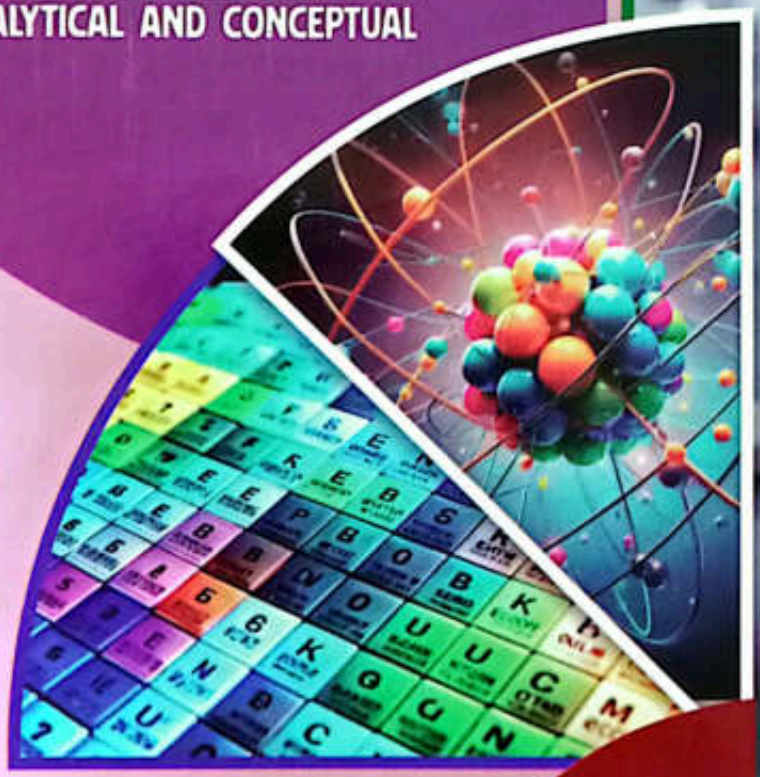
HAMDARD
Imtihani

CHEMISTRY

QUESTIONS DEVELOPED ACCORDING TO THE NEW EXAMINATION TECHNIQUES: KNOWLEDGE, UNDERSTANDING, ANALYTICAL AND CONCEPTUAL

NEW SYLLABUS



ACCORDING TO NEW SYLLABUS AND PAPER PATTERN OF PECTAA

10

PERFECT SOLUTION OF ANNUAL PAPER

- TOPIC WISE SUBJECTIVE TYPE QUESTIONS
- OBJECTIVE TYPE QUESTIONS
  (i) TOPIC WISE MCQ's (ii) TOPIC WISE SHORT ANSWER QUESTIONS
- COMPLETE SOLUTION OF EXERCISE QUESTIONS
- SOLUTION OF ADDITIONAL KNOWLEDGE BASED QUESTIONS

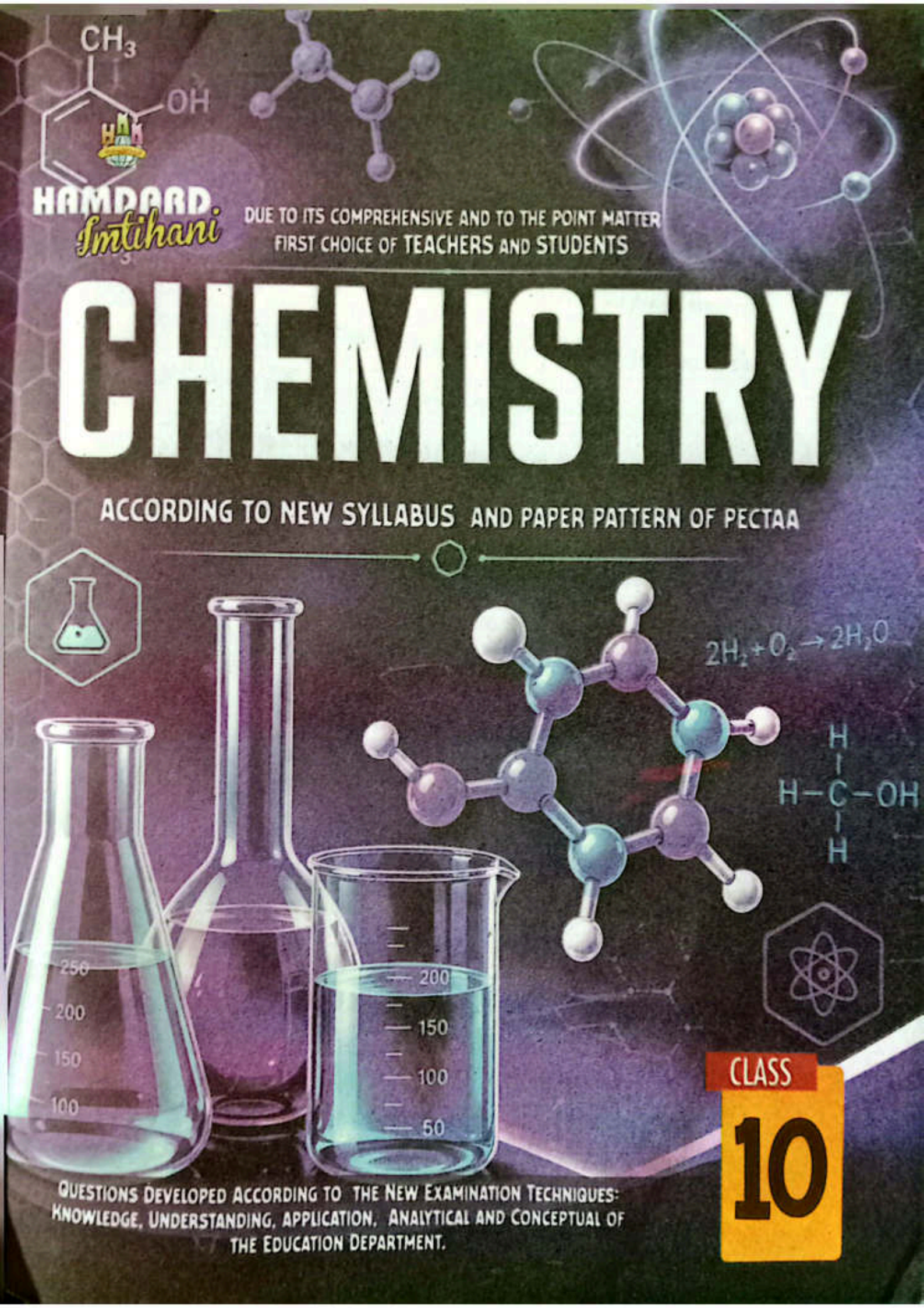
DUE TO ITS COMPREHENSIVE AND TO THE POINT MATTER FIRST CHOICE OF **TEACHERS** AND **STUDENTS**

HAMDARD Imtihani

DUE TO ITS COMPREHENSIVE AND TO THE POINT MATTER
FIRST CHOICE OF TEACHERS AND STUDENTS

CHEMISTRY

ACCORDING TO NEW SYLLABUS AND PAPER PATTERN OF PECTAA



CLASS 10

QUESTIONS DEVELOPED ACCORDING TO THE NEW EXAMINATION TECHNIQUES: KNOWLEDGE, UNDERSTANDING, APPLICATION, ANALYTICAL AND CONCEPTUAL OF THE EDUCATION DEPARTMENT.

Managing Director: Kashif Hussain Gohar

Project Director: Muhammad Asif Saeed

Project Manager: Ghulam Mustafa

Authors: Dr. Muhammad Iqbal Awan

Ahmed Bilal (M. Phil Chemistry)

Editor: Hassan Ijaz

Designed at: Hamdard Graphic & Designing Lab.

Printed at: Saleem Tanveer Printing Press, Lhr.

Printing Manager: Tariq Rasheed

Processed at: J. R. Scan

Preface

HAMDARD Kutab Khana, Urdu Bazaar, Lahore has been working for the advancement of education in the country for the last more than half a century. Due to its close cooperation with the Education Department and its positive role to educate the students, all its endeavours have brought fruit with the grace of Almighty.

HAMDARD Kutab Khana has always been very prompt in carrying out the latest changes in the syllabi of the courses. The learned teachers and students always find an updated version in the form of book in their hands. In view of this quality, **HAMDARD books** are matchless and first choice of every student.

HAMDARD Imtihani Chemistry have been specially prepared for students of English and Urdu medium schools. Each and every aspect has been thoroughly explored in completing these books in order that each youngster can easily understand the subject matter. We can safely recommend them as these books will fulfill the needs of every student, whatever his approach may be. These are as good for a beginner as well as a brilliant and shining student.

The main object of **HAMDARD Imtihani Chemistry** is to prepare the students for the annual examinations from the very outset of their academic educational year. This definitely lowers the burden on the students near their last encounter. These books serve this aim in all aspects as the sole purpose of writing these books was to help the student from the very beginning.

We hope that, like our other publications, **HAMDARD Imtihani Chemistry** shall receive the same prominent place in the hearts of learned teachers and students.

Publisher

CONTENTS

CHAPTER 14 States of Matter and Phase Changes

Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain changes of state and internal energy with change in temperature (melting, boiling, freezing, condensation, sublimation and deposition) in terms of kinetic particle theory.
- Distinguish between evaporation and boiling.
- Interpret heating and cooling curves in terms of kinetic theory
- Interpret in terms of kinetic particle theory the effects of changing pressure, temperature and volume of a gas on the other two with regards to Boyle's law, Charles's Law, and Avogadro's Law.
- Explain qualitatively the effect of external pressure on rate of boiling and evaporation
- Explain diffusion of gases in terms of kinetic particle theory
- Examine qualitatively the effect of molecular mass and temperature on the rate of diffusion
- Discuss applications of sublimation around us.
- {Examples may include: solid air fresheners and 3D printing}
- Explain, with the help of kinetic particle theory, the importance of rates of diffusion of medicines in the body

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: Explain how the kinetic particle Theory describes the behaviour, arrangement and movement of particles in the three primary states of Matter.

Ans. States of Matter:

Matter in this world exists in four physical states namely:

- Gas
- Liquid
- Solid
- Plasma

Formulation of kinetic particle Theory:

Out of these four states the properties of gases were studied first. It was suggested that physical properties of gases such as their ability to compress or expand, or diffuse

could be understood by assuming that these gases consist of particles which are continuously moving randomly. This idea then led to formulation of kinetic particle theory for gases.

Scope of Kinetic Particle Theory:

Kinetic particle theory not only explains all the laws which govern the behaviour of gases, it also explains:

- The composition of liquid and solid states of matter
- The interconversion of all three states.

This is natural because all the three physical states are distinct in their physical properties only while their chemical nature remains the same.

For Example: Water in all its three physical states remains chemically the same compound.

Postulates of Kinetic Theory for Gases Random Motion:

According to Kinetic particle theory, gases are composed of particles which are in a continuous state of random motion in all the possible directions..

The pressure exerted by a gas is due to the collisions of its particles with the walls of the container. Since the pressure of a gas in a container does not change with time at constant temperature, it is assumed that the collisions between its particles do not involve any loss or gain of energy due to friction.

The attractive forces between the particles of a gas are assumed as negligible since the particles are widely apart at low pressure.

The average kinetic energy of the particles is directly proportional to the temperature measured on Kelvin scale for all gases at the same temperature.

Postulates of Kinetic Particle Theory For Liquids:

Arrangement of Particles: According to kinetic theory, the particles in a liquid are quite close to one another. They are also moving in all possible directions.

Movements of Particles: In a liquid, the particles show all the three types of movements such as:

- Translational movement
- Rotational movement
- Vibration movement

Owing to the presence of inter-particle forces, however, a liquid has a fixed volume and it keeps its level as well

Postulates of Kinetic particle Theory For Solids:

Fixed Position of Particles: Solid substances consist of ions, atoms and molecules.

According to kinetic particle theory the inter particle forces in the solid substances are so strong that they keep their particles arranged in a fixed position.

Vibrational Motion: The particles of a solid possess vibrational motion only.

Fixed shape and Fixed volume: These restricted movements force solid substances to have a fixed shape and a fixed volume.

Q.2: Discuss conversion of a Solid into a liquid.

Ans. Heating:

The physical state of a solid substance can be changed by simple heating.

Heat increases the kinetic energy of the particles and they start vibrating at a higher frequency

Melting point: At particular temperature their vibrational motion becomes so fast that it overcomes the cohesive forces. As a result they start melting and this temperature is called the melting point of the solid.

Changing a Solid into a liquid:

At the melting point, the particles of solid not only lose their mean positions but the arrangement as well. The solid collapses and turns to a liquid. Heating a solid below its melting point increases its kinetic energy and temperature that weakens the force of attraction between its particles.

Further heating does not increase the temperature because the heat provided here is being utilized to melt all the solid substance.

Melting of ice

Q.3: How does boiling convert a liquid into a gas?

Ans. Evaporation:

The molecules of a liquid keep on coming out from the surface of a liquid at all temperatures and such an escap of molecules from surface is called evaporation.

Heating the Liquid: Heating a liquid increases the kinetic energy of its molecules and so does the process of evaporation.

Heating the liquid further, increases the kinetic energy so much that the inter particle forces are weakened to a large extent. At this point the bubbles start coming out of the liquid at a rapid pace.

At this stage if the vapour pressure of the liquid becomes equal to the external pressure, the liquid starts boiling.

Boiling point: The temperature of a liquid at which its vapour pressure becomes equal to the atmospheric or external pressure is called its boiling point.

Conversion of a liquid into a gas: At the boiling point, the heat provided to the liquid is used to convert it into gaseous form and during this its temperature remains constant.

In other words, the heat provided is used only to break the forces of attraction between its particles.

Q.4: Explain conversion of a gas into its liquid.

Ans. Cooling of a Gas:

When a gas is cooled the kinetic energy of its molecules decreases, as a result the molecules come closer with a significant force of attraction between them.

Condensation: At a suitable lower temperature the increased attractions bring the molecules so close that they are changed into a liquid form. This is called condensation.

During this transition the temperature of the gas remains constant until all the gas is changed into its liquid.

14.3 Heating and Cooling Curves

14.4 Evaporation and Boiling

Q.5: Define heating and cooling curves. Explain the various stages of heating and cooling curves for a solid substance with the help of a graph.

Ans. Heating or Cooling curve:

It is a graph drawn between the internal energy and the temperature of a system showing the temperature changes as a substance is heated through its different states.

Explanation:

Point A: When a solid substance at a point A is heated, its temperature increases.

Point B: On attaining a specific temperature, it melts as shown by the point B.

This point represents the melting point of the given solid.

Line B to C: Further heating does not increase the temperature because the heat provided here is being utilized to melt all the solid substance as represented by the line B to C.

Point C to D: When all the solid converts into the liquid the temperature starts rising again as shown in the graph for the points C to D.

Point D: At the temperature corresponding to point D the liquid starts boiling. This represents the boiling point of the liquid.

Line D to E: Again further heating does not increase the temperature till the whole liquid is converted into gas.

A line D to E in figure shows no further rise in the temperature.

Point E: The temperature again starts rising after the point E.

Steps A to F: The curve represented by the steps A to F is called a heating curve.

Cooling Curve:

It is a graph drawn between the internal energy and the temperature of a system, showing the temperature changes as a substance is cooled through its different states in reverse (e.g. from a gas to a liquid or a liquid to a solid).

Explanation

Point F: When the gas present at the point F is cooled its temperature starts decreasing.

Point E: At the point E it starts converting into a liquid.

This is called the condensation point or liquefaction point and it represents the same temperature as the boiling point.

The temperature will however remain constant during this process of condensation or liquefaction.

Point C: Further cooling will convert the liquid into solid at the point C which is called the freezing point and it represents the same temperature as the melting point.

The line C to B shows that the process of cooling is converting all the liquid into solid state at constant temperature.

Lines B to C and D to E: Lines B to C and D to E show that here the given energy is being utilized to change the phase from solid to liquid and from liquid to gas respectively.

Q.6: Draw heating curve for the physical changes water undergoes with change in temperature.

Ans. Heating Curve for water at 0°C (Melting Point):

For water a heating curve will show the rise of temperature of ice until it reaches 0°C (melting point) then it remains constant while the ice melts into liquid water.

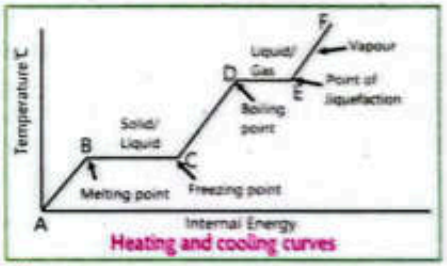
100°C (Boiling Point):

Further heating will increase the temperature again until it reaches 100°C (boiling Point). At this point it remains constant while the liquid water is converted into steam.

Cooling Curve for water:

100°C (Condensation): A cooling curve for a water will show the temperature of the steam decreasing until it reachers 100°C, it then remain constant while the steam condenses into liquid water.

0°C (Freezing): The temperature decreases again until it reaches 0°C. Finally it remains constant while the liquid water changes to ice.



Heating and cooling curves

Q.7: Differentiate between evaporation and boiling.

Ans.

Evaporation	Boiling
(i) It is a surface phenomenon. It occurs slowly and only at the surface of the liquid.	(i) A phase change when a liquid turns into a gas throughout the entire liquid forming bubbles, at a definite external atmospheric pressure.
(ii) It occurs at all temperatures but below the boiling point. It increases with increase in temperature and vice versa.	(ii) It occurs at a specific temperature at normal pressure and called the boiling point.
(iii) It produces cooling.	(iii) It does not result in cooling.
(iv) It requires a smaller amount of energy which is provided from inside the liquid.	(iv) It requires an external energy source.

Q.8: Describe effect of external pressure on the rates of evaporation and boiling.

Ans. Effect of External pressure on the Rate of Evaporation and boiling:

Rate of evaporation tends to increase by the decrease in external pressure and vice versa.

Explanation: If a liquid is in an open container, most of the molecules that escape into the vapour phase will not return to the liquid phase Instead, they will diffuse through the atmosphere away from the container.

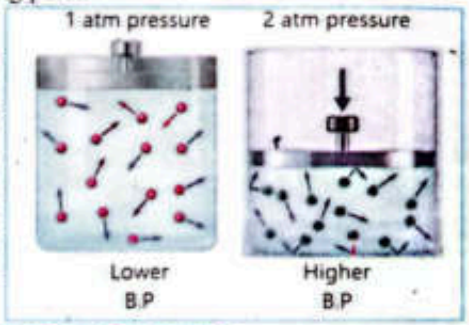
Increasing the External pressure: Increasing the external pressure will force these molecules to return back to the liquid surface making evaporation difficult.

Boiling: When a liquid boils, bubbles are formed inside the container, which then rise to the surface. At this stage, the temperature of the liquid remains constant till all the liquid boils over. This temperature is called the boiling point.

At lower Atmospheric pressure:

The boiling point decreases at lower atmospheric pressure and vice versa.

Example: If we measure the boiling point of water at Karachi it will be 100°C. However, if you will measure this boiling point at Murree it will be 98°C. The atmospheric pressure at Murree is lower than that in Karachi, so we find that the boiling point has decreased at lower atmospheric pressure.



14.5 Sublimation

14.6 Applications of Sublimation

Q.9: Write a note on sublimation and deposition.

Ans. Sublimation:

The direct conversion of a solid to vapours without melting is called sublimation.

Explanation: Just like evaporation, the energy needed for sublimation also comes from within the substance which then absorbs energy from the surrounding. This energy is sufficient to overcome the attractive forces of the neighbouring molecules which then escape into the vapour phase.

Examples:

- Solid carbon dioxide which is also called dry ice, changes directly to gaseous carbon dioxide at room temperature without first melting to liquid state.
- Disappearance of naphthalene balls which are used to keep the insects away from the woolen clothes.

Deposition: The process reverse to sublimation is called deposition, where a gas changes directly to a solid without going into the liquid state.

Example: Formation of frost in winter season is an example of deposition.

Q.10: How does the process of sublimation helpful in printing and in the usage of air freshner?

Ans. Solid Air Freshner:

The process of sublimation is used in the working of air fresheners. Solid air fresheners contain a scented substance which may evaporate with or without heating. The scented substance undergoes sublimation and disperse scented vapours throughout the room and mask unpleasant odours.

Explanation: When a solid air freshener is exposed to the atmosphere or heated in the air, its solid particles gain enough energy to overcome the attractive forces holding them together in the solid state. These particles then spread in the nearby atmosphere in the form of sweet smelling vapours.

Sublimation Printing: When the process of sublimation is used to print a design into a material or fabric, it is called sublimation printing.

Explanation: Essentially the process involues printing that transfers a design into a fabric using ink and heat.

In sublimation printing the first step is to print a design onto a special paper using sublimation inks.

The printed paper is then placed onto a fabric and heat and pressure are applied. The inks used are converted into vapours.

The printing is permanent which does not fade away with time because the ink is embedded in the fabric rather than simply attaching with the top of the fabric in a normal printing.

The heat supplied during the process opens up the pores present in the fabric, the ink enters into these pores under applied pressure, cools down and returns to a solid form.

Importance of Sublimation Printing:

The method is popular for print on demand t-shirts and it is also available on ceramic, wood and metal that have a special coating on to receive the inks which are sublimed.

14.7 Kinetic Theory and the Gas Laws

14.8 Diffusion

14.9 Importance of Rates of Diffusion of Medicines in Human Body

Q.11: State Boyle's law and explain the relationship between the pressure and volume of a gas on the basis of "Kinetic Molecular Theory".

Ans. Boyle's Law:

The law states that the volume of a given mass of a gas is inversely proportional to its pressure at constant temperature

Mathematical Expression:

Mathematically Boyle's law is written as:

$$V \times \frac{1}{P}$$

Where

V is the volume of given mass of gas P is its absolute pressure.

Explanation: According to kinetic theory, the pressure exerted by the gas in a container is caused by the collisions of its molecules with the walls of the container.

The pressure changes directly with the number of molecules colliding with the wall per unit of time.

Increased Pressure: When the pressure on the given mass of a gas is increased at constant temperature it will decrease the distance between its molecules and the volume of gas will also decrease.

Reducing Volume: If the volume of the gas will be reduced to one half of its original volume, it will double the number of molecules per unit of volume. Hence the number of collisions per unit of time on the same area of the surface will also be doubled. As a consequence of these collisions, the pressure of the gas will also be doubled.

Q.12: Describe an experimental verification of Boyle's law.

Ans. Experimental verification of Boyle's Law:

Robert Boyle proved the pressure-volume relationship by performing a simple experiment.

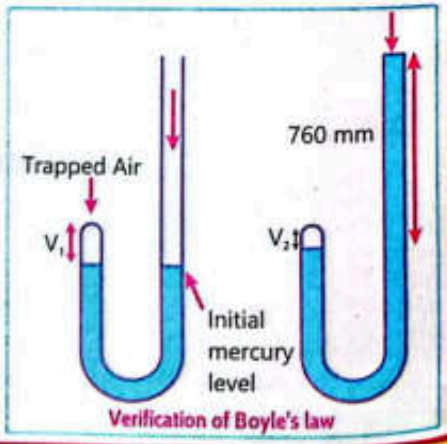
Robert Boyle used a simple J-shaped tube and sealed its shorter limb. He then poured a small amount of mercury through its open end until it jus trapped the air in the sealed end.

Since he used a small amount of mercury it did not squeeze the air inside the limb and it was now at atmospheric pressure (760 mm Hg).

Boyle then added more mercury until the difference in the height of the two columns of mercury was close to 760mm.

This mercury exerted the extra pressure on the entrapped air which was now about 2 atmosphere (2 × 760 mm).

When he read the new volume of the entrapped air it was one half of the initial volume.



Verification of Boyle's law

Conclusion:

During the experiment the mass of the gas remained fixed and the temperature also did not change.

By doubling the pressure, Boyle had reduced the volume by one half.

Q.13: State Charles's Law and explain, using kinetic theory, why the volume of a gas increases when it is heated at constant pressure?

Ans. Charles's Law:

The law states that the volume of a given mass of a gas varies directly with temperature when pressure is kept constant. The temperature must, however, be measured on absolute or Kelvin scale.

Mathematical Expression:

Mathematically Charles's law is written as:

$V \propto T$ (P and mass of gas are kept constant).

Explanation: According to kinetic theory, if temperature of a gas increases, it increases the average speed and kinetic energy of its molecules.

An increase in average speed results in more frequent and harder collisions with the walls of the container and hence its pressure increases.

If the pressure of the gas is kept constant, the increase in the temperature must increase the volume of the gas.

Experimental verification (The Piston Experiment):

Charles's law may be visualized easily if a gas is taken in a cylinder to which a piston is attached.

Heating a Gas:

When the gas is heated the piston must move up to increase the volume if the pressure is to remain constant.

Charles's law

Q.14: State Avogadro's law. Explain the relationship between the number of gas particles and the pressure they exert.

Ans. Avogadro's Law:

The law states that equal volumes of different gases must contain an equal number of molecules if the temperature and pressure are kept constant.

Mathematical Expression:

Mathematically Avogadro's law is written as:

$V \propto n$ (at constant temperature and pressure)

Explanation: According to kinetic theory, the pressure exerted by a gas is due to the number of collisions of its particles per unit area. This' in turn, depends upon the number of particles and their speed.

If you have two containers containing the same amount of a gas at the same temperature and pressure, and you increases the amount of gas in one container. Naturally the pressure of the gas in this container will increase.

To keep the pressure constant the volume of the gas must increase, This larger

volume compensates for the increased number of particles, ensuring the pressure remains the same.

Conclusion: Therefore, at constant temperature and pressure, a greater number of molecules simply requires a larger volume to maintain the same pressure.

Q.15: Explain the difference in the rates of diffusion of two gases based on kinetic theory.

Ans. Molecules present in gases are in a constant state of random motion. Due to this molecular motion the gas particles spread out and intermix from an area of high concentration to an area of low concentration. This property of gases is called diffusion.

Example: When a bottle of body perfume is opened in one corner of a room its sweet smell slowly spreads throughout the room after sometime due to the process of diffusion.

Spontaneous Process:

Diffusion is a spontaneous process during which gas particles spread out.

Diffusion of Hydrogen Gas:

The diffusion of Hydrogen gas from one container to another one.

Diffusion of gases

Kinetic Theory Explaining Diffusion of Gases:

The difference in the rates of diffusion of gases can be explained with the help of kinetic particle theory of gases.

According to the kinetic theory molecules of all the gases possess some kinetic energy at constant temperature.

Since Hydrogen is lighter than Oxygen its molecules will move faster than Oxygen at a given temperature. The rate at which Hydrogen gas will diffuse is thus much faster than that of Oxygen.

Increase in Rate of Diffusion: Rate of diffusion increases with the increase in temperature as the particles have more kinetic energy and hence they move faster. This eventually leads to rapid mixing and spreading.

Q.16: Prove with an experiment that different gases diffuse at different rates.

Ans. Apparatus:

- Two cotton plugs
- A glass long tube
- chloride gas
- Ammonia Solutions

Procedure: Two cotton plugs soaked in hydrogen chloride gas and ammonia solutions are introduced in the open ends of a 100cm long glass tube simultaneously.

Observation: The two gases produce white dense fumes of ammonium chloride at the point at which they meet in the tube. HCl molecules travel a distance of 40.5 cm while ammonia molecules cover 59.5 cm in the same duration.

Conclusion: Thus ammonia diffuses faster than hydrogen chloride gas because it is lighter than hydrogen chloride gas.

Rates of diffusion of gases

Q.17: Discuss importance of rates of diffusion of medicines in human body.

Ans. Diffusion:

The tendency of the molecules contained in a medicine to move from a region of higher concentration to one of lower concentration is called diffusion.

Diffusion Rates of Medicines: The diffusion rates of medicines control how rapidly and effectively they can be absorbed, distributed and eliminated from the body.

When the medicines are taken orally, the rates of their diffusion between the stomach and intestine control how quickly they are absorbed in the blood.

A faster diffusion rate means early absorption and hence a faster onset of action.

Effectiveness of Drug: Once the drug molecules are absorbed by the blood, they start diffusing into various tissues and organs. The rate of diffusion into various tissues and organs. The rate of diffusion here determines how quickly the drug becomes effective.

Example: Lipid soluble drugs diffuse more easily through cell membranes, making them more effective in shorter time.

More Effective Response:

Generally, a faster rate of diffusion leads to higher drug concentration at its target organ which means a more effective response.

Importance of Rates of Diffusion of Medicines in Human Body:

- Rates of diffusion play a crucial role in the delivery and movement of drugs throughout the body.
- Diffusion ensures that essential substances reach their target locations quickly which eventually helps in the treatment of diseases.

14.1 Quick Check!

1. **What is translational motion?**

Ans. **Translational Motion:**

It is a kind of motion in which molecules can move from one place to another in the same or different direction but always remains on the same axis.

2. **Is the average kinetic energy possessed by the particles of a gas and a liquid, same at the same temperature?**

Ans. Yes, the average kinetic energy possessed by the particles of a gas and a liquid are same at the same temperature.

14.2 Quick Check!

1. **Why do water vapour at 100°C cause more severe burns as compared to liquid water at the same temperature?**

Ans. When you boil water, the temperature stays at 100°C even though you keep heating. That extra heat (energy) is used to pull the water particles apart so they can become water vapour (gas). When water vapour hits your skin, it turns back into liquid and dumps all that extra heat (energy) onto you instantly.

2. **Why do we feel comfortable wearing cotton clothes in summer?**

Ans. Cotton is a natural fiber. It absorbs sweat from your body very easily. It is because it has tiny pores that let air reach the sweat. when the sweat evaporates (turns into gas) off the cotton, it carries the heat away from your skin, keeping your skin dry and cool. So you feel comfortable wearing cotton clothes in summer.

14.3 Quick Check!

1. **Does the change in temperature occur during the process of evaporation?**

Ans. No. During the process of evaporation, the temperature of the substance stays the same because the heat is being used to change the state (from liquid to gas) rather than raising the temperature.

2. **Does ice sublime?**

Ans. Yes. In very cold and dry conditions, ice can turn directly into water vapour without melting into a liquid first.

3. **Give one example each for sublimation and deposition other than mentioned in the text.**

Ans. Example of sublimation.

Dry Ice:

This is solid carbon dioxide. when it is left out at room temperature, it turns directly into a smoky gas without ever becoming a liquid.

Dry Ice (Solid CO_2):

When carbon dioxide gas is cooled very quickly under pressure, it turns directly into solid blocks or snow.

14.4 Quick Check!

1. **With the help of kinetic particle theory explain:**

(i) **How does a gas exert pressure?**

Ans. Gas particles are in constant, random motion. The pressure exerted by a gas is due to the collisions of its particles with the walls of the container.

(ii) **How does the volume of a gas change when its temperature is decreased? (Pressure and mass constant)**

Ans. When the temperature is decreased, the particles lose energy and move slower. They stay closer together, which makes the volume of a gas smaller.

14.5 Quick Check!

1. **Which gas among the following will diffuse at the fastest speed and which will diffuse at the slowest speed under similar conditions of temperature and pressure?**

NO_2, SO_2, H_2S

Ans. Among the gases listed (NO_2, SO_2, H_2S), here is how they diffuse:

- H_2S will diffuse at the fastest speed
- SO_2 will diffuse at the slowest speed.

Reason

It is because, lighter gas particles move and spread out (diffure) much faster than heavier ones. H_2S is the lighest of the three, while SO_2 is the heaviest

(ii) **Explain with the help of kinetic particle theory why does ammonia gas diffuse faster than hydrogen chloride gas?**

Ans. Ammonia gas molecules are much lighter than hydrogen chloride gas.

According to the kinetic particle theory, at the same temperature, lighter particles move at higher average speed than heavier particles.

Because ammonia particles are moving faster, they spread through the air more quickly than the heavier, slower hydrogen chloride particles.

DO YOU KNOW?

Interconversion of physical states of matter may not be brought about by changing the temperature only. Sometimes their interconversion may be affected more convniently by changing both the temperature and pressure at the same time or by varying the passure only at constant temperature. For example, ice melts from pressure in the hands of a snowball maker. For example, ice melts from pressure in the hands of a snowball maker. Ammonia gas can be liquefied at atmospheric pressure and at a temperature of –34°C. Alternatively, it can also be liquified by exerting a pressure 1 MPa and at room temperature (25°C).

INTERESTING INFORMATION

Phase change materials are used in thermal regulation, such as in clothing or building insulation, to store and release thermal energy.

THINGS TO KNOW

Molecules present in a gas and a liquid show all the three types of movements simultaneously namely, translational, rotational and vibrational.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

14.1	Internal Energy
14.2	Interconversion of Physical States

1. **According to the kinetic particle theory, what is the state of motion for particles in all matter?**

(a) Moving only when heated (b) Continuous and random
(c) Stationary and fixed (d) Moving in a circular pattern

2. **Which type of motion is possessed by particles in a solid?**

(a) Random motion (b) Vibrational motion

(c) Rotational motion (d) Translational motion

3. **What happens to the average kinetic energy of gas particles if the temperature increases?**
(a) It decreases (b) It stays the same (c) It increases (d) It becomes zero

4. **Internal energy of a substance is the sum of which two types of energy?**
(a) Heat energy and light energy (b) Kinetic energy and potential energy
(c) Nuclear energy and solar energy (d) vibrational energy and sound energy

5. **At the melting point:**
(a) The solid turns to a liquid (b) The liquid turns to a gas
(c) The gas turns to a solid (d) The gas turns to a liquid

6. **What is the process called when a gas turns back into a liquid?**
(a) Boiling (b) Melting (c) Condensation (d) Evaporation

7. **At the boiling point the vapour pressure of the liquid is equal to:**
(a) zero (b) The internal energy
(c) The melting (d) The atmospheric pressure

8. **Which state of matter has a fixed volume but no fixed shape?**
(a) Solid (b) Liquid (c) Gas (d) Plasma

9. **What happens to the movement of particles when a gas is cooled?**
(a) They repel each other more (b) They disappear
(c) They move faster (d) Their kinetic energy decreases

10. **Which of these substances exists in three Physical states while its chemical nature remains exactly the same?**
(a) Oxygen (b) Iron (c) Corbon dioxide (d) water

11. **Which states of matter show all three types of movement simultaneously?**
(a) Solids and liquids (b) Only gases
(c) Gases and liquids (d) Only solids

12. **Which state of the matter keeps its level and have a fixed volume?**
(a) Solid (b) Liquid (c) Gas (d) Plasma

13. **Which of the following movements do molecules of a gas and a liquid show?**
(a) Translational (b) Rotational (c) vibrational (d) All of these

14. **What is the name for the escape of molecules from the surface of a liquid at any temperature?**
(a) Condensation (b) Evaporation (c) Boiling (d) Melting

15. **When a gas is cooled and molecules come closer together, what is the result?**
(a) Condensation (b) Evaporation (c) Boiling (d) Melting

14.3 Heating and Cooling Curves

14.4 Evaporation and Boiling

16. **When a solid substance is heated, its temperature**
(a) Increases (b) Decreases (c) Remains same (d) Becomes Zero

17. **The condensation point is also called the**
(a) Melting point (b) Liquefaction point
(c) Boiling point (d) Freezing point

18. **During the process of condensation, the temperature**
(a) Will increase (b) Will decrease
(c) Remains constant (d) Becomes zero

19. **Which of the following represents the same temperature as the melting point?**
(a) Boiling point (b) Freezing point
(c) Condensation point (d) None of these

20. **Ammonia gas can be liquefied at atmospheric pressure and at a temperature of:**
(a) – 31°C (b) – 32°C (c) – 33°C (d) 34°C

21. **What is the boiling point of water in Murree as compared to Karachi?**
(a) 102°C (b) 100°C (c) 98°C (d) 75°C

22. **If the external pressure is increased, the rate of evaporation.**
(a) Also increases (b) Decreases
(c) Remains constant (d) Remains same

23. **The process of a gas turning directly into a liquid is called.**
(a) Sublimation (b) Condensation (c) Melting (d) Boiling

24. **At what temperature does the heating curve for water stay constant while a ice melts?**
(a) O°C (b) 100°C (c) 25°C (d) 34°C

25. **Which of the following is "Dry Ice"?**
(a) Frozen ammonia gas (b) Solid carbon dioxide
(c) Liquid nitrogen (d) Frozen oxygen

26. **Which of these factors increases the rate of evaporation?**
(a) Increasing the surface area (b) Decreasing the temperature
(c) Increasing external pressure (d) Keeping the container closed

27. **In Karachi the boiling point of water is:**
(a) 25°C (b) 50°C (c) 75°C (d) 100°C

28. **When a gas is cooled the kinetic energy of its molecules.**
(a) Decreases (b) Increases
(c) Remains constant (d) Becomes zero

29. **The temperature of a liquid at which the vapour pressure of liquid becomes equal to the atmospheric pressure is called its:**
(a) Melting point (b) Boiling point
(c) condensation point (d) Evaporation

14.5 Sublimation

14.6 Applications of Sublimation

30. **The direct conversion of a solid to vapours without melting is called.**
(a) Boiling (b) Freezing (c) Sublimation (d) Condensation

31. **What is the reverse process of sublimation called?**
(a) Melting (b) Deposition (c) Freezing (d) Boiling

32. **Which substance is used to keep insects away from woollen clothes through sublimation?**
(a) Salt crystals (b) Naphthalene balls (c) sugar cubes (d) Dry ice

33. **The formation of frost in winter is an example of which process?**
(a) Sublimation (b) Evaporation (c) Deposition (d) Condensation

34. **Which process is used in the working of air fresheners?**
(a) Evaporation (b) Condensation (c) Deposition (d) Sublimation

35. **Which two factors are applied to convert sublimation inks into vapour?**
(a) cold and light (b) Heat and pressure
(c) water and air (d) light and heat

36. **Sublimation printing can be done on fabric and.**
(a) Ceramic (b) Wood (c) Metal (d) All of these

37. **What is the process called when a gas changes directly into a solid?**
(a) Deposition (b) Condensation (c) sublimation (d) Melting

38. **Which of the following describes the formation of frost?**
(a) Evaporation (b) Melting (c) Sublimation (d) Deposition

14.7 Kinetic Theory and The Gas Laws

14.8 Diffusion

14.9 Importance of Rates of Diffusion of Medicines In Human Body

39. **Mathematically Boyle's law is written as:**
(a) $V \propto T$ (b) $V \propto \frac{1}{P}$ (c) $V \propto T$ (d) $V \propto n$

40. **How is charles' law mathematically written?**
(a) $V \propto T$ (b) $V \propto n$ (c) $V \propto \frac{1}{p}$ (d) $V \propto P$

41. **Which of the following is mathematically representation of Avogadro's law?**
(a) $V \propto \frac{1}{P}$ (b) $V \propto P$ (c) $V \propto n$ (d) $V \propto T$

42. **The basis of pressure volume relationship first observed by.**
(a) Robert Boyle (b) Alexander charles (c) Avogadro (d) Newton

43. **According to Boyle's Law what happens to the volume of a gas when the pressure is doubled at a constant temperature?**
(a) The volume is doubled (b) The volume is reduced one third
(c) The volume remains the same (d) The volume is reduced to one half

44. **Charle's law states that at constant pressure, the volume of a gas is directly proportional to its.**
(a) Atmospheric pressuse (b) Absolute (Kelvin) temperature
(c) Number of moles (d) Celsius temperature

45. **What happens to the rate of diffusion when the temperature is increased?**
(a) It remains constant (b) It decreases

(c) It increases (d) It stops completely

46. **In the human body medicines move from the stomach into the blood primanily through.**
(a) Compression (b) Active pumping (c) Diffusion (d) Evaporation

47. **Diffusion occurs most rapidly in which state of matter?**
(a) Gas (b) Liquid (c) Solid (d) Plasma

48. **If two containers have the same volume, temperature and pressure, Avogadro's Law says they must have.**
(a) Same number of molecules (b) Different speeds
(c) Same mass of gas (d) Same chemical properties

49. **Why does a scent (like perfume) spread across a room even if there is no wind?**
(a) Due to evaporation (b) Due to diffusion
(c) Due to sublimation (d) Due to deposition

50. **Which law explains why a football becomes flat or small in very cold weather?**
(a) Charle's law (b) Avagadro's law (c) Boyle's law (d) None of these

51. **If you squeeze a balloon (decreasing its volume) at constant temperature, the pressure inside will.**
(a) Becomes Zero (b) Increases (c) Decreases (d) Remains constont

52. **What happens to the pressure of a gas if the number of collisions with the walls increases?**
(a) The gas turns into a liquid (b) The pressure increases
(c) The pressure stays the same (d) The pressure decrease

53. **If you double the number of gas particles in a container while keeping T and P constant, what happens to the volume?**
(a) The volume is halved (b) The volume doubles
(c) The volume triples (d) The volume stays the same

54. **Lipid soluble drugs are often more effective because they call membrane they.**
(a) Diffuse more easily (b) Diffuse slowly
(c) Evaporate quickly (d) Do not diffuse

55. **In Boyle's experiment what was used to trap the air and apply pressure?**
(a) A piston (b) Mercury (c) Oil (d) Water

Answers

1.	(b)	2.	(b)	3.	(c)	4.	(b)	5.	(a)	6.	(c)	7.	(d)
8.	(b)	9.	(d)	10.	(d)	11.	(c)	12.	(b)	13.	(d)	14.	(b)
15.	(a)	16.	(a)	17.	(b)	18.	(c)	19.	(b)	20.	(d)	21.	(c)
22.	(b)	23.	(b)	24.	(a)	25.	(b)	26.	(a)	27.	(d)	28.	(a)
29.	(b)	30.	(c)	31.	(b)	32.	(b)	33.	(c)	34.	(d)	35.	(b)
36.	(d)	37.	(a)	38.	(d)	39.	(b)	40.	(a)	41.	(c)	42.	(a)
43.	(d)	44.	(b)	45.	(c)	46.	(c)	47.	(a)	48.	(a)	49.	(b)
50.	(a)	51.	(b)	52.	(b)	53.	(b)	54.	(a)	55.	(b)		

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

14.1 Internal Energy

14.2 Interconversion of Physical States

1. In which four physical states does matter exist in this world?

Ans. Matter in this world exists in four physical states namely gas, liquid, solid and plasma.

2. Properties of which state of matter were studied first?

Ans. Properties of gases were studied first.

3. What idea did lead to formulation of kinetic particle theory for gases?

Ans. It was suggested that physical properties of gases such as their ability to compress or expand, or diffuse could be understood by assuming that the gases consist of particles which are continuously moving randomly. This idea then led to formulation of kinetic particle theory of gases.

4. What does kinetic particle theory explain?

Ans. Kinetic particle theory explains:

- All the laws which govern the behaviour of gases.
- The composition of liquid and solid states of matter
- Interconversion of all three states.

5. What is the main idea of kinetic particle theory?

Ans. The main idea of kinetic particle theory is the all matter is made of particles that are always moving randomly.

6. What is kinetic particle theory?

Ans. Kinetic Particle Theory: It is a theory suggesting that all matter consists of particles that are in continuous random motion. It explain the properties of gases, liquids and solids, as well as their interconversion.

7. What is the main idea of kinetic particle theory?

Ans. The main idea of kinetic particle theory is that all matter is made of particles that are always moving randomly.

8. Give an example to support that all the three physical states are distinct in their physical properties only while their chemical nature remains the same.

Ans. All the three physical states are distinct in their physical properties only while their chemical nature remains the same.

Example: Water in all its three physical states remains chemically the same compond.

9. How does kinetic particle theory explain gas pressure?

Ans. According to kinetic particle theory the pressure exerted by a gas is due to the collisions of its particles with the walls of the container.

10. Why are attractive forces between gas particles assumed as negligible?

Ans. Attractive forces between gas particles are assumed as negligible since the particles are widely apart at low pressure.

11. Why do the particles of liquid have not any fixed position and shape?

Ans. The particles in a liquid are quite close to one another. They are also moving in all directions As a result the particles of liquid do not have any fixed position and shape.

12. Why does a liquid have a fixed volume?

Ans. Owing to the presence of interparticle forces, a liquid has a fixed volume and it keeps its level as well.

13. What kind of movement do the particles in a liquid show?

Ans. In a liquid, the particles show all the three types of movements namely.

- Translational
- Rotational
- Vibrational

14. Why is it assumed that the collisions between gas particles do not involve any loss or gain of energy due to friction?

Ans. Since the pressure of a gas in a container does not change with time at constant temperature, it is assumed that the collisions between its particles do not involve any loss or gain of energy due to friction.

15. What is the relationship between temperature and kinetic energy in gases?

Ans. The average kinetic energy of the particles is directly proportional to the temperature measured on kelvin scale.

16. Compare the movement of particles in solids and liquids.

Ans. In solids, particles only possess vibrational motion in fixed positions.

Liquids: In liquids, particles move in all directions and show three types of movement namely, translational, rotational and vibrational.

17. Is the average kinetic energy the same for all gases at the same temperature?

Ans. Yes, the average kinetic energy is the same for all gases at the same temperature.

18. At what scale is the temperature of a gas measured to find its kinetic energy?

Ans. According to kinetic particle forces in the solid substances are so strong that they keep their particles arranged in a fixed position.

19. What solids may consist of?

Ans. Solids may consist of ion, atoms and molecules.

20. What is the only type of motion particles have in a solid?

Ans. The particles of solid possess vibrational motion only.

21. Name the three types of movements shown by gas and liquid particles.

Ans. Gas and liquid particles show three types of movements namely translational, rotational and vibrational.

22. What is internal energy of a substance?

Ans. The internal energy of a substance is the total energy it contains. It includes the kinetic energy of its particles and the potential energy due to bonding between them.

23. What two types of energy make up internal energy?

Ans. Kinetic energy of particles of a substance and the potential energy due to bonding

between them make up internal energy.

24. What is the impact of heat on the internal energy of a system?

Ans. Heat increases the internal energy of a system.

25. How can the physical state of a solid substance be changed?

Ans. The physical state of a solid substance can be changed by simple heating.

26. Define melting point.

Ans. **Melting point:** At a particular temperature the vibrational motion of solid particles becomes so fast that It overcomes the cohesive forces. As a result the solid starts melting and this temperature is called the melting point of the solid.

27. Why does solid turn into a liquid at the melting point?

Ans. At the melting point, the particles of a solid not only lose their mean positions but the arrangement as well . The solid collapses and turns to a liquid.

28. Define evaporation.

Ans. **Evaporation:**
The molecules of a liquid keep on coming out from the surface of a liquid at all temperatures and such an escape of molecules from surface is called evaporation.

29. What is the difference between boiling and evaporation?

Ans. Boiling occurs througout the liquid at a specific temperature (boiling point), while evaporation occurs only at the surface and at any temperature.

30. Define boiling point.

Ans. **Boiling point:** The temperature of a liquid at which its vapour pressure becomes equal to the atmospheric or external pressure is called its boiling point.

31. What is condensation?

Ans. **Condensation:** At a suitable lower temperature the increased attractions bring the molecules so close that they are changed into a liquid form. This is called condensation.

32. Why does a temperature remain constant during condensation?

Ans. During condensation, as particles come together and form bonds/attractions energy is released, which keeps the temperature constant until the entire gas has turned into a liquid.

33. What does heat do to the kinetic energy of the particles?

Ans. Heat increase the kinetic energy of the particles and they start vibrating at a higher frequency.

34. Why doesn't the temperature rise while a solid is melting?

Ans. The temperature doesn't rise while a solid is metting because the heat energy is being used to weaken the force of Attraction between the particles instead of raising the temperature.

35. What is the difference between vapour pressure and atmospheric pressure at the boiling point?

Ans. At the boiling point vapour pressure and atmospheric pressure are equal to each other.

14.3 Heating and Cooling Curves

14.4 Evaporation and Boiling

36. What is a heating curve?

Ans. **Heating curve:** If is a graph drawn between the internal energy and the temperature of a system, showing how the temperature changes as a substance is heated through its different states.

37. What is a cooling curve?

Ans. **Cooling curve:** It is a graph drawn between the internal energy and the temperature of a system, showing how the temperature changes as a substance is cooled through its different states in reverse (e.g. from a gas to a liquid, or a liquid to a solid)

38. Define condensation point or liquefaction point.

Ans. **Condensation point or liquefaction point:**
It is the specific temperature at which a gas starts converting into a liquid during the cooling process for a pure substance, this is the same temperature as its boiling point.

39. Why does the temperature remain constant during the melting process?

Ans. The temperature remains constant during the melting process because the heat energy being provided is used to break the bonds between solid particles to convert them into a liquid, rather than increasing the kinetic energy of the particles.

40. How does external pressure affect the rate of evaporation?

Ans. Increasing the external pressure makes evaporation more difficult because it forc gas molecules back towards the liquid surface. Conversely, a decrease in external pressure increases the rate of evaporation.

41. How are the rates of both evaporation and boiling affected?

Ans. Rates of both evaporation and boiling are affected by the variation in the external pressure to which the liquid is subjected.

42. What does happen to rate of evaporation by the decrease in external pressure?

Ans. Rate of evaporation tends to increase by the decrease in external pressure and vice versa.

43. Why is the boiling point of water lower in Murree (98°C) than in karachi (100°C)?

Ans. Boiling occurs when vapour pressure equals external pressure. The atmospheric pressure at Murree is lower than that in Karachi, So we find that the boiling point has dreceared at lower atmospheric pressure

44. Can a phase change occur without changing temperature?

Ans. Yes, by varying the pressure, a substance can change states at a constant temperature.

For Example:

1. Ice melts from pressure in the hands of a snowball maker.
2. Ammonia gas can be liquefied by exerting a pressure 1MPa and at room temperature (25°C)

14.5 Sublimation

14.6 Applications of Sublimation

45. What is sublimation?

Ans. Sublimation:
The direct conversion of a solid to vapours without melting is called sublimation.
For example: Solid carbon dioxide which is also called dry ice, changes directly to gaseous carbon dioxide at room temperature without first melting to liquid state.

46. From where does the energy needed for sublimation came?

Ans. The energy needed for sublimation also comes from within the substance which then absorbs energy from the surroundings

47. Define deposition.

Ans. Deposition: The process reverse to sublimation is called deposition where a gas changes directly to a solid without going into the liquid state.
Example: Formation of frost in winter season.

48. Which process is used in the working of air fresheners?

Ans. The process of sublimation is used in the working of air freshenrs

49. What is sublimation printing?

Ans. Sublimation printing: When the process of sublimation is used to print a design into a material or fabric, it is called sublimation printing.

50. What does sublimation printing involve?

Ans. The process of sublimation printing involves printing that transfers a design into a fabric using ink and heat.

51. Form where does a substance absorb energy for sublimation?

Ans. A substance absorbs energy from its surrounding for sublimation.

52. Does sublimation printing stay on the top of the fabric?

Ans. No, the ink bacomes embedded inside the pores present in the fabric.

53. Why does printing in sublimation printing not fade away with time?

Ans. In sublimation printing the printing is permanent which does not fade away with time because the ink is embedded in the fabric rather than simple attaching with the top of the fabric in a normal printing.

54. On what materials can sublimation printing be used?

Ans. Sublimation printing is commonly used for T-shirts, ceramics, wood, and metals that have a special coating to receive the inks which are sublimed.

55. Name two common substances that undergo sublimation.

Ans. Two common substances that undergo

- Dry ice
- Naphthalene balls.

56. What is used to protect woolen clothes from insects?

Ans. Naphthalene balls are used to protect woolen clothes insects.

57. How do solid air fresheners work?

Ans. Solid air fresheners contain a scented substance which may evaporate with or without heating. The scented substance undergoes sublimation and disperse scented vapours throughout the room and mask unpleasant odours.

58. Why is sublimation printing considered permanent?

Ans. Unlike normal printing where ink sits on top, sublimation printing uses heat to open the pores of the fabric. The ink turns into vapours, enters the pores, and the solidifies inside the fiber as it cools.

59. What is "Dry ice"?

Ans. Dry ice is the common name for the solid carbon dioxide (CO_2).

60. What happens to naphthalene balls over time?

Ans. Naphthalene balls disappear over time because they sublime directly from a solid into a gas.

61. Does dry ice melt into a liquid at room temperature?

Ans. No, it changes directly into gaseous carbon dioxide.

62. What is a natural example of gas turning directly into a solid?

Ans. The formation of frost in winter is a natural example of gas turning directly into a solid.

63. What is needed to turn sublimation ink into vapour during printing?

Ans. Both heat and pressure are applied to turn sublimation ink into vapour during printing.

64. Can you use sublimation printing on metal?

Ans. Yes, as long as the metal has a special coating to receive the metal

14.7 Kinetic Theory and The Gas Laws

14.8 Diffusion

14.9 Importance of Rates of Diffusion of Medicines in Human Body

65. Define Boyle's law

Ans. Boyle's law: The law states that the volume of a given mass of a gas is inversely proportional to its pressure at constant temperature.

66. How is Boyle's law written mathematically?

Ans. Mathematically Boyle's law is written as:

$$V \times \frac{1}{P}$$

V = The Volume of given mass of gas

P = Absolute pressure of gas.

67. According to kinetic theory what causes the pressure of a gas in a container?

Ans. According to kinetic theory, the pressure exerted by the gas in a container is caused

by the collisions of its molecules with the walls of the container.

68. What did Robert Boyle use to prove the pressure volume relationship?

Ans. Robert Boyle used a simple J shaped tube to prove the pressure volume relationship.

69. What did Robert Boyle use to pour the J shaped tube?

Ans. Robert Boyle poured a small amount of mercury in J shaped tube.

70. What is the relationship between temperature and molecular speed?

Ans. As temperature increases, the average speed and kinetic energy of the molecules also increases.

71. How does the pressure of the gas in a container change?

Ans. The pressure of the gas in a container changes directly with the number of molecules colliding with the wall per unit of time.

72. Who did observe the basis of pressure volume relationship first?

Ans. The basis of pressure volume relationship was first observed by an Irish chemist Robert Boyle.

73. State Charle's law

Ans. Charle's law: The law states that the volume of a given mass of a gas varies directly with temperature when pressure is kept constant.

74. How is Charle's law written mattematically?

Ans. Mathematically charle's law is written as

$V \times T$

P and mass of gas are kept constant

75. Who did give the charle's law?

Ans. French scientist Jacques Alexandey Charles gave the charle's law.

76. What is Avogadro's Law?

Ans. Avogadro's Law: The law states that equal volumes of different gases must contain an equal number of molecules if the temperature and pressure are kept constant.

77. How is Avogadro's law written mathematically?

Ans. Mathematically Avogadro's law is written as $V \propto n$ (at constant temperature and pressure).

78. Explain the relationship between the number of molecules and volume.

Ans. At constant temperature and pressure, adding more gas molecules increases the number of collisions. To maintain the same pressure, the volume must increase to provide more space for the additional particles.

79. Define diffusion

Ans. Diffusion: Molecules present in gases are in a constant state of random motion. Due to this molecular Motion the gas particles spread out and intermix from an area of high concentration to an area of low concentration. This property of gases is called diffusion

80. How does the temperature affect the rate of diffusion?

Ans. Rate of diffusion increases with the increase in temperature as the particles have

more kinetic energy and hence they move faster. This eventually leads to rapid mixing and spreading.

81. Why does Ammonia (NH_3) diffuse faster than Hydrogen chloride (HCl)?

Ans. According to kinetic theory at the same temperature lighter molecules move faster than heavier ones.

Since Ammonia is lighter than Hydrogen chloside, it diffuses faster.

82. How does a gas exert pressure?

Ans. Gas pressure is caused by the continuous collisions as gas molecules with the walls of their container.

83. Why is diffusion important for medicines in the human body?

Ans. Diffusion is important for medicines in the human body because the process of diffusion ensures that essential substances reach their target locations quickly which eventually helps in the treatment of diseases.

84. What is spontaneous process in diffusion?

Ans. It means the gases mix on their own naturally without aid of any external force or energy to be applied.

85. How do medicines move from the stomach to the blood?

Ans. Medicines move through the process of diffusion traveling from an area of high concentration (stomach) to low concentration (blood)

86. What do the diffusion rates of medicine control?

Ans. The diffusion rates of medicine control how rapidly and effectively they can be absorbed, distributed and eliminated from the body.

87. What does make lipid soluble drugs more effective?

Ans. Lipid soluble drugs diffuse more easily through cell membranes, making them more effective in shorter time.

88. What does happen once the drug molecules are absorbed by the blood?

Ans. Once the drug molecules are absorbed by the blood, they start diffusing into various tissues and organs.

89. Why the rate at which hydrogen gas diffuses is much faster than oxygen"

Ans. Since hydrogen is lighter than oxygen its molecules will move faster than oxygen at a given temperature, the rate at which hydrogen gas will diffuse is thus much faster than that of oxygen.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. According to kinetic theory, the basic difference between solid, liquid and gas is due to:

(a) the difference in the movements of the particles.
(b) the chemical properties of the particles.
(c) the size of the particles.
(d) the shape of the particles.

2. **Upon heating the rate of evaporation:**
   (a) decreases (b) increases (c) remains the same
   (d) initially decreases and then increases upon further heating
3. **The inter-particle attractions are the strongest in:**
   (a) Solids (b) Liquids (c) Plasma (d) Gas
4. **Cooling the vapours of some gases change them directly into solid state. This phenomenon is called:**
   (a) evaporation (b) condensation (c) sublimation (d) deposition
5. **Physical state in which the particles possess the maximum energy:**
   (a) Solid (b) Liquid (c) Gaseous (d) Vapour
6. **How does the process of evaporation depend on the force of attraction present among the molecules of a liquid?**
   (a) It decreases with the increasing strength of attraction.
   (b) It increases with the increasing strength of attraction.
   (c) It is independent of the strength of the force of attraction.
   (d) It first increases and then decreases with the increasing strength of the force of attraction.
7. **Which gas will diffuse at the fastest rate?**
   (a) HCl (b) SO_2 (c) H_2S (d) CO_2
8. **The phase changes A and B in gas $\xrightarrow{A}$ liquid $\xrightarrow{B}$ solid are:**
   (a) Melting, evaporating (b) Condensation, melting
   (c) Condensation, freezing (d) Boiling, freezing
9. **A student noticed frost falling on the ground at 6.30 am and disappearing by 8.30 am. Which phase change was responsible for changing the frost into water vapours?**
   (a) Melting (b) Evaporation (c) Sublimation (d) Sublimation

ANSWERS

1. (a) 2. (b) 3. (a) 4. (d) 5. (c) 6. (a) 7. (c)
8. (c) 9. (c)

B. Short Answer Questions

14.1 From where does the energy come when a liquid evaporates?

Ans. When a liquid evaporates, the energy comes from the surroundings and the liquid itself. During evaporation, the surface molecules absorb heat energy from the rest of the liquid and the surroundings to overcome the atmospheric pressure and the attractive forces of other molecules and escape into the air.

14.2 Is condensation an endothermic process?

Ans. No. Condensation is an exothermic process. In condensation, gas molecules lose heat energy to their surroundings as they slow down and move closer together to form a liquid.

14.3 Why naphthalene balls (used to repel insects) disappear after sometime?

Ans. Naphthalene balls disappear after sometime due to a process called sublimation.

This is a process where a solid changes directly into a gas without passing through the liquid state. The solid napthalene molecules gain enough energy from the air to escape directly as vapours and disappear.

14.4 Why does the temperature remain constant during a phase change?

Ans. The temperature remains constant during a phase change because during a phase change the heat energy supplied is used to break the intermolecular bonds (overcoming the forces of attraction) better than increasing the kinetic energy of the particles (which would raise the temperature)

14.5 Is it possible to compress a liquid like a gas?

Ans. No. Liquids are considered incompressible. In a gas, there are large empty spaces between particles, but in a liquid, particles are already packed very closely together with almost no space to be pushed further.

14.6 Can you change the temperature at which water boils in an experiment in your lab?

Ans. Yes. The boiling point of water depends on atmospheric pressure.

- If you decrease the pressure (using a vacuum pump), water will boil at a temperature lower than 100°C
- If you increase the pressure (like in a pressure cooker), the boiling point increase.

14.7 In which season the wet clothes get dry after a relatively longer time?

Ans. Wet clothes take longer time to dry in Monsoon (Rainy) season. This is because the air is already saturated with moisture (high humidity), which slows down the rate of evaporation from the clothes.

14.8 When a solid is heated, what happens to its particles which are vibrating?

Ans. When heated, the particles gain kinetic energy and their vibrations become more rapid and vigorous. Eventually, the vibrations become strong enough to overcome the rigid bonds of the solid, leading to melting.

14.9 Do solids and liquids also diffuse just like gases?

Ans. Yes Solids and liquids also diffuse just like gases but much more slowly.

Example:

If you write on a chalkboard and leave it unclean for months, it becomes difficult to erase. This is because some particles of the chalk have diffused into the surface of the board.

14.10 Why dew is formed in the early hours of the morning?

Ans. At night, the ground and objects cool down. In the early morning, the air near these cold surfaces cools to its dew point (the temperature at which it is saturated with water vapour). The air can no longer hold all its water vapor, so the excess vapour condenses into water droplets on cold surfaces like grass or leaves

C. Constructed Response Questions

14.1 Differentiate between evaporation and boiling.

Ans. For answer see Q7.

14.2 Describe how boiling is related to the external pressure?

Ans. Boiling occurs when the vapor pressure of the liquid equals the external pressure

Lower External pressure:

When external pressure is lower, the boiling point decreases.

For Example: Water boils at a lower temperature on a mountains because the atmospheric pressure there is lower.

Higher External pressure:

When external pressure is higher, the boiling point increases.

For example: In a pressure cooker, by increasing internal pressure, water boils at a higher temperature, cooking food faster.

14.3 Why the process of evaporation does not need the input of energy?

Ans. Evaporation does not need the input of energy (heat) because it relies on the energy from its surroundings or on the kinetic energy that water molecules already possess at room temperature.

14.4 Why the heating and cooling curves for the phase changes adopt the same path?

Ans. The heating and cooling curves for the phase changes adopt the same path because.

- The heat required to break molecular bonds during heating is exactly equal to the energy released when those bonds reform during cooling.
- Under the same pressure conditions, a substance will melt and freeze at the same temperature (and boil and condense at the same temperature).

14.5 Why ice melts when the pressure is exerted on it?

Ans. Water is denser as a liquid than it is as solid ice.

When you exert pressure on ice, you force the molecules closer together, to collapse into a liquid.

14.6 Why do phase changes occur?

Ans. Phase changes happen because of changes in heat energy. This energy affects how particles behave.

D. Descriptive Questions

14.1 Explain the difference in the rates of diffusion of two gases based on kinetic theory.

Ans. For answer see Q 15.

14.2 How does the process of sublimation helpful in printing and in the usage of air freshner?

Ans. For answer see Q 10.

14.3 Draw heating curve for the physical changes water undergoes with change in temperature.

Ans. For answer see Q 6.

CHAPTER 15 Stoichiometry

Student Learning Outcomes

After studying this chapter, students will be able to:

- Use the molar gas volume, 24 dm^3 at room temperature and pressure, in calculations involving gases.
- Define concentration, use both g/dm^3 and mol/dm^3, and convert between them.
- Calculate stoichiometric relationships between substances relationships (specifically:
- reacting masses, limiting reactants,
- volume of gasses at R.T.P.,
- volumes of solution and concentrations of solutions in g/dm^3 or mol/dm^3, including conversion between cm^3 and dm^3)
- Calculate concentration of a solution in a titration using empirical data
- Calculate empirical formula and molecular formula from appropriate data
- Calculate percentage yield, percentage composition by mass and percentage purity from appropriate data.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

15.1 Molar Volume

15.2 Concentration of a Solution

15.3 Calculate the concentration of a solution in titration using empirical data

Q.1: What is molar volume. Why the concept of molar volume is useful for us?

Ans. Molar volume:

It has been found that one mole of all gases occupies a volume of 24 dm^3 at RTP. This is called molar volume.

It is worth nothing that one mole of each gas contains the same number of molecules, occupies the same volume and at the same time has different mass.

In other words the masses and the sizes of the molecules of gases do not change the volume occupied by them.

Variation in volume of a gas:

The volume of a gas varies with changes in pressure and temperature.

Room temperature and pressure: In order to compare the volumes occupied by different gases, we must adopt a set of standard conditions of temperature and pressure called room temperature and pressure (RTP).

Measurement of volumes of gases at room temperature:

The temperature of 25 °C (298.15k) and one atmosphere (760 torr) are used as standard conditions of temperature and pressure for measurement of volumes of gases at room temperature.

Usefulness of molar volume: The concept of molar volume is useful because it enables us to calculate the number of moles or masses of the gases if we know their volumes.

Q.2: What is concentration of a solution. Identify the specific units used for it.

Ans. Concentration of a solution:

Concentration of a solution is a measure of the amount that has been dissolved in a given amount of solution or solvent.

The amount of solute dissolved is expressed either in grams or in moles.

The quantity of solution is expressed in terms of its volume, dm^3 or cm^3.

Units:
- The units used for the mass /volume concentration is g/dm^3.
- The units used for the molar concentration is mol/dm^3.

Example: Calculate concentration of a solution in g/dm^3 which contains 20 g of sodium chloride dissolved in 0.2 dm^3 of water.

Solution:

Mass of solute in gram = 20 g

Volume of sodium in dm^3 = 0.2

Concentration of solution = ?

$$\text{Concentration} = \frac{\text{Mass of solute in gram}}{\text{Volume of solution in dm}^3}$$

$$= \frac{20}{0.2} = 100 \text{ g/ dm}^3$$

Q.3: How the concentration of a solution in titration is calculated using empirical data?

Ans. Titration:

The concentration of a solution can be determined by titrating it with a solution of known concentration till the end point is reached.

Things to know for titration: For the purpose, you need to know:
- The balanced chemical equation for the reaction between the two solutions.
- The volumes of the two solutions used during the titration.
- The concentration of the other solution.

Example: A titration is performed between NaOH and HCl till the end point is reached. 15 cm^3 of solution of sodium hydroxide having a molar concentration 0.5 mol/dm^3 is used to neutralize 23 cm^3 of HCl. Find out the concentration of HCl in mol/dm^3.

Solution:

- **Balanced chemical equation:**

  Balanced chemical equation for this reaction:

  $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

- **Conversion of volume of NaOH:**

  Convert the volume of NaOH used to dm^3. volume of the solution= $\frac{15}{1000}$ =0.015 dm^3.

- **Conversion of volume of HCℓ:**

  Convert the volume of HCl required to neutralize NaOH solution in dm^3.

  Volume of HCl required = $\frac{23}{1000}$ = 0.023 dm^3.

- **No of moles of NaOH:**

  No of moles of NaOH = molar concentration × volume

  = 0.5 mol/ dm^3 × 0.015 dm^3

  = 0.0075

- **According to the balanced chemical equation:**

  1 mol of NaOH has reacted with 1 mol of HCl.

- **No of moles of HCl:**

  No of moles of HCl = 0.0075

- **Concentration of HCl solution:**

  $$\text{Concentration of HCl solution} = \frac{\text{No.of moles}}{\text{Volume in dm}^3} = \frac{0.0075}{0.023}$$

  $$= 0.326 \text{ mol/dm}^3$$

  Therefore, the molar concentration of the HCl solution is 0.326 mol/dm^3.

15.4 Percentage Composition by Mass, Empirical formula and Molecular formula

15.5 Empirical formula

15.6 Limiting Reactant

Q.4: What is percentage composition of a compound. How is it useful in Stoichiometry?

Ans. Percentage composition of a compound:

Percentage composition of a compound refers to the percentage mass of each element present in the compound.

Percentage of an Element:

The percentage of an element in a compound is the number of grams of that element present in 100 grams of the compound.

Determining percentage of an Element:

The percentage of an element can be determined by applying the following

formula.

$$\text{Percentage of an element} = \frac{\text{Mass of the element in the compound}}{\text{Formula mass of the compound}} \times 100$$

Usefulness of percentage composition: Percentage composition is useful concept to determine the purity of a compound and its empirical and molecular formula.

Determining percentage composition of a compound:

Percentage composition of a compound can be determined both theoretically as well as by performing quantitative analysis.

Q.5: Write a note on empirical formula.

Ans. Empirical formula:

The formula which shows the simplest whole number ratio of atoms percent in a compound is called empirical formula.

Example: Empirical formula of:

- Hydrogen peroxide (H_2O_2) is HO
- Water (H_2O) is H_2O
- Benzene (C_6H_6) is CH.

Empirical formula of ionic compounds: All the ionic compounds are represented by their empirical formulae. These formulae show the simplest ratio present between their ions.

Sodium chloride (NaCl): The formula of sodium chloride (NaCl) represents the simplest ratio between sodium and chloride ions present in it.

Calcium chloride ($CaCl_2$): Similarly the formula of calcium chloride ($CaCl_2$) shows the ratio present between calcium and chloride ions.

Compounds having same empirical formula:

Since an empirical formula does not tell us about the actual number of atoms present in that compound rather it represents the simplest ratio of minimum ratio between atoms, it is possible that some compounds may have same empirical formula.

Examples:

- Both acetylene (C_2H_2) and benzene (C_6H6) have some empirical formula CH.
- Acetic acid (CH_3COOH) and glucose ($C_6H_{12}O_6$) also have same empirical formula CH_2O.

Q.6: How can the empirical formula of a compound be calculated?

Ans. Empirical formula of a compound can be calculated by following steps:

(i) Determine the percentage composition of the compound.

(ii) Find out the number of moles of each element. This is done by dividing the mass of each element (percentage of element) by its atomic mass.

(iii) Determine the atomic ratio of each element in the compound. This ratio can be found by dividing the number of moles of each element by the smallest number of moles.

(iv) If the atomic ratio obtained is simple whole number, it gives the empirical formula.

otherwise multiply this ratio with suitable digit to get the whole number ratio.

(v) Use this whole number ratio as a subscript for the elements to get the empirical formula.

Example: The percentage composition of a compound shows it to contain 25.26% M_g and 74.74% Chlorine. Find out its empirical formula.

Solution:

Change the percentage of elements to grams:

Mg = 25.26 % = 25.26 g

Cl = 74.74 % = 74.74 g

No. of moles of each element:

$$Mg = \frac{25.26}{24} = 1.05$$

$$Cl = \frac{74.74}{35.5} = 2.10$$

Atomic ratio of each element:

$$Mg = \frac{1.05}{1.05} = 1$$

$$Cl = \frac{2.10}{1.05} = 2$$

The empirical formula of magnesium chloride is $MgCl_2$.

Q.7: Define molecular formula. How is it calculated?

Ans. Molecular formula:

Molecular formula of an element or a compound represents the actual number of atoms present in the molecule of these substances.

Examples: Water, hydrogen peroxide, ethylene and sulphur have molecular formulae H_2O, H_2O_2, C_2H_4 and S_8 respectively.

Calculation of molecular formula: Molecular formula of a compound can be calculated by multiplying a whole number with the empirical formula of that compound.

Molecular formula = n (Empirical formula)

Where $$n = \frac{\text{Molecular Mass}}{\text{Empirical Formula Mass}}$$

Example: Let's find out molecular formula of benzene, if its empirical formula is CH and molecular mass is 78.

Solution:

Empirical formula of benzene = CH

Empirical formula mass of benzene = 12 + 1 = 13

Molecular mass of benzene = 78

$$n = \frac{78}{13}$$

Therefore the molecular = 6 (Empirical formula)

Formula of benzene $= 6 \times CH = C_6H_6$

So molecular formula of benzene is C_6H_6.

Q.8: How is chemical equation helpful in calculations?

Ans. A complete and balanced chemical equation tells us the mole ratio or mass ratio between the reactants and the products.

With the help of this ratio we can find out:

- The masses of the products from the given masses of the reactants.
- The masses of the reactants from the given masses of the products.

Example: The following equation tells us that one mole (100 g) calcium carbonate reacts with two moles (73 g) of hydrochloric acid to produce one mole (111 g) of $CaCl_2$, one mole (18 g) of water and one mole (44 g) of carbon dioxide.

$$\underset{\text{1 mole}\ \ 100\text{ g}}{CaCO_{3\,(s)}} + \underset{\text{2 moles}\ \ 73\text{ g}}{2HCl_{(aq)}} \longrightarrow \underset{\text{1 mole}\ \ 111\text{ g}}{CaCl_{2\,(aq)}} + \underset{\text{1 mole}\ \ 18\text{ g}}{H_2O_{(l)}} + \underset{\text{1 mole}\ \ 44\text{ g}}{CO_{2\,(g)}}$$

Q.9: What is a limiting reactant? Explain why it is called limiting.

Ans. In a chemical reaction, reactants are not always mixed according to stoichiometric ratio shown in the balanced chemical equation.

The use of excess reactants in experiments: Most often in experimental works, one or more reactants is used in large excess. This is done deliberately to ensure that the other expensive reactant is used completely. In this way the reactant which is used in excess in left behind at the end of the reaction and the other reactant is consumed completely.

Limiting reactant: The reactant which is consumed earlier is called the limiting reactant.

In fact, it is the limiting reactant which controls the amount of the product formed in a chemical reaction.

How to identify a limiting reactant: A limiting reactant present in a chemical reaction can be identified by carrying out the following steps.

(i) Calculate the number of moles of the reactants from the amounts provided.

(ii) Calculate the number of moles of the product which will from with the given moles of reactants.

(iii) Identify the reactant which gives the least amount of the product. This reactant will be the limiting reactant.

15.7 Yield

Q.10: Define actual yield and the theoretical yield. How is percentage yield calculated?

Ans. Actual yield:

The quantity of the product obtained when chemical reaction is performed is called

the actual yield . This yield is always less than the theoretical yield.

Theoretical yield: The theoretical yield is the amount of product which we calculate assuming that all reactants react according to the balanced chemical reaction.

Interest of a chemist: Percentage yield is calculated by applying the following formula:

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

Q.11: What is meant by Percentage purity? Explain with an example.

Ans. Percentage purity:

In chemistry, purity refers to the degree to which a substance is free from impuritites. Percentage purity of compound indicates the amount of pure compound present in an impure sample.

Percentage purity of a sample is calculated by the following formula.

$$\text{Percentage purity} = \frac{\text{Mass of the pure sample}}{\text{Total mass of the impure sample}} \times 100$$

Example: 12.0 g sample of a pharmaceutical product was found to contain 11.57 g of the active drug. Find out the percentage purity of the sample.

Solution:

$$\text{Percentage purity} = \frac{\text{Mass of the pure drug}}{\text{Total mass of sample}}$$

$$= \frac{11.57}{12.0} \times 100 = 96.4\%$$

Examples

15.1 Calculate the number of moles of nitrogen gas present when it occupies a volume of 2.5 dm³ at RTP.

Solution:

24 dm³ is occupied by how many moles of nitrogen = 1 mole

1 dm³ will be occupied by how many moles of nitrogen $= \frac{1}{24}$ mole

2.5 dm³ will be occupied by how many moles of nitrogn $= \frac{1}{24} \times 2.5 = 0.10$ mole

You can use the following equation as well as to solve this problem.

$$\text{No. of moles of a gss} = \frac{\text{Volume of the gas at RTP}}{\text{Molar volume of the gas}} \quad \text{.....(1)}$$

15.2 Calculate the volume of 0.5 mol of hydrogen at RTP.

Solution:

Apply the requation (1) $0.5 = \frac{\text{Volume of hydrogen}}{24} = 1$ mole

Volume of hydrogen = $0.5 \times 24 = 12 dm^3$

15.3 Calculate the volume occupied by 200 g carbon dioxide at RTP.

Solution:

$$\text{No. of moles} = \frac{\text{Volume}}{\text{Molar Volume}}$$

$$\text{Volume} = \text{No. of moles} \times \text{Molar volume}$$

$$\text{Since no. of moles} = \frac{\text{Mass}}{\text{Molar Mass}}$$

So,

$$\text{Volume} = \frac{\text{Mass}}{\text{Molar Mass}} \times \text{Molar volume}$$

$$\text{Volume} = \frac{200 g}{44 g} \times 24\ dm^3 = 109\ dm^3$$

15.4 Calculate concentration of a solution in g/dm^3 which contains 20 g of sodium chloride dissolved in 0.2 dm^3 of water.

Solution:

$$\text{Concentration} = \frac{\text{Mass of solute in gram}}{\text{Volume of solution in } dm^3}$$

$$= \frac{20}{0.2} = 100\ g/dm^3$$

15.5 500 cm^3 of hydrochloric acid contains 1.8 g of dissolved hydrogen chloride. Calculate the concentration of the acid in g/dm^3.

Solution:

$$\text{Volume of hydrochloric acid in } dm^3 = \frac{500 cm^3}{1000} = 0.5\ dm^3$$

$$\text{Concentration of hydrochloric acid in } dm^3 = \frac{1.8}{0.5} = 3.6\ g/dm^3$$

15.6 Calculate the mass of copper sulphate in grams dissolved in 2 dm^3 of the solution to get a solution with a concentration 15 g/dm^3.

Solution:

Mass of solute in gram = Concentration in g/dm^3 × volume in dm^3

$= 15 \times 2 = 30$ g

15.7 A solution is prepared by dissolving 10 g of NaOH in 1.2 dm^3 of water. Calculate the concentration of the solution in mol/dm^3.

Solution:

Amount of NaOH = 10g

$$\text{No of moles of NaOH} = \frac{10}{40} = 0.25\ mol$$

$$\text{Concentration of the solution} = \frac{0.25}{1.2}$$

Concentration of the solution = $0.21\ mol/dm^3$

15.9 Find out the percentage composition of $Ca(OH)_2$

Solution:

Formula mass of $Ca(OH)_2 = 40 + 32 + 2 = 74$

Applying the formula given in equation (2)

$$\text{Percentage of an element} = \frac{\text{Mass of the element in the compound}}{\text{Formula mass of the compound}} \times 100$$

$$\text{Percentage of Ca} = \frac{40}{74} \times 100 = 54.05\%$$

$$\text{Percentage of Oxygen} = \frac{32}{74} \times 100 = 43.24\%$$

$$\text{Percentage of Hydrogen} = \frac{2}{74} \times 100 = 2.70\ \%$$

15.10 8.657 g of a compound were decomposed into its elements. It give 5.217g of carbon, 0.962 g of hydrogen and 2.478 g of oxygen. Find out the percentage composition of the compound.

Solution:

Applying the following formula

$$\text{Percentage of element} = \frac{\text{Mass of element}}{\text{Mass of compound}} \times 100$$

$$\text{Percentage of carbon} = \frac{5.217 g}{8.657 g} \times 100 = 60.26\ \%$$

$$\text{Percentage of hydrogen} = \frac{0.962 g}{8.657 g} \times 100 = 11.11\%$$

$$\text{Percentage of oxygen} = \frac{2.478 g}{8.657 g} \times 100 = 28.62\%$$

So, 100 g of the compound under study contains 60.26 g of carbon, 11.11 g of hydrogen and 28.62 g of oxygen.

15.11 The percentage composition of a compound shows it to contain 25.26% Mg and 74.74 Chlorine. Find out its empirical formula.

Solution:

1. Change the percentage of elements to gram

   Mg = 25.26 % = 26.26 g Cl = 74.74 = 74.74 g

2. No. of moles of each element

Mg $= \frac{26.26}{24} = 1.05$ Cl $= \frac{74.74}{35.5} = 2.10$

3. Atomic ratio of each element

Mg $= \frac{1.05}{1.05} = 1$ Cl $= \frac{2.10}{1.05} = 2$

The empirical formula of magnesium chloride is $MgCl_2$

15.12 The percentage composition of an organic compound by mass is 64.8% carbon, 15.62% hydrogen and 21.58% oxygen. Find out its empirical formula.

Solution:

Change the percentage of elements to gram:

C = 64.8 % H = 15.62 % O = 21.58 %

= 64. g = 15.62 g O = 21.58 g

No. of moles of each element:

C $= \frac{64.8}{12} = 5.4$ H $= \frac{15.62}{1.35} = 15.62$ O $= \frac{21.58}{16} = 1.35$

Atomic ratio of each element

C $= \frac{5.4}{1.35} = 4$ H $= \frac{15.62}{1.35} = 10$ O $= \frac{1.35}{1.35} = 1$

The empirical formula of the compound is $C_4H_{10}O$.

15.14 Glucose has an empirical formula CH_2O and its molecular mass is 180g mol. What will be its molecular formula?

Solution:

Empirical formula of glucose = CH_2O

Empirical formula mass of glucose = 12 + 2 + 16 = 30

Molecular mass of glucose = 180

$$n = \frac{180}{30} = 6$$

Molecular formula of glucose = $6(CH_2O) = C_6H_{12}O_6$

So molecular formula of glucose will be $C_6H_{12}O_6$

15.15 25 g of lime stone ($CaCO_3$) react with an excess of hydrochloric acid according to the above equation. How much calcium chloride ($CaCl_2$) will be produced?

Solution:

According to the equation

100 g of lime stone react to produce calcium chloride = 111 g

1 g of lime stome will react to produce calcium chloride $= \frac{111g}{100}$

25 g of lime stone will react to produce calcium chloride $= \frac{111}{100} \times 25 = 27.75$ g

15.16 Calculate the amount of carbon dioxide in grams produced when 25g of glucose reacts with 40 g of oxygen in the following photosynthesis reaction.

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$

Glucose

Solution:

In order to find out the amount of CO_2 in this reaction, we will have to identify which of the reactants is a limiting reactant

No. of moles of the reactants:

No. of moles of glucose $= \frac{25}{180} = 0.138$ mol

No of moles of oxygen $= \frac{40}{32} = 1.25$ mol

Calculate the no of moles of CO_2, which will be given by each of the reactants:

1 mole of glucose gives = 6 moles of CO_2

0.138 mol of glucose will give $= \frac{6}{1} \times 0.1385$

$= 0.83$ mol

6 moles of oxygen gives = 6 moles of CO_2

1.25 mol of oxygen will give $= \frac{6}{6} \times 1.25$

$= 1.25$ mol

Since CO_2 obtained from glucose than that of oxygen, so glucose is the limiting reactant.

Amount of CO_2 produced = $0.83 \times 44 = 36.5$ g

15.17 A chemist reacts 50 g of Zn with excess of nitric acid to get 80.2 g $Zn(NO_3)2$. Calculate the theoretical yield and the percentage yield of this reaction.

Solution:

Balanced chemical equation for the reaction

$Zn_{(s)} + 2HNO_{3(aq)} \longrightarrow Zn(NO_3)_{2\,aq} + H_2(g)$

No of moles of Zn $= \frac{50}{65.37} = 0.76$ mol

Amount of Zn $(NO_3)_2$ = 80.2 g

Theoretical yield

According to the balanced chemical equation

1 mol of Zinc gives = 1 mol of Zn $(NO_3)_2$

Amount of Zn (NO_3) in grams = $0.76 \times 189.38 = 143.92$ g

Percentage yield:

$$\text{Percentage Yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$= \frac{80.2}{143.92} \times 100 = 55.7\ \%$$

15.1 Quick Check!

Calculate the amount CO_2 in 100 dm³ at RTP?

Solution. Given data

Gas = carbon dioxide (CO_2)
Given volume (v) = 100 dm³
Molar volume at RTP = 24 dm³/mole
Number of moles = ?

$$\text{No. of moles (n)} = \frac{\text{Volume of the gas at RTP}}{\text{Molar volume of the gas}}$$

$$= \frac{100\ dm^3}{24\ dm^3/mol}$$

= 4.17 moles

15.2 Quick Check!

What mass of $CuSO_4$ is present in 5- cm³ of a 5×10^{-2} mol/dm³ aqueous solution?

Solution. Given data

$$\text{Volume of solution} = \frac{50 cm^3}{1000} = 15.2$$

Concentration of solution = 5 × 10-2 mol/dm³ (0.05mol/dm³)
Molar mass of $CuSO_4$ = 159.5 g/mol
Number of moles = Concentration in mol/dm³ (0.05 mol/dm³)
= 0.05 mol/dm³ × 0.05 dm³
= 0.0025 moles
Mass of in $CuSO_4$solution = No. of moles × Molar Mass
= 0.0025 × 159.5
= 0.39875 g
= 0.40 g

15.3 Quick Check!

Calculate the volume of 0.1mol/ dm³ oxlic acid ($C_2O_4H_2$) solution to exactly neutralize 25 cm³ of 0.1 mol/dm³ KOH solution.

Solution. 1. Balanced chemical equation:

$$C_2O_4H_2 + 2KOH \longrightarrow K_2C_2O_4 + 2H_2O$$

The ratio of Acid : Bare is 1 : 2

2. Calculate moles of KOH:

Volume of KOH = 25 cm³
Concentration of KOH = 0.1 mol/dm³

$$\text{Moles of KOH} = \text{Concentration} \times \frac{\text{Volume}}{1000}$$

$$= 0.1 \times \frac{25}{1000} = 0.0025 \text{ moles}$$

3. Calculate moles of oxalic acid needed:

Using the 1 : 2 ratio from the balanced equation

$$\text{Moles of acid} = \frac{\text{Moles of Bare}}{2}$$

$$\text{Moles of acid} = \frac{0.0025}{2} = 0.00125 \text{ moles}$$

4. Calculate volume of oxalic acid:

Moles of oxalic acid = 0.00125 moles
Concentration of oxalic = 0.1 mol/dm³

$$\text{Volume} = \frac{\text{Moles}}{\text{Concentration}} \times 1000$$

$$= \frac{0.00125}{0.1} \times 1000$$

$$= 0.0125 \times 1000 = 12.5\ cm^3$$

Therefor the volume of 0.1 mol/dm³ oxalic acid required is 12.5 cm³

15.4 Quick Check!

Calculate the percentage of sulphate ions (SO_4^{-2}) in $Al_2(SO_4)_3$.

Solution.
Atomic mass of Al = 27
Atomic mass of S = 32
Atomic mass of O = 16

Molar mass of one sulphate ion (SO_4):

Molar mass of SO_4 = 32 + (4 × 16)
= 32 (64) = 96

Molar mass of aluminium shulphate ($Al_2(SO_4)_3$):

Mass of Al = 2 × 27 = 54
Mass of 3 (SO_4) = 3 × 96 = 288
Total molar mass = 54 + 288
= 342 g/m

Applying the percentage composition formula:

$$\text{Percentage of an element } (SO_4^{-2}) = \frac{\text{Mass of the element in the compound}}{\text{Molar mass of the compound}} \times 100$$

$$= \frac{288}{342} \times 100$$

$$= 0.8421 \times 100 = 84.21\ \%$$

The percentage of sulphate ions (SO_4^{-2}) in $Al_2(SO_4)_3$ is 84.21 %

15.5 Quick Check!

A 0.5 g sample of compound contains 0.418 g of antimony (Sb) and 0.082 g of oxygen. What is the empirical formula of the compound?

Solution. Molar Masses

Antimony (Sb) = 121.8 g / mol
Oxygen (O) = 16.0 g3 / mol

No. of moles of each element

Moles of Sb

$$Sb = \frac{0.418\ g}{121.08\ g/mol} = 0.00343 \text{ mol}$$

Moles of O

$$O = \frac{0.082\ g}{16.0\ g/mol} = 0.005125\ mol$$

Atomic ratio of each element

$$Sb = \frac{0.00343}{0.00343} = 1$$

$$O = \frac{0.005125}{0.00343} = 1.494 \text{ (close to 1.5)}$$

Conevert to whole number

Since we cannot have a fraction in a formula (1.5), we multiply both numbers by 2 to get the simplest whole number ratio:

$Sb = 1 \times 2 = 2$

$O = 1.5 \times 2 = 3$

The empirical formula of the compound is Sb_4O_3.

15.6 Quick Check!

An unknown hydrocarbon contains 85.71 carbon. its molar mass is 84g/mol. What is its molecular formula?

Solution.

Carbon = 85.71 %

Molar mass = 84 g / mol

Molecular formula = ?

Finding the empirical formula:

A hydrocarbon contains only carbon (C) and hydrogen (H).

- Carbon = 85.71 %
- Hydrogen = 100 % – 85.71 % = 14.129 %

Assume a 100 g sample:

- Moles of C = 85.71 g / 12.0 = 7.14 mol
- Moles of H = 14.29 g / 1.0 = 14.29 mol

Mole ratio

- $C = \frac{7.14}{7.14} = 1$
- $H = \frac{14.29}{7.14} = 2$

The empirical formula is CH_2

- **Finding the molecular formula:**

1. Calculate empirical formula mass:

$CH_2 = 12 + (2 \times 1) = 14$ g/mol

2. Find the n:

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

3. Multiply the empirical formula by n:

Molecular formula = 6 (CH_2)

$= C_6H_{12}$

Therefore, the molecular formula of the hydrocarbon is C_6H_{12}

15.7 Quick Check!

Why it is necessary for a chemical equation to be balanced before it can be used in calculation?

Ans. It is necessary for a chemical equation to be balanced before it can be used in calculation because a complete and balanced chemical equation tells us the mole ratio or mass ratio between the reactants and the products. With the help of this ratio we can find out the masses of the products from the given masses of the reactants or the masses of the reactants from the given masses of the products.

15.8 Quick Check!

If you react 100 g of chlorine gas with 500 g of KI, which reactant will be the limiting reactant?

$$Cl_{2\,(g)} + 2KI_{(aq)} \longrightarrow KCl_{(aq)} + I_{2\,(g4)}$$

Solution. Given data

Chlorine gas = 100 g

KI = 500 g

Calculating available moles:

Moles of Cl_2:

$$\text{No. of moles} = \frac{\text{Volume}}{\text{Molar mass}}$$

$$n = \frac{100\ g}{71 g/mol}$$

$= 1.41$ moles

Moles of KI

$$\text{No. of moles} = \frac{\text{Volume}}{\text{Molar mass}}$$

$$n = \frac{50\ g}{166 g/mol}$$

$= 3.01$ moles

Determine the limiting reactant

$$Cl_{2\,(g)} + 2KI \longrightarrow 2Cl_{(aq)} + I_{2\,(g)}$$

The mole ration of Cl_2 : KI is 1 : 2

Moles of KI required for 1.41 moles of Cl_2:

$1.41 \times 2 = 2.82$ moles

We have 3.01 moles of kJ, which is more than the 2.82 moles needed.

Since we have more KI than required, KI is the excess reactant and Cl_2 is the limiting reactant.

15.9 Quick Check!

Find out the theoretical yield and percent yield of oxygen generated by heating 40 g of $KClO_3$ (M = 122.5). The mass of oxygen gas produced is 14.9 g

$$2KClO_{3\,(s)} \longrightarrow 2KCl_{(s)} + 3O_{2\,(g)}$$

Solution. Given data

Mass of $KClO_3$ = 40 g

Molar mass (M) = 122.5 g / mol

Mass of oxygen = 14.9 g

Theoretical yield of oxygen = ?

Percentage yield of oxygen = ?

Calculate theoretical yield of oxygen:

Find the moles of reactant

$$n = \frac{\text{Volume}}{\text{Molar mass}}$$

$$n = \frac{40\ g}{122.5\ g / mol}$$

$$= 0.3265\ mol$$

- **Use the mole ratio from the balanced equation**

$2KClO_3 \longrightarrow 2KCl + 3O_2$

The ratio of $KClO_3 : O_2$ is 2 : 3

$$\text{Moles of } O_2 = 0.3265 \times \frac{3}{2} = 0.4898\ mol$$

- **Convert moles of to mass (Theoretical yield)**

Molar mass of O_2 : $16 \times 2 = 32$ g / mol

Theoretical yield = 0.4898 mol × 32 g / mol

= 15.67 g

Calculate percentage yield

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yieldc}} \times 100$$

$$= \frac{14.9}{15.67} \times 100$$

$$= 95.1\ \%$$

INTERESTING INFORMATION

- The composition of all the chemical products which are in our daily use, such as shampoos, cleaners, soaps, perfumes and fertilizers are formed using stoichiometric calculations.

INTERESTING INFORMATION

- Stoichiometry is essential for optimizing chemical reactions in many industries.

INTERESTING INFORMATION

- Stoichiometry is used to determine the optimal dosages of medications for patients based on their weight, age and other factors.

POINT TO NOTE

- Molar concentration and molarity both refer to the concentration of a solute in a solution.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

15.1 Molar Volume

15.2 Concentration of a Solution

15.3 Calculate the concentration of a solution in titration using empirical data

1. **What is the room temperatrue for standard conditions:**
   (a) 0 °C (b) 25 °C (c) 75 °C (d) 100 °C
2. **At RTP, one mole of any gas occupies a volume of:**
   (a) 22 dm^3 (b) 23 dm^3 (c) 24 dm^3 (d) 25 dm^3
3. **Which factor does NOT change the volume occupied by one mole of a gas at RTP?**
   (a) Temperature (b) Pressure
   (c) Size of the molecules (d) Number of moles
4. **The pressure value used for standard RTP conditions is:**
   (a) 100 kpa (b) 1 atmosphere (760 torr)
   (c) 273 torr (d) 24 atmosphere
5. **Concentration of a solution is a measure of the amount of solute dissolved in a given amount of:**
   (a) Solution or solvent (b) Only solute
   (c) Solid crystals (d) Catalyst
6. **What is the standard unit for the mass/volume concentration?**
   (a) mol /kg (b) g /cm^3 (c) mg /ℓ (d) g / dm^3
7. **Molar concenttration is expressed in which of the following units?**
   (a) g / dm^3 (b) mol / g (c) mol / dm^3 (d) dm^3 / mol
8. **If 20 g of sodium is dissolved in 0.2 dm^3 of water, the concentration is:**
   (a) 10 g / dm^3 (b) 40 g / dm^3 (c) 80 g / dm^3 (d) 100 g / dm^3
9. **In a titration, the solution is added until the _____ point is reached.**
   (a) Starting (b) Boiling (c) End (d) Freezing
10. **To determine the concentration of a solution via titration, you must know the:**
    (a) Density of the flask (b) Room humidity
    (c) Colours of the solute (d) Balanced chemical equation
11. **Empirical data required for titration calculations includes:**
    (a) Volumes of two solutions used (b) The atmpospheric pressure only
    (c) The weight of the burette (d) None of these

12. **Titration is a techinque used to find the concentration of a solution by reacting it with:**
(a) Water only (b) Solution of known concentration
(c) Insoluble salt (d) Gaseous catalyst

13. **In the formula for concentration, what is the denominator?**
(a) Mass of solute in grams (b) Mass of solvent in kg
(c) Volume of solution In dm^3 (d) Temperature of the solution

14. **for titration purposes, you need to know the concentration of:**
(a) Both solutions beforehand (b) The other (known) solution
(c) indicator (d) Both a and b.

15. **It is esential for optimizing chemical reactions in many industires.**
(a) Stoichiometry (b) Biochemistry
(c) Organic chemistry (d) Electrochemistry

15.4 Percentage Composition by Mass, Empirical formula and Molecular formula

15.5 Empirical formula

15.6 Limiting reactant

15.7 Yield

16. **The percentage mass of each element present in a compound is known as:**
(a) Molecular mass (b) Percentage composition
(c) Empirical ratio (d) Molar volume

17. **What is formula mass of $Ca(OH)_2$?**
(a) 58 (b) 62 (c) 74 (d) 85

18. **The formula that represents the simplest whole number ratio of atoms in a compound is the:**
(a) Emirical formula (b) Molecular formula
(c) Molar volume (d) Percentage composition

19. **Benzene (C_6H_6) and acetylne (C_2H_2) both have the same empirical formula, which is:**
(a) CH_2 (b) C_2H (c) CH (d) CH_4

20. **To find the molecular formula from an 'empirical formula, the multiplier 'n' is calculated by:**
(a) Empricial mass / Molecular mass
(b) Molecular mass / Empirical formula mass
(c) Atomic mass × moles (d) Actual yield × Theoretical yield

21. **The reactant that is consumed earlier in a reaction and controls the amount of product formed is the:**
(a) Excess reactant (b) Catalyst
(c) Limitng reactant (d) Theoretical reactant

22. **How many moles of HCl are needed to react with 1 mole of $CaCO_3$ in the given reaction?**
(a) 1 mole (b) 2 moles (c) 3 moles (d) 4 moles

23. **The quantity of product actually obtained when a chemical raction is performed is called:**
(a) Theoretical yield (b) Actual yield
(c) Percent purity (d) Stoichiometric yield

24. **What is the empirical formula of a compund containing 25.26% Mg and 74.74 % chlorine (At . mass : Mg = 24, Cl = 35.5)**
(a) MgCl (b) $MgCl_2$ (c) Mg_2Cl (d) $MgCl_3$

25. **Empirical formula of magnesium chloride is:**
(a) $MgCl_2$ (b) 2 MgCl (c) Mg_2Cl_2 (d) 2 $MgCl_2$

26. **Glucose has an empirical formula of CH_2O and a molecular mass of 180. What is its molecular formula?**
(a) $C_2H_4O_2$ (b) $C_4H_8O_4$ (c) $C_6H_{12}O_6$ (d) $C_4H_8O_4$

27. **Empirical formula of glucose is:**
(a) $C_3H_6O_3$ (b) CH_2O (c) C_6H_6 (d) CHO

28. **Empirical formula of water is:**
(a) H_2O (b) $2H_2O$ (c) H_2O_2 (d) HO

29. **Which of the following is an empirical formula of benzene?**
(a) C_6H_6 (b) $C_6H_{12}O_6$ (c) CH (d) 6CH

Answers

1.	(b)	2.	(c)	3.	(c)	4.	(b)	5.	(a)	6.	(d)	7.	(c)
8.	(c)	9.	(d)	10.	(d)	11.	(a)	12.	(b)	13.	(a)	14.	(b)
15.	(a)	16.	(b)	17.	(b)	18.	(a)	19.	(c)	20.	(b)	21.	(c)
22.	(b)	23.	(b)	24.	(b)	25.	(b)	26.	(c)	27.	(b)	28.	(a)
29.	(c)													

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

15.1 Molar Volume

15.2 Concentration of a Solution

15.3 Calculate the concentration of a solution in titration using empirical data

1. **Define molar volume.**

Ans. Molar volume: One mole of all gases occupies a volume of 24 dm^3 at RTP. This is called molar volume.

2. What is the value for room temperature and pressure (RTP) at standard conditions?

Ans. The standard conditions for RTP is; temperature of 25 °C(298.15 k) and a pressure of one atmosphere (760 torr).

3. What is the numerical value of molar volume at RTP?

Ans. At RTP, one mole of any gas occupies a volume of 24 dm^3.

4. Do the size and mass of gas molecules affect the molar volume?

Ans. No. one mole of different gasses will contain the same number of molecules and occupy the same volume (24 d m^3 at RTP), even though they have different masses and molecular sizes.

5. Define concentration of a solution.

Ans. Concentration of a solution: Concentration of a solution is a measure of the amount of solute that has been dissolved in a given amount of solution or solvent.

6. In what units is the mass/volume concentration typically expressed?

Ans. It is expressed in g /d m^3.

7. What is the unit for molar concentration?

Ans. The unit for molar concentration is mol / dm^3.

8. Give the formula for calculating concentration in g / dm^3.

Ans. $$\text{Concentration} = \frac{\text{Mass of solute in gram}}{\text{Volume of solution in } dm^3}$$

9. How can the concentration of a solution be determined?

Ans. The concentration of a solution can be determined by titrating it with a solution of known concentration till the end point is reached.

10. What is titration?

Ans. Titration: Titration is a technique where the concentration of an unknown solution is determined by reacting it with a solution of known concentration until the end point is reached.

11. What three pieces of empirical data are needed to calculate concentration via titration?

Ans. (i) The balanced chemical equation for the reaction between the two solutions.
(ii) The volumes of the two solutions used during the titration.
(iii) The concentration of the other solution.

12. How is the number of moles or masses of gases calculated using molar volume?

Ans. It is calculated by knowing the volume of the gas and using the relationship that 1 mole = 24 d m^3 at RTP.

15.4 Percentage Composition by Mass, Empirical formula and Molecular formula

15.5 Empirical formula

15.6 + 15.7 Limiting Reactant + Yield

13. Define percentage composition of a compound.

Ans. Percentage composition of a compound: Percentage composition of a compound refers to the percentage mass of each element present in the compound.

14. What is the percentage of an element in a compound?

Ans. The percentage of an element in a compound is the number of grams of that element present in 100 grams of the compound.

15. What is the formula to calculate the percentage of an element in a compound.?

Ans. The percentage of an element in a compound can be determined by applying the following formula:

$$\text{Percentage of an element} = \frac{\text{Mass of the element in compound}}{\text{Formula mass of the compound}} \times 100$$

16. Define empirical formula.

Ans. Empirical Formula: The formula which shows the simplest whole number ratio of atoms present in a compound is called empirical formula.

Example: Empirical formula of:

- Hydrogen peroide (H_2O_2) is HO
- Water (H_2O) is H_2O
- Benzene (C_6H_6) is CH.

17. How can the percentage composition of a compound be determined?

Ans. Percentage composition of a compound can be determined both theoretically as well as by performing quantitative analysis.

18. What is a useful concept to determine the purity of a compound and its empirical and molecular formula?

Ans. Percentage composition is a useful concept to determine the purity of a compound and its empirical and molecular formula.

19. Give two examples of compounds having the same empirical formula.

Ans. Acetic acid (CH_3COOH) and Glucose ($C_6H_{12}O_6$) have the same empirical formula CH_2O.

20. Define molecular formula.

Ans. Molecular formula: Molecular formula of an element or a compound represents the actual numbers of present in the molecule of these substances.

Examples: Water, hydrogen, peroxide, ethylene and sulphur have molecular formula H_2O, H_2O_2, C_2H_4 and S_8 respectively.

21. What is relationship between molecular formula and empirical formula?

Ans. Molecular formula of a compound can be calculated by multiplying a whole number with the empirical formula of that compound.

Molecular formula = n (Empirical formula)

Where $n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$

22. What information does a balanced chemical equation provide for stoichiometry?

Ans. A complete and balanced chemical equation tell us the mole ratio or mass ratio between the reactants and the products.

23. Define limiting reactant.

Ans. Limiting Reactant: The reactant which is consumed earlier in a chemical reaction is called limiting reactant. In fact, it controls the amount of the product formed in a chemical reaction.

24. Differentiate between theoretical yield and actual yield.

Ans. Theoretical Yield: It is the amount of product which we calculate assuming that all the reactants react according to the balanced chemical equation.

Actual Yield: The quantity of the product determined when chemical reaction is performed is called the actual yield.

25. Why is the actual yield often less than the theoretical yield?

Ans. It can be due to side reactions, reversible reactions, less of product during filtration crystallization, or mechanical errors during the experiment.

26. How do you calculate, percentage yield?

Ans. Percentage yield is calculated by applying the following formula

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

27. Define percentage purity.

Ans. Percentage Purity: It refers to the degree to which a substances is free from impurities.

28. What does percentage purity of compound indicate?

Ans. Percentage purity of compound indicates the amount of pure compound present in an impure sample.

29. How is the percentage purity of a sample calculated?

Ans. Percentage purity of a sample is calculated by the following formula:

$$\text{Percentage Purity} = \frac{\text{Mass of the pure sample}}{\text{Total mass of the impure sample}} \times 100$$

30. In stoichiometry what must be done before calculating the mass of products?

Ans. In stoichiometry, before calculating the mass of products you must have a balanced chemical equation.

31. How do you find the "Atomic Ratio" of elements?

Ans. Divide the number of moles of each element by the smallest number of moles obtained.

32. What is importance of stoichiometry in the field of medical?

Ans. Stoichiometry is used to determine the optimal dosages of medications for patients

based on their weight, age and other factors.

33. How are the composition of all the chemical products which are in our daily use such as shampoos, cleaners, perfumes and fertilizers formed?

Ans. The composition of all the chemical products which are in our daily use such as shampoos, cleaners, perfumes and fertilizers are formed using stoichiometric calculations.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Volume occupied by 15 moles of ammonia gas at RTP:

(a) 224 dm^3 (b) 160 dm^3 (c) 360 dm^3 (d) 265 dm^3

2. How many moles of natural gas CH_4 will be present in a cylinder if its volume is 18 dm^3 at RTP?

(a) 0.75 mol (b) 0.67 mol (c) 0.85 mol (d) 0.56 mol

3. What will the molar concentration of potassium hydroxide solution if 2.0 g of it are dissolved in 100 cm^3 of solution?

(a) 0.36 mol/dm^3 (b) 0.53mol/dm^3 (c) 0.70mol/dm^3 (d) 0.45mol/dm^3

4. What will be the mass of NaCl needed to make up 15 dm^3 of its solution with a concentration of 0.7 g/dm^3?

(a) 21 g (b) 10.5 g (c) 31.5 g (d) 5.4 g

5. Find out the concentration of H_2SO_4 in mol/dm^3 if its 10 cm^3 react with 20 cm^3 of NaOH solution having concentration 0.1 mol/dm^3.

(a) 0.01 mol/dm^3 (b) 0.001 mol/dm^3 (c) 0.1 mol/dm^3 (d) 0.15 mol/dm^3

6. If the molar mass of a compound is 178 g/mol and its empirical formula is $C_3H_5O_3$. What is its molecular formula?

(a) $C_3H_5O_3$ (b) $C_6H_{10}O_6$ (c) $C_9H_{15}O_9$ (d) $C_8H_{10}O_8$

7. When natural gas burns in air, which component is the limiting reactant?

(a) Both components (b) Neither component is a limiting reactant
(c) Air (d) Natural gas

8. If the actual yield of a compound is 0.198 g while the theoretical yield is 0.217g. What will be the percentage yield?

(a) 50% (b) 91.2% (c) 80% (d) 90

Answers

1. (c) **2.** (a) **3.** (a) **4.** (b) **5.** (c) **6.** (b) **7.** (d) **8.** (b)

B. Short Answer Questions

15.1 What is the molar volume of a gas at RTP?

Ans. The molar volume of any gas at room temperature and pressure (RTP) is 24 dm^3. This means that one mole of each gas contains the same number of molecules,

occupies the same volume under these specific conditions (25 °C or 298.15 K) and 1 atmosphere (760 torr) pressure.

15.2 How does the concept of molar volume useful for us?

Ans. The concept of molar volume is useful for us because it enables us to calculate the number of moles or masses of the gases if we know their volumes.

15.3 How does the molar volume relate to the Avogadro's law?

Ans. Molar volume is a direct practical application of Avogadro's Law. Which states that equal volumes of different gases must contain an equal number of molecules if the temperature and pressure are kept constant. It is because:

1 mole of any substance always contain 6.02×10^{23} particles (Avogadro's number).

Avogadro's Law implies that 1 mole of any gas must occupy the same volume.

Molar volume (24 dm^3) is simply the specific volume that this "Avogadro's number" of gas particles occupies at RTP.

15.4. Why two different compounds may show the same empirical formula?

Ans. Two different compounds may have the same empirical formula because an empirical formula does not tell us about the actual number of atoms present in that compound rather it represents the simplest ratio between atoms.

Example:

Both acetylene (C_2H_2) and benzene (C_6H_6) have same empirical formula CH, because both have a 1 : 1 ratio of carbon to Hydrogen atoms.

Similarly both acetic acid (CH_3COOH) and glucose ($C_2H_{12}O_6$) have same empirical formula CH_2O, because both have a 1 : 2 ratio of carbon and Hydrogen atoms.

15.5 Why is percentage yield important?

Ans. Percentage yield is the efficiency of the chemical reaction. It is important in both laboratory and industrial fields.

Efficiency Measurement:

It tells a chemist how much of the theoretical maximum product was actually obtained.

Economic Viablity:

In industrial manufacturing (like producing medicines or fertilizers), a high percentage yield is essential to keep costs low and maximize profit.

Resource Managment:

It helps in identifying the waste of raw materials by improving the yield, companies can reduce the amount of starting materials needed, which is more sustainable.

15.6 What is the concentration of a solution in mol/dm^3 if it contains 49 g of H_2SO_4 in one dm^3 of solution?

Ans. To find the concentration in mol/dm^3, we first need to convert the mass of H_2SO_4 into moles.

(i) Calculate the molar mass of H_2SO_4

Using the atomic masses : H = 1, S = 32 , O = 16

Molar mass = $(2 \times 1) + 32 + (4 \times 16)$

Molar mass = $2 + 32 + 64 = 98$ g/mol.

(ii) Calculate the number of moles

$$\text{Moles} = \frac{\text{Given mass}}{\text{Molar mass}}$$

$$\text{Moles} = \frac{49\ \text{g}}{98\ \text{g/mol}} = 0.5 \text{ moles}$$

(iii) Calculate the concentration:

Since the volume of the solution is 1 dm^3, the concentration is simply the number of moles per dm^3.

$$\text{Concenration} = \frac{\text{Moles}}{\text{Volume in dm}^3}$$

$$= \frac{0.5\,\text{mol}}{1\,\text{dm}^3} = 0.5 \text{ mol/dm}^3$$

So the concentration of a solution is 0.5 mol/dm^3.

C. Constructed Response Questions

15.1 How would you identify the limiting reactant in a chemical reaction?

Ans. For answer see Q.9

15.2 Why is it important to find the purity of a compound which is used as a medicine?

Ans. Purity: Purity refers to the degree to which a substance is free from impurities.

Importance of finding the purity of a conmpound: It is important to find the purity of a compound which is used as a medicines for three main reasons.

Toxicological safety: During the synthesis of a drug, harmful by-products or impurities can be created. Even in trace amounts, these can cause severe allergic reactions, organ damage or long term toxicity.

Precise Dosage: Medicine must have a specific concentration of the active ingredient. If a compound is only 80 % pure, a patient taking a 100 mg pill is only receiving 80 m g of the drug, which may fail to treat the illness.

Stability and shelf life: Impurities can act as catalysts that speed up the decomposition of the medicine, making it expire faster.

15.3 Will there be a limiting reactant in a reversible reaction?

Ans. Generally no. In a reversible reaction, the concept of a limiting reactant is not typically applicable in the same way it is for irreversible (one-way) reactions.

Reason:

In an irreversible reaction, the limiting reactant is used up until it reaches to zero. However, in a reversible reaction, a state of chemical equilibrium is reached where both reactants and products coexist.

Outcome:

Since the reaction never goes to 100 % completion in one direction, no reactant is ever "completely consumed". Therefore, technically, there is no "limiting" factor that stops the reaction by disappearing entirely, instead, the reaction is limited by the equilibrium constant (Kc).

15.4 How do you know if a formula is empirical or not?

Ans. Empirical Formula: The formula which shows the simplest whole number ratio of atoms present in a compound is called empirical formula.

Determining if a formula is empirical or not: You can determine if a formula is empirical or not by checking the mathematical ratio of the atoms.

A formula is empirical if the subscripts of the elements are in their simplest whole number ratio and cannot be divided further by a common factor.

Example 1 : H_2O(Ratio 2 : 1)

The formula of water (H_2O) represents the simplest ratio (2 : 1) between Hydrogen and Oxygen atoms present in it. You cannot simplify this further. So, H_2O is an empirical formula of water.

15.5 Write down one method to find out the molecular mass of a compound without knowing its molecular formula.

Ans. The effective way to find out the molecular mass of a compound without knowing its molecular formula is using the molar volume of a gas, which is the volume occupied by one mole of any substance at a specific temperature and pressure.

At standard temperature (25 °C or 298.15 k) and one atmosphere (760 torr), one mole of any gas occupies a volume of 24 dm^3.

Here is how molar volume is used to calculate molecular mass:

The Fundamental Principle:

The molar mass (M) of a substance is the mass of one mole of its particles, measured in grams per mole (g / mol). If you can determine the mass of a gas sample (m) and determine how many moles (n) that sample contains, you can calculate the molar mass:

$$n = \frac{m}{M} = \frac{V}{Vm}$$

By rearranging this formula, you can find out the molar mass (M).

$$M = \frac{m.Vm}{V}$$

Where

- n = Number of moles
- m = Known mass (measured in grams (g))
- M = Molecular mass (Expressed in g/mol)
- V = Volume (Actual volume of gas)
- Vm = Molar volume (24 dm^3)

D. Numerical Problems

15.1 Calculate the number of moles, volume and number of molecules in 4.0 g of CH_4 at RTP.

Sol. Molar mass of $CH_4 = 12 + (1 \times 4) = 16$ g/mol

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{4.0\,g}{16\,g/mol} = 0.25 \text{ moles}$$

Molar volume = 24 dm^3

Volume = No. of moles × Molar volume:

$= 0.25 \times 24 = 6.0\ dm^3$

Number of molecules = Moles × 6.02×10^{23}

$= 1.505 \times 10^{23}$ molecules.

15.2 What mass of NaCl need to be dissolved in 150 cm^3 of a solution if the concentration of the solution is 0.4 mol/dm^3?

Sol. Volume = 150 cm^3 = 0.15 dm^3

Concentration = 0.4 mol/dm^3

Finding moles = ?

Moles = Concentration × Volume

$= 0.4 \times 0.15 = 0.06$ moles

Finding mass (Molar mass of NaCl = 58.5 g/mol)

Mass = Moles × Molar mass

$= 0.06 \times 58.5$

$= 3.51$ g.

15.3 Find out the percentage of sodium in $NaHCO_3$.

Sol. Molar Mass of $NaHCO_3$:

$23(Na) + 1(H) + 12(C) + 48(O_3) = 84$ g/mol

Percentage of Na = ?

$$\text{Percentage of Na} = \frac{\text{Mass of Na}}{\text{Molar mass of } NaHCO_3} \times 100$$

$$= \frac{23}{84} \times 100$$

$= 27.38\ \%$

15.4 A sulphide of iron contains 1.926 g of sulphur and 2.333 g of iron. Find out the empirical formula of this compound.

Sol. Moles of iron (Fe) = 2.333 g/56 = 0.0416 moles

Moles of sulphur (s) = 1.926 g/32 = 0.0602 moles

Molar ratio = ?

$$Fe = \frac{0.0416}{0.0416} = 1$$

$$S = \frac{0.0602}{0.0416} = 1.44 = 1.5$$

Whole number ratio:

Multiply by 2 = Fe_2S_3

Empirical formula of iron sulphide = Fe_2S_3

15.5 A compound contains by mass, 40.0% C, 6.71 % H and 53.3 % oxygen. A 0.320 mole of this compound weighs 28.8 g. What is the molecular formula of this compound?

Sol. Molecular formula of the compound = ?

Empirical formula calculation = ?

$$\text{Carbon (C)} = \frac{40.0}{12} = 3.33$$

$$\text{Hydrogen (H)} = \frac{6.71}{1} = 6.71$$

$$\text{Oxygen (O)} = \frac{53.3}{16} = 3.33$$

Ratio C : H : O = 1 : 2 : 1

Empirical formula = CH_2O

(Mass = 30 g/mol)

Molar mass of compound = ?

$$\text{Molar mass} = \frac{\text{Mass}}{\text{Moles}} = \frac{28.8\text{g}}{0.320\text{mol}} = 90 \text{ g/mol}$$

Molecular formula of compound = ?

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

$$n = \frac{90}{30}$$

$$= 3$$

Multiply CH_2O by 3 = $C_3H_6O_3$

15.6 The formation of ammonia gas is given by the following equation:

$$3H_{2\,(g)} + N_{2\,(g)} \longrightarrow 2NH_{3\,(g)}$$

If you start reacting 12 g of H_2 with 64 g of N_2, which will be the limiting reactant?

Sol.

$$\text{Moles of } H_2 = \frac{12}{2} = 6 \text{ moles}$$

$$\text{Moles of } N_2 = \frac{64\text{g}}{28} = 2.28 \text{ moles}$$

1 mole of N_2 needs 3 moles of H_2.

2.28 moles of N_2 should need = 2.28×3

= 6.84 moles of H_2

Since we have only 6 moles of H_2, So H_2 is the limiting reactant.

15.7 When 305 g of $AgNO_3$ is reacted with excess of $MgCl_2$ it produces 23.7 g of $Mg(NO_3)$. What is the percentage yield of the reaction?

$$2AgNO_{3\,(aq)} + MgCl_{2\,(aq)} \longrightarrow Mg(NO_3)_{2\,(aq)} + 2AgCl_{(s)}$$

Sol. Percentage yield of $Mg(NO_3)_2$ = ?

1. Equation Ratio:
2. Moles $AgNO_3$ produce 1 mole $Mg(NO_3)_2$
3. $$\text{Moles of } AgNO_3 = \frac{305\text{ g}}{170\text{ g/mol}} = 1.794 \text{ moles}$$
4. Theoretical mass = 0.897 moles × 148.3 g/mol = 133 g
5. $$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$= \left(\frac{23.7}{133}\right) \times 100$$

$$= 17.8\ \%$$

15.8 A sample of metal has a total mass of 3.66 kg and contains 2.45 kg of gold. What is the percentage purity of gold in this sample?

Sol. Percentage purity of gold = ?

Total mass = 3.66 kg

Pure gold mass = 2.45 kg

$$\text{Percentage purity} = \frac{\text{Mass of the pure sample}}{\text{Total mass of the impure sample}}$$

$$= \frac{2.45}{3.66} \times 100$$

$$= 66.94\ \%$$

CHAPTER 16 Electrochemistry

Student Learning Outcomes

After studying this chapter, students will be able to:

- Define redox reactions as simultaneous oxidation and reduction in terms of oxygen, hydrogen, electrons and changes in oxidation state
- Use roman numerals to indicate oxidation number of an element in a compound
- Identify oxidizing and reducing agents in a redox reaction
- Recognize that the oxidation number of elements in their free state is zero
- Derive the formula of ionic compounds from ionic charges and oxidation numbers
- Identify that the oxidation number of a monoatomic ion is the same as the charge on the ion
- Explain that the sum of the oxidation numbers in a neutral compound is zero
- Explain that the sum of the oxidation numbers in an ion is equal to the charge on the ion
- Identify redox reactions by the colour changes involved when using acidified aqueous potassium manganate (VII) to (II) or aqueous potassium iodide
- Define electrolysis as decomposition of ionic compound, in molten or aqueous solution, by passage of electric current
- Identify and label in simple electrolytic cells, the anode (+), cathode (-), electrolyte and direction of flow of electrons in external circuit,
- Describe the transfer of charge in external circuit, movement of ions in the electrolyte and transfer of electrons at electrodes
- Identify the products formed at electrodes and describe the observations made during the electrolysis of molten lead (II) chloride, concentrated dilute sulfuric acid using inert electrodes (platinum or carbon/graphite)
- State that hydrogen- oxygen fuel cell uses hydrogen and oxygen to produce electricity with water as the only chemical product
- Describe the advantages and disadvantages of using hydrogen-oxygen fuel cells in comparison with gasoline /petrol engines in vehicles.
- Define corrosion and discuss methods to prevent it. (some examples may include barrier method such as using paint, galvanizing, electroplating; sacrificial protection such as using magnesium blocks in ships)
- Identify the products formed at electrodes and describe the observations made during the electrolysis of dilute copper (II) sulphate using inert electrode or copper electrode
- Predict the identity of products of electrolysis of a halide compound in dilute or concentrated solution
- Construct ionic half-equations for reaction at either electrode.
- Describe electroplating and its applications.
- Sketch a schematic diagram for a voltaic cell e.g., Daniel cell
- Use the voltage data given for voltaic cells to determine order of reactivity of any two metals

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: How the oxidation number of atoms in compounds and ions can be found out?

Ans. Oxidation Number

The oxidation number is an apparent charge on an atom in a compound or an ion. It may have a positive or a negative sign.

Oxidation Number of Atoms in Compounds and Ions

The oxidation number of atoms can be found out by applying the following rules.

1. Atom present in a free element has an oxidation number zero.

Example: The oxidation number of sodium in sodium metal is zero. Similarly, oxidation number of oxygen in ozone(O_3) is also zero.

2. For monoatomic ions, the oxidation number is equal to the charge present on the ion.

Example: The oxidation number of Ca^{2+} is +2 while that of Al^{3+} is +3.

3. The elements present in group 1 (except hydrogen) in the periodic table are assigned oxidation number +1, those of group 2, +2 and those of group 3, +3.
4. In binary compounds the more electronegative atom is always assigned a negative oxidation number. For example, fluorine, being the most electronegative atom, will always be given -1 oxidation number. Similarly, in NH_3 and H_2S, nitrogen and sulphur are assigned the oxidation number of -3 and -2 respectively.
5. The elements of group 17 are normally given oxidation number -1 when they are combined with less electronegative element.

Example: Chlorine in all such compounds as HCl, PCl_3, $CHCl_3$ has been assigned an oxidation number -1.

6. Hydrogen is assigned an oxidation number +1 when it is in combination with more electronegative atoms while it is given oxidation number -1 when it is combined with less electronegative atoms.

Example: In HCl, the oxidation number of hydrogen is +1, while in sodium hydride

(NaH) it bears an oxidation number -1.

7. The element oxygen is assigned an oxidation number -2 in most of its compounds.
8. The sum of oxidation numbers of all the atoms present in a neutral compound is always zero. In a polyatomic ion the sum of oxidation numbers is equal to the charge present on that ion.

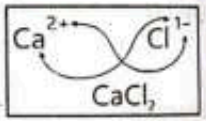
Q.2: Explain with examples how the formula of ionic compound can be written using oxidation numbers.

Ans. Writing Chemical Formulas of Ionic Compounds by applying Oxidation Numbers:

We can write the chemical formula of a compound if we know the oxidation numbers of its constituent elements. The periodic table and the electronic structure of the atoms can help us in predicting the principal oxidation number of the element. The formula of the compound may then be written using the oxidation number of the atoms present in that compound. For example, we shall write the formula of calcium chloride in the following way.

The element calcium is present in group II of the periodic table and its principal oxidation number is +2.

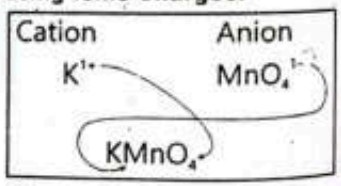
Chlorine is present in Group 17 and we know that when it is attached with less electronegative element in binary compounds its oxidation number is -1. The formula for calcium chloride will, therefore, be $CaCl_2$ because only with this formula the sum of the oxidation numbers of both the elements will add upto zero.



Q.3: Discuss with examples how the chemical formulas of ionic compounds can be written using ionic charges.

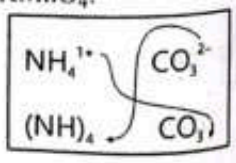
Ans. Writing Chemical Formulas of Ionic Compounds using Ionic Charges:

In order to write the formula of potassium permanganate, write first the formulae of permanganate ion, MnO_4^{1-} and potassium ion K^{1+}. Then combine the two ions together to form an electrically neutral compound.



The formula for potassium permanganate will, therefore, be $KMnO_4$.

When writing the formulae of ionic compounds containing more than one polyatomic ions, we take the formula of the ion in brackets and indicate the number of such ions with a subscript. The formula for ammonium carbonate will be written as follows.



The formula for ammonium carbonate will, therefore, be $(NH_4)_2CO_3$.

Q.4: Write a note on oxidation.

Ans. Oxidation

Oxidation is described in three principal ways.

1. Oxidation is defined as a process in which oxygen is either added or hydrogen is removed.

For example;

(i) Oxygen combines with other elements in the formation of their oxides. Elements in these processes are said to be oxidized and oxygen is reduced. Rusting of iron or burning of magnesium in air are oxidation processes.

$$4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$$
$$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$$

In the above reactions Fe and Mg are being oxidized while oxygen is being reduced. Oxygen is an oxidising agent while iron and magnesium are reducing agents.

(ii) Hydrogen is removed from a compound by oxygen in the following examples; hydrogen is removed from CH_4 and HCl by oxygen or a compound containing oxygen.

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$$
$$4HCl_{(aq)} + MnO_{2(s)} \rightarrow MnCl_{2(aq)} + 2H_2O_{(l)}$$

CH_4 and HCl in these reactions are being oxidized while O_2 and MnO_2 are being reduced. CH_4 and HCl are called reducing agents while O_2 and MnO_2 are called oxidising agents.

2. Oxidation is a process in which electron or electrons are lost.

For example; Copper may lose one or two electrons to give Cu1+ or Cu2+ ions respectively. In both these processes, we say, copper is being oxidised. Hence, copper is called an reducing agent.

$$Cu \rightarrow Cu^{1+} + e^-$$
$$Cu \rightarrow Cu^{2+} + 2e^-$$

3. Oxidation is process in which oxidation number or oxidation state of an element increases.

In the above two processes, the oxidation number of copper has increased from zero to +1 [Cu (I)] and +2 [Cu (II)] respectively.

Q.5: Write a note on reduction.

Ans. Reduction

Reduction is described in three principal ways.

1. Reduction is defined as either addition of hydrogen or removal of oxygen. For example,

(i) Hydrogen is added in chlorine to give hydrogen chloride gas.

$$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$$

(ii) In the following reaction, hydrogen is heated with metal oxide when oxygen comes out of the compound and combines with hydrogen to give a molecule of water.

$$CuO_{(s)} + H_{2(g)} \xrightarrow{Heat} Cu_{(s)} + H_2O_{(l)}$$

In the above examples, Cl_2 and CuO are being reduced and hydrogen (in both cases) is being oxidized. Cl_2 and CuO are called oxidizing agents while hydrogen in both the reactions will be reducing agent.

2. Reduction is a process in which electron or electrons are gained. For example,

$$Fe^{3+} + e^- \rightarrow Fe^{2+}$$
$$Mn^{7+} + 5e^- \rightarrow Mn^{2+}$$

In both the above examples, ions of iron and manganese are being reduced. Hence, they are called oxidising agents.

3. Reduction is a process in which oxidation number of an element decreases. In the above examples oxidation number of iron is reduced from +3 [Fe(III)] to +2[Fe(II)] while oxidation number of manganese is reduced from +7[Mn(VII)] to +2[Mn(II)].

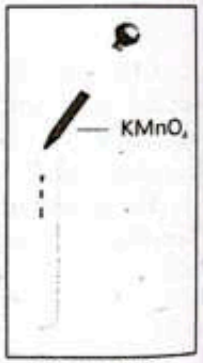
Q.6: Explain Oxidation-Reduction Reactions.

Ans. Oxidation-Reduction (Redox) Reaction

A chemical reaction which involves simultaneous oxidation and reduction is called an oxidation-reduction or redox reaction.

Principle: The reaction may involve the complete transference of electron or electrons to form ionic bonds or a partial transfer or shift of electron or electrons to form covalent bonds.

Explanation: Potassium permanganate acts as a very powerful oxidising agent in acidic medium. It oxidizes oxalic acid into carbon dioxide. During the reaction the dark purple solution of potassium permanganate changes to colourless. In the presence of dilute sulphuric acid the reaction proceeds as follows.



Decolourization

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$[O] + H_2C_2O_4 \rightarrow 2CO_2 + H_2O] \times 5$$
$$2KMnO_{4(aq)} + 3H_2SO_{4(aq)} + 5H_2C_2O_{4(aq)} \rightarrow K_2SO_{4(aq)} + 2MnSO_{4(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$$

Let us assign oxidation number to each element in these compounds to find out the oxidising and reducing agents.

$$\overset{+1\ +7\ 4(-2)}{2KMnO_4} + \overset{2(+1)\ +6\ 4(-2)}{3H_2SO_4} + \overset{2(+1)\ 2(+3)\ 4(-2)}{5H_2C_2O_4} \rightarrow \overset{2(+1)\ +6\ 4(-2)}{K_2SO_4} + \overset{+2\ +6\ 4(-2)}{2MnSO_4} + \overset{+4\ 2(-2)}{10CO_2} + \overset{2(+1)\ -2}{8H_2O}$$

$$Mn^{+7} \xrightarrow{+5e^-} Mn^{+2} \quad \text{(Reduction)}$$
$$C^{+3} \xrightarrow{-e^-} C^{+4} \quad \text{(Oxidation)}$$

Oxidation number of manganese has decreased from +7 to +2 and that of carbon has increased from +3 to +4.

So, each manganese atom accepts five electrons to get reduced and each carbon atom loses one electron to get oxidized. KMnO4 is, therefore, an oxidizing agent while oxalic acid in this reaction acts as a reducing agent.

Aqueous potassium iodide is also oxidized to iodine in acidified potassium permanganate. The formation of iodine in this reaction results in a colour change, typically from colourless to yellow-brown.

$$\overset{+1\ +7\ 4(-2)}{2KMnO_{4(aq)}} + \overset{2(+1)\ +6\ 4(-2)}{8H_2SO_{4(aq)}} + \overset{+1\ -1}{10KI_{(aq)}} \rightarrow \overset{+2\ +6\ 4(-2)}{6K_2SO_{4(aq)}} + \overset{0}{5I_{2(aq)}} + \overset{2(+1)\ -2}{8H_2O_{(l)}}$$

$$Mn^{+7} \xrightarrow{+5e^-} Mn^{+2} \quad \text{(Reduction)}$$
$$2I^{-1} \xrightarrow{-2e^-} I_2^0 \quad \text{(Oxidation)}$$

In this reaction, the permanganate ion (MnO_4^{2-}) is reduced to manganese (II) ion (Mn^{2+}) and the iodide ion (I^{1-}) is oxidized to iodine (I_2). Potassium permanganate, therefore, acts as an oxidizing agent while potassium iodide accts as a reducing agents.

Q.7: Define electrolysis. How does the process of electrolysis take place?

Ans. Electrolysis:

The process in which an electricity is passed through fused ionic compounds or their aqueous solution, they are decomposed into their constituents, is called electrolysis.

Electrolytes: The compounds which are decomposed into their constituents during the electrolysis are called electrolytes.

Chemical Reaction: During electrolysis, a non-spontaneous chemical reaction takes place with the help of electrical energy.

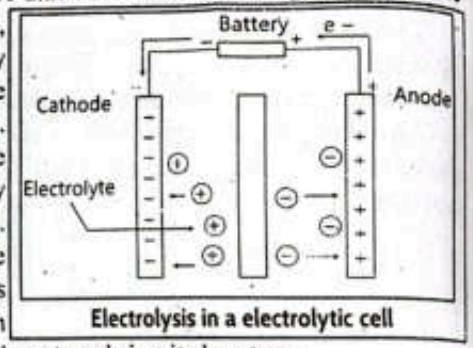
Electrolytic Cell: The process of electrolysis can be carried out in an electrolytic bath called an electrolytic cell with the help of two electrodes through which electric current enters and leaves the cell, These electrodes may be made of graphite or any other metal.

Anode: It is a positive electrode through which electrons enter the external circuit.

Cathode: It is a negative electrode through which electrons leave the external circuit.

Explanation: Electrolyte present in the cell is in the form of freely moving ions. During electrolysis, the electrolyte is decomposed into its components by applying an external voltage. Thus external voltage source (battery) forces the non-spontaneous reaction to occur by pumping electrons towards one of the electrodes, thereby, giving it a negative

charge. The positive ions of the electrolyte are attracted towards the negative electrode and get reduced by accepting electrons from it, making it the cathode. The battery simultaneously withdraws electrons from the other electrode, giving it a positive charge. The negative ions of the electrolyte are attracted towards this and get oxidized by losing their electrons, making it the anode. Electrons flow in the external circuit while ions move towards their respective electrodes inside the cell. If the oxidation and reduction at the electrodes cease, the flow of electricity in the external circuit also stops.



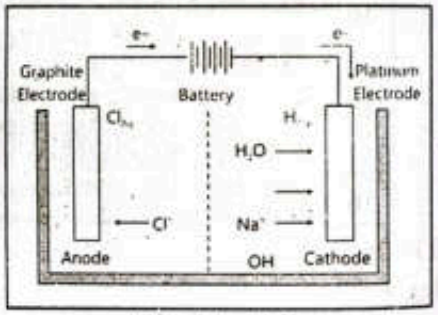
Electrolysis in a electrolytic cell

Q.8: Explain electrolysis of a concentrated aqueous solution of sodium chloride (Brine) using inert electrodes (Graphite/Pt).

Ans. Electrolysis of a Concentrated Aqueous Solution of Sodium Chloride (Brine) using inert electrodes (Graphite/Pt):

The electrolysis of a concentrated solution of sodium chloride, also called brine, produces hydrogen gas at the cathode, chlorine gas at the anode, and sodium hydroxide solution as a byproduct.

The electrolytic cell used in this electrolysis. The cathode used in this cell is made of platinum while the anode must be made of graphite to avoid the reaction with chlorine gas.



Electrolysis of brine

The following ions are present in the solution

$Na^+_{(aq)}, Cl^-_{(aq)}$ from sodium chloride

$H^+_{(aq)}, OH^-_{(aq)}$ from water

Na^+ and H_2O, both migrate towards the cathode. Since water molecules and hydrogen ions have a greater tendency to get reduced as compared to sodium ions (Na^+), so they pick up electrons from the cathode to form hydrogen gas.

At the Cathode:

$$2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$$

or

$$2H_2O + 2e^- \longrightarrow H_{2(g)} + 2OH^-$$

The ionic equilibrium of water is, thus, disturbed due to the discharge of H^+ and more water molecules are ionized to restore it. The solution around the cathode becomes alkaline due to the formation of hydroxide ions (OH^-).

At the Anode:

$$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e$$

The solution gradually gets alkaline due to the presence of OH^-. The volumes of hydrogen and chlorine gases obtained are equal.

The overall equation for this electrolysis is:

$$2\,NaCl_{(aq)} + 2H_2O_{(l)} \longrightarrow H_{2(g)} + Cl_{2(g)} + 2NaOH_{(aq)}$$

Q.9: Describe electrolysis of dilute aqueous solutions of metal halides.

Ans. Electrolysis of Dilute Aqueous Solutions of Metal Halides:

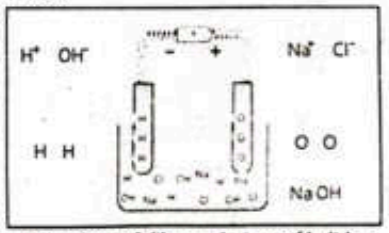
When the aqueous solutions of metal halides are subjected to electrolysis, the situation becomes more complicated due to the presence of water. Water is a very weak electrolyte and upon ionization it gives very small amount of hydrogen and hydroxide ions.

$$H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

This will mean that the electrolyte will consist of more than one type of ions which will approach both cathode and anode. Hence there can be a choice over which ions will get discharged.

For example, if an aqueous solution of sodium chloride is electrolyzed, both sodium and hydrogen cations are attracted towards the cathode and both chlorides and hydroxide ions are attracted towards the anode. Which of these ions will preferentially be discharged depends upon the tendency of the elements to lose or gain electrons. The elements present at the top of electrochemical series possess more tendency to lose electrons as compared to the elements present at the bottom.

If a metal is below hydrogen in the electrochemical series, then the metal ion is discharged. Metals like this include copper and silver. If dilute copper chloride is electrolyzed, copper metal is obtained at the cathode.



Electrolysis of dilute solutions of halides

If a metal is placed higher in the electrochemical series then hydrogen ion is discharged. Metals like this include lithium, sodium and magnesium. If dilute solution of sodium chloride is electrolyzed, hydrogen gas is obtained at the cathode.

Metals like lead and nickel present a more complicated picture. If aqueous solutions of halides of these metals are electrolyzed, then the products obtained at the cathode depends on the concentrations of the halide solutions. If the solution is concentrated then metal is deposited at the cathode. If the solution is very dilute, hydrogen is evolved. At in-between concentrations both metal and hydrogen are obtained.

At anode, the electrolysis of dilute solutions of halides will deposit oxygen because hydroxide ions are preferentially discharged due to their higher concentrations.

Reaction at the Cathode:

$$2M^{+}_{(aq)} + 2e^{-} \longrightarrow 2M_{(s)}$$

or

$$2H^{+}_{(g)} + 2e^{-} \longrightarrow H_{2(g)}$$

$$2H_2O_{(l)} + 2e^{-} \longrightarrow H_{2(g)} + 2OH^{-}_{(aq)}$$

Reaction at the Anode:

$$2X^{-}_{(g)} \longrightarrow X_{2(g)} + 2e^{-}$$

$$4\,OH^{-}_{(aq)} \longrightarrow O_{2\,(g)} + 2H_2O_{(l)} + 4e^{-}$$

Electrochemical Series

Stronger reducing agent ↑ / Weaker oxidizing agent ↓

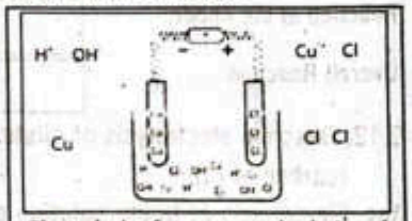
Lithium	$Li^{+}(aq) + e \rightleftharpoons Li(s)$	-3.04
Potassium	$K^{+}(aq) + e \rightleftharpoons K(s)$	-2.93
Calcium	$Ca^{2+}(aq) + 2e^{-} \rightleftharpoons Ca(s)$	-2.86
Sodium	$Na^{+}(aq) + e \rightleftharpoons Na(s)$	-2.71
Magnesium	$Mg^{2+}(aq) + 2e^{-} \rightleftharpoons Mg(s)$	-2.37
Aluminum	$Al^{3+}(aq) + 3e^{-} \rightleftharpoons Al(s)$	-1.66
Water	$2H_2O(l) + 2e \rightleftharpoons H_2(g) + 2OH^{-}(aq)$	-0.82
Zinc	$Zn^{2+}(aq) + 2e \rightleftharpoons Zn(s)$	-0.76
Iron (II)	$Fe^{2+}(aq) + 2e \rightleftharpoons Fe(s)$	-0.44
Cadmium	$Cd^{2+}(aq) + 2e \rightleftharpoons Cd(s)$	-0.40
Nickel	$Ni^{2+}(aq) + 2e^{-} \rightleftharpoons Ni(s)$	-0.25
Lead	$Pb^{2+}(aq) + 2e^{-} \rightleftharpoons Pb(s)$	-0.12
Hydrogen	$2H^{+}(aq) + 2e^{-} \rightleftharpoons H_2(g)$	0
Sulfur	$S(aq) + 2H^{+}(aq) + 2e \rightleftharpoons H_2S(aq)$	0.14
Tin	$Sn^{4+}(aq) + 2e \rightleftharpoons Sn^{2+}(aq)$	0.15
Copper	$Cu^{2+}(aq) + 2e^{-} \rightleftharpoons Cu(s)$	0.34
Iodine	$I_2(g) + 2e^{-} \rightleftharpoons 2I^{-}(aq)$	0.53
Iron (III)	$Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$	0.77
Silver	$Ag^{+}(aq) + e \rightleftharpoons Ag(s)$	0.79
Bromine	$Br_2(g) + 2e \rightleftharpoons 2Br^{-}(aq)$	1.06
Chlorine	$Cl_2(g) + 2e \rightleftharpoons 2Cl^{-}(aq)$	1.35
Gold	$Au^{+}(aq) + e^{-} \rightleftharpoons Au(s)$	1.69
Hydrogen peroxide	$H_2O_2(aq) + 2H^{+}(aq) + 2e^{-} \rightleftharpoons 2H_2O(l)$	1.77
Fluorine	$F_2(g) + 2e \rightleftharpoons 2F^{-}(aq)$	2.87

Weaker reducing agent ↓ / Stronger oxidizing agent ↓

Q.10: Discuss the electrolysis of concentrated solutions of metal halides.

Ans. Electrolysis of Concentrated Aqueous Solutions of Metal Halides:

If the concentrated aqueous solutions of metal halides are electrolyzed the hydrogen ions are discharged at the cathode if the metal is present higher than hydrogen in electrochemical series. For example, electrolysis of concentrated aqueous solution of sodium chloride will produce hydrogen gas at the cathode.



Electrolysis of concentrated solution of copper chloride

However, for less reactive metals like copper and silver the metal ions are discharged at the cathode.

At the anode, the halide ions are preferentially discharged due to their higher concentration.

Reaction at the Cathode:

$$2M^{+}_{(aq)} + 2e^{-} \longrightarrow 2M_{(s)}$$

$$2H^{+} + 2e^{-} \longrightarrow H_2$$

Reaction at the Anode:

$$2X^{-} \longrightarrow X_{2\,(g)} + 2e^{-}$$

Q.11: Explain electrolysis of molten lead (II) chloride.

Ans. Electrolysis of Molten Lead (II) Chloride:

Lead (II) chloride is solid at room temperature. To make it an electrolyte it must be heated upto 501°C to get molten lead chloride. Heat will render ions free to move and conduct electricity. The molten lead is then taken in a heated crucible where its temperature is maintained above 500°C.

Two inert electrodes (graphite or platinum) are then immersed in it. Upon electrolysis the lead (II) ions will move towards the cathode where they are discharged forming lead in the liquid state. The chloride ions migrate towards the anode where they lose electrons to give chlorine gas. The electrolysis must be carried out at the temperature above the melting point of lead chloride.

Reaction at the Cathode: $Pb^{2+}_{(l)} + 2e^- \longrightarrow Pb_{(l)}$ (Reduction)

Reaction at the Anode: $2Cl^-_{(l)} \longrightarrow Cl_{2(g)} + 2e^-$ (Oxidation)

Overall Reaction: $PbCl_{2(l)} \longrightarrow Pb_{(l)} + Cl_{2(g)}$

Q.12: Describe electrolysis of dilute solution of sulphuric acid using inert electrodes (carbon or Pt).

Ans. Electrolysis of Dilute solution of Sulphuric Acid using inert electrodes (Carbon or Pt):

Electrolysis of dilute aqueous solution of sulphuric acid produces hydrogen and oxygen gases. In other words this electrolysis involves the decomposition of water. Inert electrodes like platinum or graphite are used for this electrolysis because they did not react with the electrolyte.

In an aqueous solution of dilute sulphuric acid H^+ and SO_4^{2-} are given by sulphuric acid while the ionization of water forms H^+ and OH^-.

At the cathode, hydrogen ions gain electrons to give hydrogen gas. At the anode both SO_4^{2-} and OH^- are attracted but OH^- lose electrons to give oxygen gas. Sulphate ions are not discharged at the anode because they are difficult to be oxidized compared to hydroxide ions. As the electrolysis moves ahead, the concentration of sulphuric acid increases because the water present is being decomposed.

Reaction at the Cathode: $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$ (Reduction)

Reaction at the Anode: $4\,OH^-_{(aq)} \longrightarrow O_{2(g)} + 2H_2O_{(l)} + 4e^-$ (Oxidation)

Q.13: Discuss electrolysis of dilute aqueous solution of copper sulphate using inert electrodes or copper electrodes.

Ans. Electrolysis of Dilute Aqueous solution of Copper Sulphate using Inert electrodes or Copper electrodes:

The electrolysis of aqueous solution of copper(II) sulphate with inert electrodes result in the decomposition of water and the copper(II) sulphate. Copper metal is deposited at the cathode (inert) and oxygen gas is produced at the anode (inert).

Reaction at the Cathode: $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$ (Reduction)

Reaction at the Anode: $4\,OH^-_{(aq)} \longrightarrow O_{2(g)} + 2H_2O_{(l)} + 4e^-$ (Oxidation)

Since the concentration of copper ions decreases slowly so the blue colour of the solution fades away with the passage of time.

If copper electrodes are used instead of inert electrodes, the copper metal atoms from the copper anode start going into the solution in the form of copper ions and the electrode mass starts decreasing.

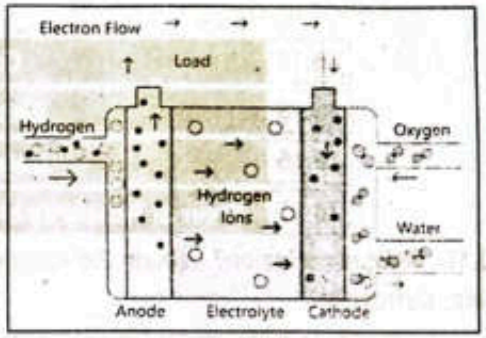
Reaction at the Cathode: $Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$ (Reduction)

Reaction at the Anode: $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e$ (Oxidation)

Q.14: Describe the working of a fuel cell.

Ans. Working of a Fuel Cell:

Fuel cells provide a method in which chemical energy is converted to electrical energy. These cells use gaseous fuels like hydrogen and oxygen to produce electricity. A fuel cell is composed of two hollow tubes which act as electrodes. They are made of porous compressed carbon saturated with platinum which acts as a catalyst. The electrolyte used in this cell is aqueous potassium hydroxide. At the anode, hydrogen is oxidized to water and at the cathode oxygen is reduced to hydroxide ions.



Fuel cell

At anode: $[H_{2(g)} + 2OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + 2e^-]2$

At Cathode: $O_{2(g)} + 2H_2O_{(l)} + 4e^- \longrightarrow 4OH^-$

Overall Reaction: $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$

The fuel cell produces electricity and water continuously provided the reactants are continuously supplied. They are very efficient because they convert 75% of the bond energy of fuels to electricity.

Q.15: Discuss advantages and disadvantages of fuel cells.

Ans. Advantages of Fuel Cells:

(i) The hydrogen-oxygen fuel cells have a clear advantage over the traditional fossil fuels, petrol and diesel, used to drive the vehicles. They produce zero emission of carbon dioxide because water is the only product. Fossil fuels, on the other hand, produce carbon dioxide, nitrogen oxides and sulphur oxides which are very harmful to the environment.

(ii) Fuel cells can convert a large proportion of chemical energy present in fuels into electrical energy as compared to the energy conversion of the fossil fuels. In other words, they are more efficient.

(iii) Fuel cells produce less noise pollution.

(iv) Hydrogen used in fuel cells can be obtained from renewable sources like solar or wind power. This fact renders fuel cells more sustainable.

Disadvantages of Fuel Cells:

(i) Fuel cells at present, are very expensive because the production of hydrogen by electrolysis of water incurs high cost.

(ii) Hydrogen being highly inflammable requires very special storage and transportation facilities which further increases the cost of fuel cells.

(iii) Fuel cells and electric motors are less durable than petrol and diesel engines so they are not so long lasting.

Q.16: What is corrosion? Explain the reactions involved in corrosion of iron.

Ans. Corrosion:

Corrosion is a natural process due to which a metal suffers gradual decay when it interacts chemically with its environment.

During this interaction the surface of metal is coated with compounds such as oxides, sulphides and carbonates.

Example: A common example is rusting of iron, where iron reacts with oxygen and water present in the atmosphere to form hydrated iron (III) oxide. Once iron begins to rust, the process will continue as rust is porous and allows both air and moisture to come into contact with fresh metal underneath. Hence, all the metal will corrode given enough time.

The process of corrosion of iron appears to require two important chemicals, oxygen and water, which are involved in the following electrochemical reactions. Iron loses electrons to form Fe (II) ions.

$$2Fe_{(s)} \longrightarrow 2Fe^{2+}_{(aq)} + 4e^-$$

Oxygen gains these electrons in the presence of water to form hydroxide ions.

$$O_{2(g)} + 2H_2O_{(aq)} + 4e^- \longrightarrow 4OH^-_{(aq)}$$

Fe^{2+} then react with more oxygen and water to form iron (III) hydroxide which is rust.

$$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Fe(OH)_{2(s)}$$

$$4Fe(OH)_{2(s)} + O_{2(g)} + 2H_2O_{(l)} \longrightarrow 4Fe(OH)_{3(s)}$$

Q.17: How can corrosion be prevented?

Ans. Prevention of Corrosion:

Coating of the metal surface: Corrosion can be avoided by coating the metal surface with some barriers that prevent the contact of metal surface with the atmosphere. For this purpose, the metal surfaces are protected by either greasing with oil or painting. Other methods of protection are galvanizing, electroplating and sacrificial protection.

Galvanization: Galvanization is a common method to protect iron or steel from rusting. It involves the dipping of an iron sheet in a bath of molten zinc. A layer of zinc metal gets deposited on the iron sheet and prevents rusting. Tin cans are actually steel cans which have been coated with a thin layer of tin.

Sacrificial Protection: In sacrificial protection a more reactive metal like zinc or magnesium is used which will corrode in place of the less reactive metal like iron. Magnesium is often employed to protect steel in buried fuel tanks and pipe lines and ship hulls submerged in sea water.

The difference in the activity of the two metals (Mg and Fe) causes a current to flow between them, producing corrosion on the more active metal protecting the less active metal iron.

Q.18: Explain electroplating giving examples.

Ans. Electroplating:

It is a process in which a metal is deposited on another metal electrolytic ally.

Objectives of Electroplating: There are three main objectives of electroplating.

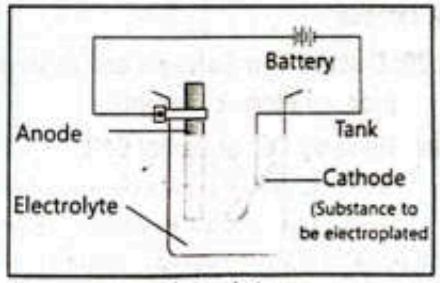
(i) **Decoration:** To deposit the noble metals like gold and silver on the inexpensive metals to enhance their beauty.

(ii) **Protection:** To protect the metals from rusting as well as from the reaction of organic acids.

(iii) **Repair:** To weld the broken parts of the machinery by electrodeposition of metals. Generally copper, silver, chromium, nickel and gold are electroplated.

Procedure of Electroplating:

The article to be electroplated is first cleaned with sand and then washed with caustic soda solution and finally with plenty of water. This article is then, made a cathode, while the metal to be deposited is made anode. The electrolyte is a salt of the metal being deposited and the electroplating is carried out in a tank made of cement, glass or wood. It is called an electrolytic tank.



Electroplating

The electrolyte chosen should have the following properties:

(i) very soluble in water (ii) good conductor

(iii) not easily oxidized or reduced or hydrolyzed (iv) inexpensive

Electrodes are dipped in the electrolytic tank containing the electrolyte and electric current is passed. A thin layer of the noble metal is deposited on the article to be electroplated. The following conditions should be fulfilled to get good deposits.

i. High current density ii. Low temperature
iii. Higher concentration of the metal in its electrolyte

Q.19: Write a note on the following:

(a) Silver Plating (b) Copper Plating

Ans. (a) Silver Plating:

The procedure for silver plating is the same as in electroplating except that the electrolyte used is the solution of potassium argento cyanide, k $[Ag(CN)_2]$, and the anode is of pure silver.

The following ions are formed in the electrolytic solution.

$$K[Ag(CN)_2]_{(aq)} \rightleftharpoons K^+_{(aq)} + [Ag(CN)_2]^-_{(aq)}$$

$$[Ag(CN)_2]^-_{(aq)} \rightleftharpoons Ag^+_{(aq)} + 2CN^-_{(aq)}$$

When the electric current is passed, Ag^+ ions migrate towards the cathode and deposit after picking up electrons. Cyanide ions move towards the anode, where they react with silver to form AgCN, which combines with KCN to reproduce the electrolyte, $K[Ag(CN)_2]$.

(b) Copper Plating:

In copper plating, the anode is made of copper metal and the electrolyte is $CuSO_4$ to which a few drops of sulphuric acid are added to prevent its hydrolysis. The article to be electroplated is made the cathode. The following electrolytic reactions take place, at the electrodes.

At Anode: $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^-$

At cathode: $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$

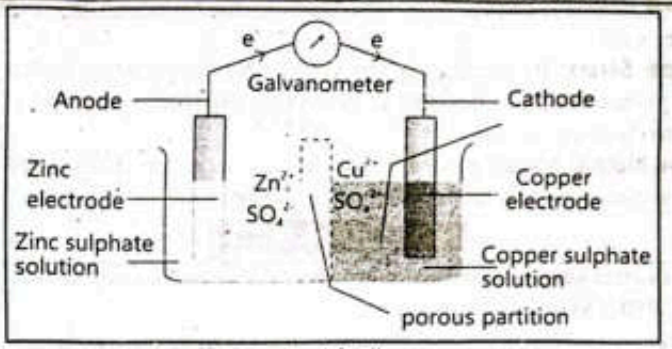
Q.20: Discuss how Galvanic cell or Daniel cell uses oxidation-reduction reactions to produce electric current?

Ans. Galvanic Cell or Daniel Cell:

Galvanic cell or Daniel cell uses oxidation reactions to produce electric current.

In galvanic cell, a zinc plate is dipped in zinc sulphate solution while a copper plate is dipped in copper sulphate solution. The two solutions are kept separate by a porous partition through which ions can pass but the solutions cannot. The two electrodes are connected by a wire through a galvanometer which measures the electric current.

At the surface of zinc electrode, each zinc atom loses two electrons and goes into the solution as zinc ions. These electrons travel through the external wire to copper electrode where they are used to discharge copper ions into copper atoms which are deposited at this electrode. An oxidation reaction takes place at zinc electrode and it is called anode while reduction takes place at copper electrode and it is called cathode.



Daniel Cell

The following reactions take place at the two electrodes.

At anode: $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$ (Oxidation) — Standard Oxidation Potential = + 0.76

At cathode: $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$ (Reduction) — Standard Reduction Potential = + 0.34

Overall cell reaction: $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$ — Cell voltage E° = 1.10 volts

Half Cells: Both parts of the cell are called half cells. No reaction can take place in any isolated half cell. Both the reactions take place simultaneously at both half cells. In this cell, electrons travel in the external circuit while ions travel through the porous partition in the internal circuit.

Production of Daniel Cell: Daniel cell produces a voltage of around 1.10 volts under standard conditions.

Q.21: How the reactivity of metals can be found out by using voltage data obtained from galvanic cell?

Ans. Order of Reactivity of Metals Using Voltage Data:

The reactivity of metals can be found out by using voltage data obtained from galvanic cells.

According to the available data the reactivity of metals depends upon how readily it is oxidized or lose electrons to form positive ions.

Establishment of a Galvanic Cell: If a galvanic cell is established between two metals, the more reactive metal will lose electrons to form positive ions.

Voltage Generated by a Galvanic cell: The voltage generated by a galvanic cell measures the comparative tendencies of the metals to lose electrons.

Higher voltage: A higher voltage indicates that the difference in the tendency of one metal (more reactive metal) to lose electrons is for more than the other.

Magnesium is more reactive than Iron: If a cell is established between magnesium and copper it produces a higher voltage than a cell established between iron and copper. This will mean that magnesium is more reactive than iron because it has a tendency to lose

electrons more easily.

Electrochemical Series: By measuring the voltage produced when different metal pairs are used in a voltaic cell, it is possible to determine the reactivity series of metals which is called electrochemical series.

More Reactive Metals: Metals placed higher in this series are considered more reactive and easily lose electrons than the metals placed lower in the series.

16.1 Quick Check!

1. Assign oxidation number to the marked atom of the following compounds:

$K_2\underline{Cr_2}O_7$, $(NH_4)_2\underline{S}O_4$

(i) $K_2\underline{Cr_2}O_7$ (Potassium dichromate)

Ans. K = +1, O = –2, let Cr = x

- 2(+1) + 2(x) + 7(–2) = 0
- 2 + 2x – 14 = 0
- 2x = 12
- x = +6
- Oxidation number of Cr is +6

(ii) $(NH_4)_2\underline{S}O_4$ (Ammonium Sulphate)

Ans. S = x, O = –2

- x + 4 (–2) = –2
- x – 8 = –2
- x = +6
- Oxidation number of S is + 6.

16.2 Quick Check!

1. Write the formulae of the following ionic compounds with the help of oxidation numbers of their constituent atoms. Aluminum nitride, Sodium sulfite and Sodium hydrogen carbonate.

Ans. Aluminum nitride: Al^{+3} and $N^{-3} \longrightarrow AlN$

- **Sodium Sulfite:** Na^{+1} and $SO_3^{-2} \longrightarrow Na_2SO_3$
- **Sodium Hydrogen Carbonate:** Na^{+1} and $HCO_3^{-1} \longrightarrow NaHCO_3$

2. Write the formulae of following ionic compounds with the help of charges present on their ions. Ammonium acetate, Calcium phosphate and Potassium chromate.

Ans. Ammonium acetate:

$$NH_4^+ + CH_3COO^- \longrightarrow CH_3COONH_4$$

Calcium phosphate:

$Ca^{2+} + PO_4^{3-} \longrightarrow Ca_3(PO_4)_2$

- **Potassium chromate:**

$K^{1+} + Cr_4^{2-} \longrightarrow K_2CrO_4$

16.3 Quick Check!

1. Identify the oxidising agent and the reducing agent in the following reactions.

(i) $2CuSO_4 + 4KI \longrightarrow 2CuI + I_2 + 2K_2SO_4$

Ans.
- Cu goes from + 2 to +1 (Reduced).
  Oxidising Agent: CuSO4
- I goes from –1 to 0 (Oxidized)
  Reducing Agent: KI

(ii) $H_2S + Cl_2 \longrightarrow S + 2HCl$

Ans.
- Cl goes from 0 to –1 (Reduced)
  Oxidising Agent: Cl_2
- S goes from –2 to 0 (Oxidized)
  Reducing Agent: H_2S

16.4 Quick Check!

1. Why carbon electrodes are used in the electrolysis of concentrated solution of NaCl?

Ans. Carbon (graphite) electrodes are used because they are inert (do not react with the products like chlorine gas) and are excellent conductors of electricity.

16.5 Quick Check!

1. Which other electrolyte can be used in hydrogen-oxygen fuel cell?

Ans. Apart from alkaline solutions (like KOH), phosphoric acid or solid polymers (PEM) can be used as electrolysis in hydrogen-oxygen fuel calls.

16.6 Quick Check!

1. What conditions are required for rusting of iron.

Ans. Presence of oxygen (air) and moisture (water) are required for rusting.

2. If a sample of iron and a sample of zinc come into contact, which will corrode? Explain your answer.

Ans. Iron Vs. Zinc: Zinc will corrode. Zinc is more reactive (more electropositive) than iron. In a process called "Sacrificial protection", the more active metal (Zinc) oxidizes first to protect the less active metal (iron).

16.7 Quick Check!

1. What is the principle behind electroplating?

Ans. Principle: It is based on electrolysis. A metal coating is desposited on an object by reducing metal ions from an electrolyte solution using an electric current.

2. How electroplating is used to repair worn-out areas of metal objects?

Ans. Repairing Metal Objects: Electroplating can deposit a layer of metal (like chromium or Nickel) onto. Worn-out areas to restore the object's thickness, shape, and provide a protective, shiny finish.

16.8 Quick Check!

1. Compare an electrolytic and a galvanic cell.

Ans.

Electrolytic Cell	Galvanic Cell
Converts electrical energy to chemical energy.	Converts chemical energy to electrical energy.
It is non-spontameous reaction (requires a battery)	It is spontaneous reaction.

2. Write down the reactions which occur in a Zn – Mg galvanic cell.

Ans. Zn–Mg Galvanic cell reactions

- **Anode (Oxidation)**

$Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$ (Mg is more reactive)

- **Cathode (Reduction)**

$Zn^{2+}_{(aq)} + 2e^- \longrightarrow Zn_{(s)}$

- **Overall**

$Mg_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + Zn_{(s)}$

DO YOU KNOW?

- Spontaneous reactions occur naturally without any energy input, while non-spontaneous reactions require a continuous input of energy.

INTERESTING INFORMATION

- The terms anode and cathode always refer to the electrodes at which oxidation and reduction occur respectively. However the charges carried by electrodes in a battery and electrolytic cell are different.
- Oxidation numbers do not represent the real electrical charges present on atoms except in simple ions. However, the oxidation numbers are useful for keeping track of the redox reactions.
- A group of chemically unreactive and valuable metals are called noble metals. They include gold, silver and platinum.
- Electrolysis played a crucial role in the discovery and industrial production of elements like fluorine and aluminum.
- Chromium plating is usually done on iron or on steel. As chromium metal does not directly adhere to the iron properly, therefore, iron is first copper or nickel plated.
- The term oxidation state is also used interchangeably of oxidation number. In water, hydrogen has an oxidation number of +1 and it is said to be in the +1 oxidation state.

Examples

16.1 Assign oxidation number to sulphur in SO_4^{2-}

Sol. $S + 4\,O = -2$

$S + 4(-2) = -2$

$S - 8 = -2$

$S = 8 - 2$

$S = +6$

The oxidation number of S in SO_4^{2-} is +6.

16.2 Find out the oxidation number of manganese in $KMnO_4$.

Sol. $K + Mn + 4\,O = 0$

$(+1) + Mn\ 4\,(-2) = 0$

$Mn - 7 = 0$

$Mn = +7$

The oxidation number of Mn is $KMnO_4$ is +7.

16.3 Find out the oxidation number of Fe in Fe_2O_3.

Sol. $2Fe + 3\,O = 0$

$2Fe + 3\,(-2) = 0$

$2Fe - 6 = 0$

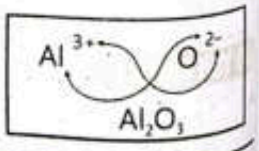
$2Fe = +6$

$Fe = +3$

Oxidation number of one atom of Fe is +3

16.4 Write the chemical formula of aluminum oxide with the help of oxidation numbers of the elements involved.

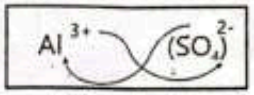
Sol. Aluminum is present in Group 13 so its principal oxidation number shall be +3. Oxygen being more electronegative atom normally shows -2 oxidation state in normal oxides. The formula of aluminum oxide will



then be Al_2O_3 because the some of oxidation numbers of both elements will be equal to zero with this formula.

16.5 Write down the formula for aluminum sulphate.

Sol.



The formula for aluminum sulphate is $Al_2(SO_4)_3$.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

16.1+16.2 +16.3+16.4 +16.5 — Oxidation Number of Atoms in Compounds and Ions + Writing Chemical Formulae of Ionic Compounds by applying Oxidation Numbers + Writing Chemical formulae of Ionic compounds using ionic charges + Oxidation and Reduction + Oxidation - Reduction Reactions

1. **What is the oxidation number of hydrogen in a metal hydride like NaH?**
   (a) +1 (b) –0 (c) –1 (d) +2
2. **The chemical process in which an atom or ion gains electrons is called**
   (a) Oxidation (b) Reduction (c) Electrolysis (d) Corrosion
3. **In a neutral compound, the sum of the oxidation numbers of all atoms is always:**
   (a) 0 (b) +1 (c) –1 (d) +2
4. **Which of the following is the correct formula for aluminum sulphate?**
   (a) $AlSO_4$ (b) Al_2SO_4 (c) $Al_3(SO_4)_2$ (d) $Al_2(SO_4)_3$
5. **What is the oxidation number of sulfur (s) in H_2SO_4?**
   (a) +4 (b) +6 (c) –2 (d) +2
6. **The movement of which of the following allows on aqueous solution to conduct electricity?**
   (a) Free electrons (b) Protons (c) Mobile ions (d) Newtrons
7. **In the reaction $CuO + H_2 \longrightarrow Cu + H_2O$, which substance is being oxidized?**
   (a) CuO (b) H_2 (c) Cu (d) H_2O
8. **Which of there is a common by-product of a hydrogen-oxygen fuel cell?**
   (a) Carbon dioxide (b) Sulfur dioxide (c) Water (d) Methane

16.6 + 16.7 +16.8+16.9 — **Electrolysis + Electrolysis of a Concentrated Aqueous Solution of Sodium Chloride (Brine) using inert electrodes (Graphite / Pt) + Electrolysis of Dilute and Concentrated Aqueous solutions of Metal Halides + Electrolysis of Concentrated Aqueous Solutions of Metal Halides**

9. **What is the process of decomposing a chemical compound into its constituents by passing an electric current through it?**
   (a) Neutralization (b) Evaporation (c) Ionization (d) Electrolysis
10. **In an electrolytic cell, the electrode connected to the positive terminal of the battery is the:**
   (a) Electrolyte (b) Anode (c) Cathode (d) Anolyte
11. **During electrolysis, reduction (gain of electrons) always occurs at the:**
   (a) Cathode (b) Anode (c) Battery (d) External circuit
12. **In the electrolysis of connected sodium chloride (Brine), which gas is released at the anode?**
   (a) Nitrogen (N_2) (b) Oxygen (O_2) (c) Hydrogen (H_2) (d) Chlorine (Cl_2)
13. **According to the electrochemical series, which of there metals is the strongest reducing agent?**
   (a) Gold (Au) (b) Lithium (Li) (c) Silver (Ag) (d) Nickel (Ni)
14. **When an aqueous solution of copper (II) sulfate is electrolyzed with inert electrodes, what is depoisted at the cathode?**
   (a) Sulfur dioxide (b) Copper metal (c) Hydrogen gas (d) Oxygen gas

16.10+16.11 +16.12+16.13 — **Electrolysis of Molten Lead (II) chloride + Electrolysis of Dilute solution of Sulphuric acid using inert electrodes (carbon or Pt) + Electrolysis of Dilute Aqueous Solution of Copper Sulphate using inert electrodes or Copper electrodes + Fuel Cells**

15. **At what temperature does lead (II) chloride melt to become an electrolyte?**
   (a) 100°C (b) 501°C (c) 801°C (d) 373°C
16. **During the electrolysis of molten $PbCl_2$, what is formed at the cathode?**
   (a) Chlorine gas (b) Oxygen gas (c) Molten lead (d) Hydrogen gas
17. **In the electrolysis of dilute sulphuric acid, which ion is discharged at the anode?**
   (a) SO_4^{2-} (b) OH^- (c) H^+ (d) Cl^-
18. **When aqueous $CuSO_4$ is electrolyzed using inert (carbon) electrodes, what gas is produced at the anode?**
   (a) Oxygen (b) Hydrogen (c) Carbon dioxide (d) Sulphur dioxide
19. **A fuel cell converts chemical energy directly into:**
   (a) Heat energy (b) Mechanical energy
   (c) Sound energy (d) Electrical energy

20. **What is the by-product of a hydrogen-oxygen fuel cell?**
   (a) Carbon dioxide (b) Water (c) Methane (d) Nitrogen oxide
21. **Which catalyst is commonly used in the porous carbon electrodes of a fuel cell?**
   (a) Copper (b) Zinc (c) Platinum (d) Iron

16.14+16.15 +16.16+16.17 — **Corrosion + Electroplating + Galvanic cells + Order of Reactivity of Metals using Voltage Data**

22. **Which two substances are essentially required for the rusting of iron?**
   (a) Nitrogen and water (b) Oxygen and water
   (c) Carbon dioxide and water (d) Hydrogen and water
23. **Rusting is considered an electrochemical process where iron loses electrons to form:**
   (a) Fe (III) ions (b) Fe (II) oxides (c) Oxide ions (d) Hydroxide ions
24. **Galvanization involves coating iron with a thin layer of which metal?**
   (a) Copper (b) Zinc (c) Gold (d) Silver
25. **In sacrificial protection, which metal is often used to protect buried fuel tanks?**
   (a) Magnesium (b) Tin (c) Lead (d) Copper
26. **During electroplating, the object to be plated is always made the:**
   (a) Cathode (b) Anode (c) Electrolyte (d) Sath bridge
27. **In a Daniel cell, the zinc electrode acts as the:**
   (a) Electrolyte (b) Porous partition (c) Anode (d) Cathode
28. **In the electroplating of copper, the electrolyte used is:**
   (a) Copper sulphate (b) Silver nitrate
   (c) Sodium chloride (d) Potassium cyanide
29. **Under standard conditions, Daniel cell produced a voltage of around:**
   (a) 1.10 volts (b) 1.20 volts (c) 1.30 volts (d) 1.40 volts
30. **A Galvanic cell (like the Daniel cell) converts the chemical energy into:**
   (a) Sound energy (b) Electrical energy (c) Light energy (d) Heat energy

Answers

1.	(c)	2.	(b)	3.	(a)	4.	(d)	5.	(b)	6.	(c)	7.	(b)	8.	(c)
9.	(d)	10.	(b)	11.	(a)	12.	(d)	13.	(b)	14.	(b)	15.	(b)	16.	(c)
17.	(b)	18.	(a)	19.	(d)	20.	(b)	21.	(c)	22.	(b)	23.	(a)	24.	(b)
25.	(a)	26.	(a)	27.	(c)	28.	(a)	29.	(a)	30.	(b)				

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

16.1 + 16.2 + 16.3 + 16.4 + 16.5	Oxidation Number of Atoms in Compounds and Ions + Writing Chemical Formulae of Ionic Compounds by applying Oxidation Numbers + Writing Chemical formulae of Ionic compounds using ionic charges + Oxidation and Reduction + Oxidation - Reduction Reactions

1. Define oxidation number.

Ans. Oxidation number: The oxidation number is an apparent charge on an atom in a compound or an ion. It may have a positive or a negative sign.

2. How does oxidation number help us?

Ans. Oxidation number helps us:

- To identify whether the reaction involves oxidation and reduction or not.
- To identify oxidizing and reducing agents in a given oxidation-reduction reaction.
- To write chemical formulas and names of the chemical compounds.
- To keep track of the new distribution of electrons during an oxidation-reduction reaction.

3. What is the oxidation numbers of any element in its free (uncombined) state?

Ans. The oxidation number of an atom in a free element is always zero (e.g; Na, O_2 or Cl_2 all have an oxidation of O)

4. What is the sum of oxidation numbers in a neutral compound?

Ans. The algebraic sum of oxidation numbers of all atoms in a neutral compound is always zero.

5. How is the oxidation number assigned to a monoatomic ion?

An. The oxidation number is equal to the actual charge present on the ion (e.g; Ca^{2+} is +2 and Cl^- is –1)

6. Define oxidation in terms of electrons.

Ans. Oxidation is a process in which electron or electrons are lost.

7. Define reduction in terms of electrons.

Ans. Reduction is a process in which electron or electrons are gained.

8. What is a redox reaction?

Ans. Redox Reaction: A chemical reaction which involves simultaneous oxidation and reduction is called an oxidation-reduction or redox reaction.
The reaction may involve the complete transference of electron or electrons to form ionic bonds or a partial transfer or shift of electron to form covalent bonds.

9. What is an oxidizing agent?

Ans. An oxidizing agent is a substance that gains electrons and gets reduced itself. It causes the oxidation of another substance.

10. What is a reducing agent?

Ans. A reducing agent is a substance that loses electrons and gets oxidized itself. It causes the reduction of another substance.

11. Why does the purple colour of potassium permaganate ($KMnO_4$) disappear in a reaction with oxalic acid?

Ans. The purple colour disappears because the Mn^{+7} (permanganate ion) is reduced to Mn^{+2} (manganese ion), which is colourless in dilute solution.

12. What is a polyatomic ion?

Ans. Polyatomic ion: A group of atoms that are bonded together and carry an overall not charge (e.g., carbonate CO_3^{2-} or Ammonium NH_4^+).

16.6+16.7 +16.8 +16.9	Electrolysis + Electrolysis of a Concentrated Aqueous Solution of Sodium Chloride (Brine) using inert electrodes (Graphite / Pt) + Electrolysis of Dilute and Concentrated Aqueous solutions of Metal Halides + Electrolysis of Concentrated Aqueous Solutions of Metal Halides

13. Define electrolysis.

Ans. Electrolysis: The process in which an electricity is passed through fused ionic compounds or their aqueous solution, they are decomposed into their constituents. is called electrolysis.

14. What is an electrolytic cell?

Ans. Electrolytic Cell: An electrolytic cell is an apparatus consisting of a vessel (electrolytic both), an electrolyte, and two electrodes connected to an external voltage source (battery) to carry out electrolysis.

15. In What the process of electrolysis can be carried out?

Ans. The process of electrolysis can be carried out in an electrolytic both called an electrolytic cell with the help of two electrodes through which electric current enters and leaves the cell.

16. Define the anode and cathode in an electrolytic cell.

Ans. Anode: It is a positive electrode through which electrons enter the external circuit.
Cathode: It is a negative electrode through which electrons leave the external circuit.

17. Why must can electrolyte must be in fused (molten) state or in solution form?

Ans. In solid form, ions are held tightly in a lattice and cannot move. In a fused or aqueous state, the ions are free to move toward the electrodes to conduct electricity.

18. What is Brine?

Ans. Brine: Brine is a concentrated aqueous solution of sodium chloride (NaCl).

19. Which gases are produced during the electrolysis of Brine?

Ans. During the electrolysis of Brine, following gases are produced:

At the cathode: Hydrogen gas (H_2)

At the Anode: Chlorine gas (Cl_2)

20. What determines which ion will be discharged at an electrode when multiple ions are present?

Ans. The discharged depends on the electrochemical series. Elements with a higher tendency to lose or gain electrons (bared on their position in the series) will be preferentially discharged.

21. If a metal is below hydrogen in the electrochemical series, what is discharged at the cathode?

Ans. If a metal is below hydrogen in the electrochemical series, then the metal ion is discharged.

22. If a metal is above hydrogen in the electrochemical series, what is produced at the cathode?

Ans. If a metal is above hydrogen in the electrochemical series, then hydrogen ion is discharged.

23. Why is the solution around the cathode becomes alkaline during the electrolysis of brine?

Ans. The solution around the cathode becomes alkaline during the electrolysis of brine due to the formation of hydroxide ions (OH^-).

24. Why is platinum sometimes used as an electrode?

Ans. Platinum is an inert electrode, meaning it conducts electricity but does not chemically react with the electrolyte or the products (like chlorine gas) during the process.

25. Mention two industrial applications of electrolysis.

Ans. (i) Production of elements like Aluminum, sodium and fluorine.

(ii) Manufacturing of chemicals like sodium hydroxide (NaOH).

16.10+6.11 +16.12+16.13	Electrolysis of Molten Lead (II) chloride + Electrolysis of Dilute solution of Sulphuric acid using inert electrodes (carbon or Pt) + Electrolysis of Dilute Aqueous Solution of Copper Sulphate using inert electrodes or Copper electrodes + Fuel Cells

26. Why must lead (II) chloride be heated to 501°C before electrolysis can ocur?

Ans. Lead chloride (II) is a solid at room temperature. Heating it to 501°C melts it, making it an electrolyte where ions are free to move and conduct electricity.

27. What happens to the concentration of sulphuric acid as electrolysis proceeds?

Ans. As the electrolysis proceeds, the concentration of sulphuric acid increases because the water present is being decomposed.

28. What is deposited at the cathode during the electrolysis of dilute aqueous solution of copper sulphate using inert electrodes?

Ans. Copper metal is deposited at the cathode (inert) during the electrolysis of aqueous solution of copper sulphate using inert electrodes.

29. Which gas is produced during the electrolysis of dilute aqueous solution of copper sulphate using inert electrodes?

Ans. Oxygen gas is produced at anode (inert) during the electrolysis of dilute aqueous solution of copper sulphate using inert electrodes.

30. Why the blue colour of the solution fades away during the electrolysis of dilute aqueous solution of copper sulphate using inert electrodes?

Ans. During the electrolysis of dilute aqueous solution of copper sulphate using inert electrodes, since the concentration of copper ions decreases slowly so the blue colour of the solution fades away with the passage of time.

31. How does the process change when copper electrodes are used instead of inert electrodes in $CuSO_4$ solution?

Ans. If copper electrodes are used instead of inert electrodes, the copper metal atoms from the copper anode start moving into the solution in the form of copper ions and the electrode mass starts decreasing.

32. Define a fuel cell.

Ans. Fuel Cell: It is a device that provides a method in which chemical energy is converted to electrical energy. It uses gaseous fuels like hydrogen and oxygen to produce electricity.

33. What are the electrodes in a hydrogen-oxygen fuel cell usually made of?

Ans. The electrodes are made of porous compressed carbon saturated with platinum which acts as a catalyst.

34. Why is a fuel cell considered highly efficient compared to traditional engines?

Ans. A fuel cell is very efficient because it converts 75% of the bond energy of fuels to electricity, whereas traditional heat engines lose much more energy as heat.

16.14+16.15 +16.16+16.17	Corrosion + Electroplating + Galvanic cells + Order of Reactivity of Metals using Voltage Data

35. Define corrosion and give a common example.

Ans. Corrosion: Corrosion is a natural process due to which a metal suffers gradual decay when it interacts chemically with its environment.

Example: A common example is rusting of iron.

36. Why does iron continue to corrode until it is completely destroyed?

Ans. Once iron begins to rust, the process will continue as rust is porous and allows both air and moisture to come into contact with fresh metal underneath. Hence, all the

metal will corrode given enough time.

37. What is Galvanization?

Ans. Galvanization: Galvanization is a common method to protect iron or steel from rusting. It involves the dipping of an iron sheet in a bath of molten zinc. A layer of zinc metal gets deposited on the iron sheet and prevents rusting.

Example: Tin cans are actually steel cans which have been coated with a thin layer of tin.

38. Define electroplating.

Ans. Electroplating: It is a process in which a metal is deposited on another metal electrolytically.

39. What properties should a chosen electrolyte have?

Ans. The electrolyte chosen should have the following properties:

- Very soluble in water.
- Good conductor.
- Not easily oxidized or reduced or hydrolyzed.
- Inexpensive.

40. What conditions should be fulfilled to get good deposits on the electroplates during the electroplating?

Ans. The following conditions should be fulfilled to get good deposits.

- High current density
- Low temperature
- High concentration of the metal in its electrolyte.

41. What does Daniel cell use to produce electric current?

Ans. Daniel cell uses oxidation-reduction reactions to produce electric current.

42. In the electroplating process, which electrode is the object to be plated?

Ans. The article or object to be plated is always made the cathode (the negative electrode), while the metal to be deposit is made the anode.

43. What is a Galvanic (Voltaic) cell?

Ans. Galvanic Cell: A galvanic cell is an electrochemical cell that converts chemical energy into electrical energy through spontaneous oxidation-reduction (redox) reactions.

44. What is the function of the porous partition in a Daniel cell?

Ans. The porous partition in a Daniel cell keeps the two electrolyte solutions (Zinc Sulphate and Copper Sulphate) separate but allows ions to pass through to complete the electrical circuit.

45. How can voltage data be used to determine the reactivity of metals?

Ans. A higher voltage generated in a galvanic cell indicates a greater difference in the reactivity of the two metals used. Metals that lose electrons more easily (more reactive) produce higher voltages when paired with a standard electrode.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. The oxidation number of Mn in K_2MnO_4:

(a) +7 (b) +5 (c) +6 (d) −6

2. Which element in the following reaction is being reduced?

$$4HBr_{(aq)} + MnO_{2(s)} \longrightarrow MnBr_{2(aq)} + Br_{2(l)} + 2H_2O_{(l)}$$

(a) Br (b) Mn (c) H (d) Both Mn and H

3. During electrolysis of dilute solution of H_2SO_4, using Pt electrodes, which process takes place at the cathode?

(a) Reduction (b) Neither oxidation nor reduction
(c) Oxidation (d) First oxidation and then reduction

4. Which product you will get at the anode when an aqueous solution of $CuSO_4$ is electrolysed using copper electrodes?

(a) Cu (b) O_2 (c) H_2
(d) No product, instead copper metal will go into the solution as Cu^{2+}.

5. Which of the following statements is NOT correct about Zn-Cu electrochemical cell?

(a) Anode is negatively charged (b) Reduction occurs at anode
(c) Cathode is positively charged (d) Reduction occurs at cathode

6. Which product will be obtained at the anode when a concentrated solution of NaCl will be electrolysed?

(a) Cl_2 (b) O_2
(c) More O_2 and less Cl_2 (d) More Cl_2 and less O_2

7. When a dilute aqueous solution of $ZnCl_2$ is electrolysed which product you will get at the cathode?

(a) H_2 (b) Zn (c) O_2 (d) Zn and O_2

8. What is produced at the cathode in hydrogen-oxygen fuel cell?

(a) H^+ (b) O^{2-} (c) H_2O (d) OH^{1-}

9. Which of the following metals is highest in the electrochemical series?

(a) Tin (b) Iron (c) Magnesium (d) Zinc

Answers

1. (c) 2. (b) 3. (a) 4. (d) 5. (b) 6. (a) 7. (a)
8. (d) 9. (c)

B. Short Answer Questions

16.1 What happens when electricity is passed through an aqueous solution of NaCl?

Ans. When electricity passes through aqueous solution of NaCl (electrolysis), the salt dissociates into Na^+ and Cl^- ions.

At the Anode: Cl^- ions lose electrons to form chlorine gas (Cl_2).

At the cathode: H+ ions (from water) gain electrons to form hydrogen gas (H_2).

In solution: Na^+ and OH^- ions remain, forming sodium hydroxide (NaOH).

16.2 What are the main objectives of electroplating?

Ans. For answer see Q18 (Long Subjective Questions). First part

16.3 Mention one difference between an electrolytic cell and a galvanic cell.

Ans.

Electrolytic Cell	Galvanic Cell
Converts electrical energy to chemical energy.	Converts chemical energy to electrical energy.
It is non-spontameous reaction (requires a battery)	It is spontaneous reaction.

16.4 Through which electrode, electrons leave the electrolytic cell?

Ans. Electrons leave the electrolytic cell through the anode.

Reason: Electrons flow from the external power source (battery) into the cathode, and they exit the electrolyte through the anode to return to the positive terminal of the battery.

16.5 How does an electrolyte conduct electricity?

Ans. An electrolyte conducts electricity through the movements of ions.

- When a salt or acid is dissolved in water or melted, it dissociates into positive ions (cations) and negative ions (anions).
- When an electric current is applied, the cations move toward the negative electrode (cathode) and the anions move toward the positive electrode (anode), allowing the current to flow through the liquid.

16.6 What will happen if a strip of Cu metal is dipped in $FeSO_4$ solution?

Ans. If a strip of Cu metal is dipped in $FeSO_4$ solution, no reaction will occur.

Reason: In the reactivity series, copper (Cu) is less reactive than iron (Fe). Because copper is lower in the series, it cannot displace iron from its sulfate solution.

16.7 Why fuel cells are regarded as environment friendly?

Ans. Fuel cells are regarded as environmental friendly because of two main reasons:

- **Zero Harmful Emissions:** Unlike internal combustion engines, the only by-product of a hydrogen-oxygen fuel cell is pure water and heat.
- **Higher efficiency (less fuel waste):**
  Fuel cells convert chemical energy directly into electrical energy without combustion, so they are more efficient than conventional engines. This results in less fuel consumption and reduced environmental impact.

C. Constructed Response Questions

16.1 Calculate the oxidation number of chlorine atom in $Ca(ClO_3)_2$.

Ans. To find the oxidation number of chlorine, we use the known oxidation number for calcium and oxygen.

- **Calcium (Ca):** +2 (Group 2 element)
- **Oxygen (O):** –2 (usually)
- **Chlorine (Cl):** x

The sum of oxidation numbers in a neutral compound is 0.

$1(+2) + 2[x + 3(-2)] = 0$

$2 + 2[x - 6] = 0$

$2 + 2x - 12 = 0$

$2x - 10 = 0$

$2x = +10$

$x = +5$

The oxidation number of chlorine in $Ca(ClO_3)_2$ is + 5.

16.2 How can H_2O_2 behave as an oxidizing agent?

Ans. Hydrogen peroxide (H_2O_2) acts as an oxidizing agent because the oxygen atom in it is an intermidiate oxidation state of –1. It can easily accept electrons to reach the more stable –2 state (as found in water).

Example: $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

16.3 Why different products are formed at the electrodes when a dilute and concentrated aqueous solutions of NaCl are electrolysed?

Ans. This happens due to the selective discharge of ions, which depends on their concentration.

In Dilute NaCl: At the anode, OH^- ions are in higher concentration and are discharged to produce oxygen gas.

In Concentrated NaCl (Brine): At the anode, the high concentration of Cl^- ions resulting in the production of chlorine gas.

16.4 Why corrosion becomes fast during rainy season?

Ans. Corrosion (rusting) is an electrochemical process that requires water and oxygen. During the rainy season:

- The high moisture/humidity provides the necessary electrolyte for the movement of ions.
- Rainwater often contains dissolved gases (like CO_2) that make it slightly acidic, increasing its conductivity and accelerating the redox reaction.

16.5 If a galvanic cell is established between Cu and Ag, what reactions do you expect at the electrodes?

Ans. In the electrochemical series, copper (Cu) is more reactive than silver (Ag). Therefore, Cu will be the anode and Ag will be the cathode.

- At Anode (Oxidation)

$$Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e$$

- At Cathode (Reduction)

$$Ag^{+}_{(aq)} + e^{-} \longrightarrow Ag_{(s)}$$

16.6 What is the function of a porous partition in a galvanic cell?

Ans. The porous partition (or salt bridge) serves two main purposes.

- **Completes the Circuit:** It allows the flow of ions between the two half-cells.
- **Maintains Electrical Neutrality:** It prevents the accumulation of charges in the half-cells by allowing ions to migrate, ensuring the cell continues to function.

16.7 How do fuel cells produce electricity?

Ans. For answer see Q14 (Long Subjective Qeustions)

16.8 How can the chemical reactivity of metals be compared by using electrochemical series?

Ans. The electrochemical series ranks metals based on their standard reduction potentials:

- **Higher in the series:** Metals have lower reduction potentials (or higher oxidation potentials). They lose electrons easily, are more reactive, and can displace metals below them from their salt solutions.
- **Lower in the series:** Metals have higher reduction potentials. They are less reactive and act as better oxidizing agents.

D. Descriptive Questions

16.1 Explain with examples how the formula of ionic compound can be written using oxidation numbers.

Ans. For Answer see Q2 (Long Subjective Questions)

16.2 Find the oxidation numbers of the indicated elements in the following compounds.

$$\mathbf{Al(\overline{N}O_3)_3,\ H_2\overline{S}_2O_7,\ Na_2S_2O_3}$$

Ans. To find these, we use the rule that the sum of oxidation number in a neutral compound is 0. Common oxidation numbers used here:

H = + 1, O = –2, Na = + 1, Al = + 3

Al $(\overline{N}O_3)_3$: Since the nitrate ion (NO_3^-) has a charge of –1, we can calculate N within that ion:

- Let N = x
- x + 3 (–2) = –1
- x – 6 = –1
- x = +5

Oxidation number of N is +5.

$H_2\overline{S}_2O_7$:

- 2 (H) + 2 (S) + 7 (O) = 0
- 2 (+1) + 2 (x) + 7 (–2) = 0
- 2 + 2x – 14 = 0
- 2x – 12 = 0
- 2x = 12
- x = +6

Oxidation number of S is +6.

$Na_2\overline{S}_2O_3$:

- 2 (Na) + 2 (S) + 3 (O) = 0
- 2 (+1) + 2 (x) + 3 (–2) = 0
- 2 + 2x – 6 = 0
- 2x – 4 = 0
- 2x = 4
- x = + 2

16.3 Write down the formulae of the following compounds using ionic charges. Sodium hypochlorite, calcium oxalate, ammonium phosphate and calcium nitrite

Ans. To write the formulae of the following compounds using ionic charges, we balance the positive and negative charges so the final compound is neutral.

Compound Name	Ions Involved	Chemical Formula
Sodium hypochlorite	Na^+ and ClO^-	NaClO
Calcium oxalate	Ca^{2+} and $C_2O_4^{2-}$	CaC_2O_4
Ammonium Phosphate	NH_4^+ and PO_4^{3-}	$(NH_4)_3PO_4$
Calcium nitrite	Ca^{2+} and NO_2^-	$Ca(NO_2)_2$

16.4 Describe the working of a fuel cell.

Ans. For Answer see Q 14

16.5 Discuss the electrolysis of concentrated solutions of metal halides.

Ans. For Answer see Q 10

16.6 Explain electroplating giving examples.

Ans. For Answer see Q 18

16.7 What is corrosion? Explain the reactions involved in corrosion of iron.

Ans. For Answer see Q 16

CHAPTER 17 Reaction Kinetics

Student Learning Outcomes

After studying this chapter, students will be able to::

- Describe collision theory in terms of number of particles per unit volume, frequency of collisions of particles, kinetic energy of particles and activation energy.
- State that catalyst increases the rate of reaction provides alternate pathway with lower activation energy, and remains unchanged at the end of a reaction.
- Describe the physical parameters that may be affected by the rate of reaction including change in mass, temperature, and formation of gas.
- Interpret data, including graphs, for investigating rate of reaction.
- Explain the effect on rate of reaction of changing concentration of a reactant, pressure of gases, surface area of solids, temperature, presence of catalyst (including enzymes) using collision theory.
- Justify the importance of chemical kinetics in the food industry to determine ideal harvesting and transportation times for produce.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: Describe the main points of the collision theory of reaction rate.

Ans. A reaction takes place only when the participating particles (atoms, molecules or ions) collide with one another. It has been observed that a very small fraction of collisions lead to the formation of products. In the majority of collisions the reactant particles simply bounce back without any change.

Effective Collisions:

Collisions which lead to reaction are called effective collisions.

The rate of a reaction depends upon the number of effective collisions which, in turn, depends upon the following factors.

(i) The number of particles per unit volume:

The larger the number of particles per unit volume, larger is the possibility of

effective collisions. In other words, higher the concentration of the reactants, more the number of molecules and hence more will be the number of collisions between them.

(ii) The frequency of Collisions:

A greater number of collisions per second will also result in the increase in the number of effective collisions. At higher temperature the velocities of the molecules increase resulting in the increase in the frequency of collisions. This increase in the frequency of collisions will also increase the number of successful collisions.

(iii) The kinetic energy of the particles:

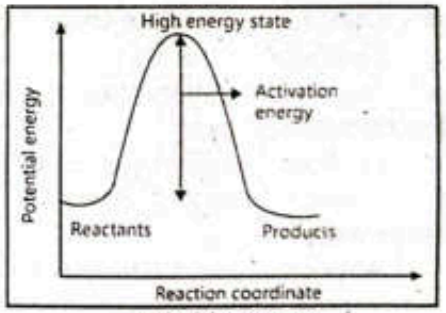
The kinetic theory of particles says that all matter is composed of tiny constant moving particles. Their motion is due to kinetic energy they possess. As the temperature increases, the kinetic energy of the particles also increases. As a result, the particles start moving fast leading to more vigorous motion. The fast moving particles will have more chances to collide with each other.

(iv) Activation energy

According to collision theory, the colliding particles will lead to effective collisions only when they possess sufficient energy to break the bonds present in the reactant molecules. This minimum energy required to start a chemical reaction is called its activation energy.

Generally, at a particular temperature, most of the molecules of the reactant possess average energy. A fraction of total molecules will, however have more than the average energy. Particles will react only when average energy of this small fraction of molecules exceeds the energy needed to activate molecules so that they can undergo a chemical reaction.

When the reactant particles come close to each other at the time of collision, they slow down and the kinetic energy they possess, is converted to increase their potential energy. This process can be understood with the help of a graph drawn between the path of reaction and the potential energy of the system. When the reactant particles possessing activation energy collide they form high energy state with the corresponding increase in the potential energy of the system. After this stage the reactants are converted into the stable products and the potential energy of the system falls down.



Path of the reaction

Q.2: Discuss how change in a mass during a chemical reaction takes place.

Ans. Change in mass during a chemical reaction:

The total mass during a chemical reaction always remains the same. This is the requirement of the law of conservation of mass which is always obeyed. However, some reactions may appear to proceed with a change in mass which can usually be explained

because a reactant or a product is a gas in such reactions.

If a reaction is carried out in an open container where gases can escape or enter, the apparent mass change can occur if a gas is either absorbed or evolved. For example, if a gas is evolved, we shall observe a decrease in mass and if a gas is absorbed, the apparent mass will increase.

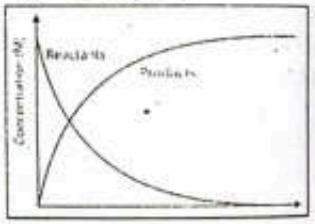
If a ribbon of magnesium is burnt in an open crucible, the mass of the product (MgO) formed will be greater than the reactant (Mg). This increase in mass has occurred due to the reaction of magnesium with oxygen present in air. However, if the two reactants (Mg and O_2) are allowed to react in a closed container, the total mass will remain the same before and after the reaction.

Formation of a gas during a chemical reaction:

If a reaction is performed between marble chips and dilute hydrochloric acid in an open container, the mass of products will apparently be less than that of reactants. This apparent decrease in mass is due to evolution of CO2 gas during the reaction which escapes into the atmosphere.

$$CaCO_{3\,(s)} + 2HCl_{\,(aq)} \longrightarrow CaCl_{2\,(aq)} + H_2O_{\,(l)} + CO_{2\,(g)}$$

When a reaction moves ahead the concentrations of the reactants decrease until all the reactants are used up. At the same time, the concentrations of the products increase and reach the maximum value at the end of the reaction.



Concentration time graph

Q.3: Explain change in temperature during a chemical reaction.

Ans. Change in temperature during a chemical reaction.

Chemical reactions are quite often accompanied by the changes in the temperature indicating whether they are exothermic or endothermic.

Exothermic Reaction:

Exothermic reactions heat energy is released which is absorbed by the surrounding causing their temperature to increase.

For example:

When quick lime (CaO) reacts with water, slaked lime $Ca(OH)_2$ is formed and a lot of heat energy is released.

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2\,(s)}$$

Endothermic Reactions:

In endothermic reactions heat energy is absorbed causing the surrounding to cool down.

For Example:

When ammonium chloride or ammonium nitrate is dissolved in water, heat energy is absorbed causing the container to cool down.

Effect of Temperature on the Rate of the Reaction:

Increasing the temperature of the reaction, increases its rate. For many reactions, the rate doubles with every 10 °C rise in temperature.

Cooking food uses high temperature to speed up chemical reactions that break down the components of food making it edible.

17.4 Factors Affecting the Rates of Reactions

17.5 Importance of Chemical Kinetics in Food Industry

Q.4: Discuss the effect of concentration of the reactions.

Ans. Effect of Concentrations of the Reactions:

In order for the reaction to occur, the reactants must come in contact with each other. For this reason, the reactions are most often carried out in one phase. For example, in liquid solutions or in gas phase.

When the reactants are present in the same phase, their particles are able to meet on the molecular level and thus are able to collide with each other easily. The higher the number of particles of the reactants per unit volume, higher will be chances of effective collisions and hence higher will be the rate of reaction.

Effect of an Increase or Drecrease in the Concentrations of the Reactants:

An increase or decrease in concentrations of the reactants will result in increase or decrease in the rate of reaction respectively.

For Example:

- Combustion of coal in air (21% oxygen) proceeds relatively slowly as compared to the reaction in pure oxygen.
- Lime stone reacts with different concentrations of hydrochloric acid at different rates.

Experiment:

An experiment can be performed to show the increase in the rate of reaction with the increase in the concentration of hydrochloric acid.

Procedure: 1

Take a flat- bottomed conical flask fitted with a delivery tube which is connected to a syringe.

The flasks contains:

- Granules of limestone taken in excess.
- A fixed volume of one molar hydrochloric acid.

After the start of reaction carbon dioxide is generated which is collected in the syringe.

The scale present on the syringe directly measure the volume of carbon dioxide gas evolved.

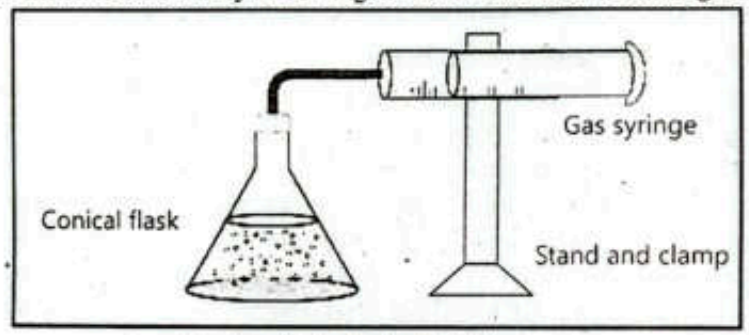
Conditions for the Experiment:

It is essential to keep all the variables constant in this experiment. For example,

- The volume of one molar hydrochloric acid.
- The temperature at which the experiment is being carried out.
- The mass and size of lime stone granules.

Measuring volume of carbon dioxide evolved:

The reaction is followed by measuring the volume of carbon dioxide gas evolved.

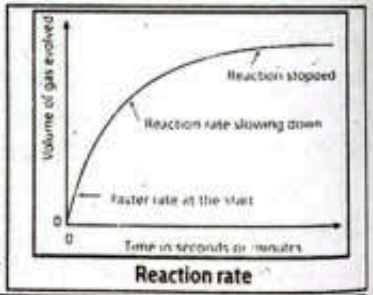


Reaction of hydrochloric acid with limestone

Rate of Reaction shown by a Graph:

The change in the rate of reaction is then seen when a graph is drawn between the time in seconds or minutes against the volume of gas evolved

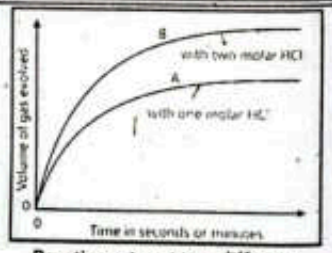
The graph obtained is in the form of a curve. We can measure the rate of reaction during a time interval by drawing a tangent on this curve. The results show that the reaction starts with a very fast rate which then progressively slows down as the concentration of hydrochloric acid decreases. After a while the reaction stops because the whole of hydrochloric acid has been utilized.



Reaction rate

The two curves A and B represent two separate experiments done with one and two molar concentrations of HCl respectively.

The greater the concentration, the steeper is the curve at the start of the experiment which means faster rate of reaction.



Reaction rates at two different concentrations

The more concentrated is the acid, the more are the chances of effective collisions.

Q.5: Discuss the effect of temperature at which a reaction is carried out.

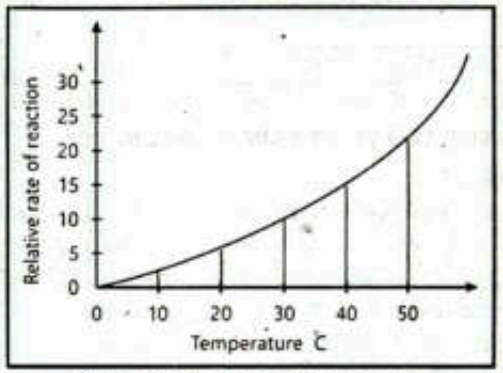
Ans. Everyday Observation:

It is an everyday observation that the rates of chemical reactions increase with increase in temperature.

Examples:

- Food cooks faster at higher temperatures than at lower ones.
- The oxidation of iron is very slow at room temperature but proceeds very fast at high temperature.

In many cases the rate of reaction is nearly doubled when the temperature is increased by 10 °C.



Rise in rate of reaction with temperature

The graph shown in the figure explains this rapid increase in the rate of reaction with the rise in temperaturre.

According to the Collision Theory

According to the collision theory, the rate of reaction depends upon the frequency of successful collisions between reactant molecules.

As the temperature of a reaction is increased, the kinetic energy of the participating reacting particles also increases. This, in turn increases the velocities of their movements. As a result the collisions which lead to the occurrence of reactions also increase, enhancing the rate of reaction.

Q.6: Explain the following factors affecting the rate of reaction:

(a) Reactants present in gas phase.

(b) Effect of surface area of solids.

Ans. (a) Reactants present in gas phase:

If reactants in a reaction are present in gas phase, their concentration can be changed by changing their pressure. For example, the rate of reaction between hydrogen

and chlorine can be doubled if the pressure of chlorine gas is double provided the other component hydrogen is present in excess.

(b) Effect of surface area of solids:

Reactions involving solids take place on their surfaces and the rates of their reactions depend to a great extent on the area of the surface contact between them. The larger the surface area of the solids, the more is possibility of their particles to come in contact with each other and the higher is the rate of reaction. Finely divided solids, because of the greater surface area available, react more rapidlly than do large pieces of the same substances.

For examples: Aluminum foil reacts with warm sodium hydroxide but in finely divided state it reacts rapidly with even cold aqueous solution of sodium hydroxide evolving hydrogen gas.

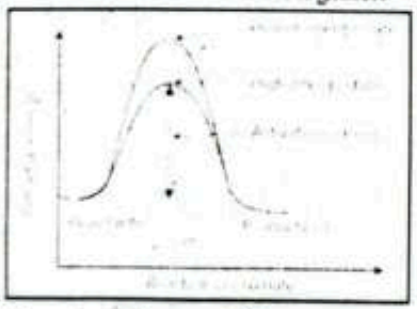
$$2Al_{(s)} + 2NaOH_{(aq)} + 6H_2O_{(l)} \longrightarrow 2NaAl(OH)_{4\,(aq)} + 3H_{2\,(g)}$$

Similarly, a large piece of wood will burn slowly while small pieces burn rapidly.

Q.7: Explain the effect of catalyst on a chemical reaction?

Ans. Effect of catalyst:

A catalyst is a substance which alters the rate of the reaction but it is not consumed during the course of reaction. It's role is to alter the way the reaction takes place by substantially lowering its activation energy. When the activation energy is lowered, more and more particles of the reactants will start forming the high energy state and the rate of reaction will increase. For example, platinum metal serves as a catalyst during the addition of hydrogen in ethene. Both hydrogen and ethene are known to adsorb on the surface of platinum metal and the bonds, present in them, get weakened. Thus, the surface of metal helps the reactant molecule to react together.



Path of reaction with or witought the presence of catalyst

In the presence of a catalyst, the activation energy is sufficiently lowered allowing more and more molecules to react together.

Q.8: Write briefly about the role enzymes play in our body as biological catalysts.

Ans. Enzymes:

Enzymes are biological catalyst.

Role of enzymes:

These are basically protiens which help to speed up specific chemical reactions taking place in our body.

Explanation:

Enzymes react with the reactant molecules using the active sites present in them. Once bound with the reactant molecule the particular bonds in the reactant molecule are sufficiently weakened for the reaction to take place. The product formed then dissociates itself from enzyme which is then free to bind another reactant molecule. The active sites present in enzymes are very specific such that a particular enzyme can catalyze a specific reaction only.

Q.9: How does chemical kinetics play an important role in the food industry?

Ans. Importance of chemical kinetics in food industry:

The study of reaction rates and the factors which affect these rates play an important role in food industry.

The rates of chemical reactions which are involved during food ripening and food spoilage are studied for different types of fruits and vegetables. The information thus obtained is used to minimize the losses due to spoilage. Food scientists can determine the optimum conditions for harvesting, storage and transportation of food products by studying the rates of enzymatic reactions, oxidation or microbial growth.

Fruits and vegetables ripen owing to the reactions which involve enzymes. These reactions convert starches into sugars, soften tissues and develop characteristics flavour and colours. With the help of rates of these enzymatic reactions, farmers can predict when the product will reach at its peak quality and ready for harvesting. For example, the rate of production of ethene during ripening can be monitored to determine the best time to harvest the fruits.

Some enzymes which are naturally present in foods can spoil the foods which them undergo changes in texture, flavour and nutritional value. Again understanding the rates of these enzymatic reactions will allow us to plan how to stop this spoilage.

For example, if a fruit is known to degrade rapidly during transportation or storage owing to high temperature, refrigeration can be employed to prevent rapid spoilage.

17.1 Quick Check!

1. How will you increase the frequency of collisions?

Ans. The frequency of collisions can be increased by:

- Increasing temperature
- Increasing concentration
- Increasing pressure (for gases)

2. What happens to the reactant particles after collision?

Ans. After collisions, one of two things happens:

- A very small fraction of collisions lead to the formation of products.
- The reactant particles simply bounce back without any change.

17.2 Quick Check!

1. Why a catalyst is mostly used in finely divided from?

Ans. A catalyst is used as a fine powder (finely divided) to increase its surface area. a larger surface area provides more "active sites" where reactant molecules can absorb and react which significantly speeds up the reaction compared to using a single large piece of catalyst.

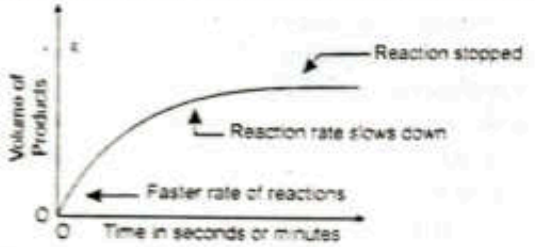
2. How do you increase the number of succesful collisions?

Ans. Succeful (effective) collisions are increased by:

- **Adding a catalyst:**
  This lowers the activation energy, allowing greater fraction of particles to have enough energy to react.
- **Increasing Temperature :**
  This provides more particles with the minimum required activation energy.

3. How does the concenctrations of the products change during reaction? Explain with the help of a graph.

Ans. At the start of a reaction, the concentration of reactants is high, while the concentration of proeducts is zero. The reaction starts with a very fast rate. As the reaction proceeds, the concentration of products increases rapidly. Over time, as reactants are consumed, the rate of product formation slows down because the whole of the reactants have been utilized.



17.3 Quick Check!

1. How would you determine the best time of fruit harvestrng?

Ans. The best time of fruit harvesting is determined by monitoring the rate of production of ethane during ripening. By understanding the kinetics of the enzymatic reactions that convert starches to sugars and change fruit texture, farmers can harvest when the fruit is at its peak quality for transport or consumption.

2. Why some fruits and vegetables get destroyed early during summer than during winter.

Ans. Chemical and enzymatic reactions follow the rule that reaction rates increase with temperature.
In summer, the high ambient temperature speeds up the rates of oxidation and microbial growth, leading to rapid spoilage.
In winter, the lower temperatures act like natural refrigeration, slowing these kinetic processes down.

THINGS TO KNOW

- Understanding kinetics helps us to control the reaction conditions in order to speed up or slow down reactions as needed.

INTERESTING INFORMATION

- Understanding the kinetics of oxidation reactions of fats helps to prevent spoilage of butter.

INTERESTING INFORMATION

- Enzyme based biosensors are used to detect glucose in blood.

INTERESTING INFORMATION

- Kinetics helps us to increase the yield of a reaction and minimize the waste.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

1. According to collision theory, what are collisons that result in the formation of products called?

(a) Random Collsions (b) Effective Collisions
(c) Elastic Collisions (d) Frequent Collsions

2. The minimum energy required to start a chemcial reaction known as?

(a) Thermal energy (b) Kinetic energy
(c) Activation energy (d) Potential energy

3. What typically happens to the rate of many reactions for every 10 °C rise in temeprature?

(a) It doubles (b) It halves (c) It stays the same (d) It triples

4. Which types of reaction releases heat energy into the surroundings?

(a) Neutralization (b) Exothermic (c) Endothermic (d) Decomposition

5. What happens to the concentration of products as a reaction moves toward completion?

(a) It stays constant (b) It decreases
(c) It increases (d) It becomes zero

6. **Dissolving ammonium chloride in water makes the container feel cold. This is example of a/an:**
   (a) Fast reaction (b) Activation reaction
   (c) Endothermic reaction (d) Exothermic reaction
7. **When CaO (quick lime) reacts with water, what happens to the temperature?**
   (a) It remains at 0 °C (b) It increases
   (c) It decreases (d) It fluctuates randomly
8. **How does increasing the concentration of reactants (particles per unit volume) affect the reaction rate?**
   (a) It increases the rate (b) It increases activation energy
   (c) It has no effect on the rate (d) It decrease the rate.

17.4 Factors Affecting the Rates of Reactions

17.5 Importance of Chemical Kinetics in Food Industry

9. **Which form of a solid reactant will react the fastest with a liquid?**
   (a) Finely divided powdered (b) A few medium-sized lumps
   (c) One large crystal. (d) A flast sheet of the solid
10. **What happens to a catalyst at the end of a reaction?**
   (a) It is completely used up. (b) It remains chemically unchanged
   (c) It is turned into a product (d) It evaporates
11. **Enzymes are best described as:**
   (a) Products of spoilage (b) Biological Catalyst
   (c) Inorganic reactants (d) Temperature inhibitors
12. **What process do enzymes catalyze to ripen fruits?**
   (a) Freezing the fruit tissue (b) Conversion of starches into sugars
   (c) Conversion of sogars into starches (d) Increasing the oxygen content
13. **Enzymes are best described as:**
   (a) Products of spoilage (b) Biological catalysts
   (c) Inorganic reactants (d) Temperature inhibitors
14. **Which gas production rate can be monitored to deteremine the best time for fruit harvasting?**
   (a) Ethene (b) Nitrogen (c) Hydrogen (d) Carbon monoxide
15. **In many cases the rate of reaction is double when the temperature is increased by:**
   (a) 10 °C (b) 20 °C (c) 30 °C (d) 40 °C

Answers

1.	(b)	2.	(c)	3.	(a)	4.	(b)	5.	(c)	6.	(c)	7.	(b)
8.	(a)	9.	(a)	10.	(b)	11.	(b)	12.	(b)	13.	(b)	14.	(a)
15.	(a)												

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

17.1 Collision Theory of Reaction Rate

17.2 Change in Mass during a Chemical Reaction

17.3 Change in Temperature During a Chemical Reaction

1. **Define rate of reaction.**

Ans. **Rate of reaction:**
Rate of reaction is the speed at which the reaction takes place.

2. **What is the basic requirement of collision theory for a racthon to occurs.**

Ans. According to the theory, a reaction takes palce only when the participating particles (atoms, molecules or ions) collide with one anotehr.

3. **What are "effective collisions"?**

Ans. Collisions which lead to reaction are called effective collisions.

4. **How does the number of particles per unit volume affect the reaction state?**

Ans. The larger the number of particles per unit volume, larger is the possibility of effective collisons and a faster reaction rate.

5. **What is the effect of temperature on the frequency of colitsons?**

Ans. At higher temperature the velocities of the molecules increase resulting in the increase in the frequency of collisions.

6. **How does kinetic energy relate to the reaction rate?**

Ans. As temperature increases, the kinetic energy of the particles also increases. As a result, the particles start moving fast leading to more vigorous motion. The fast moving particles will have more chances to collide with each other.

7. **Does the total mass of substances change during a chemical reaction?**

Ans. No, According to the law of conservation of mass, the total mass remains the same throughout the reaction.

8. **Why does the mass of marble chips seem to decrease when reacted with dilute HCl in an open container?**

Ans. The apparent decrease in mass is due to evolution of CO_2 gas during the reaction which escapes into the atmosphere.

9. **What happens to the concentration of reactants and products as a reaction moves ahead?**

Ans. When a reaction moves ahead the concentration of the reactants decrease until all the reactants are used up. At the same time, the concentrations of the products increase and reach the maximum value at the end of the reaction.

10. Differentiate between exothermic and endothermic reactions.

Ans. Exothermic Reactions:

In exothermic reaction heat energy is relased which is absorbed by the surrounding causing their temperature to increase.

For example: When quick lime (CaO) reacts with water, slaked lime $Ca(OH)_2$ is formed and a lot of energy is realsed.

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2\,(s)}$$

Endothermic Reaction: In endothermic reaction heat energy is absorbed causing the surrounding to cool down.

For example: When ammonium chloride or ammonium nitrate is dissolved in water, heat energy is absorbed causing the container cool down.

11. How much does the reaction rate typically increase with temperature?

Ans. Increasing the temperature of the reactions, increases its rate. For many reactions, the rate doubles with energy 10 °C rise in temperature.

17.4 Factors Affecting the Rates of Reactions

17.5 Importance of Chemical Kinetics in Food Industry

12. How does the concentration of reactants affect the rate of reaction?

Ans. An increase are decrease in concentrations of the reactants will result in increase or decreases in the rate of reaction respectively.

For Example:

Combustion of coal in air (21 % oxygen) proceeds relatively slowly as compared to the reaction in pure oxygen.

13. How does pressure affect the rate for gases?

Ans. If reactants in a reaction are present in gas phase, their concentrations can be changed by changing their pressure.

For Example: The rate of reaction between hydrogen and chlorine can be doubled if the prssure of chlorine gas is doubled provided the other component hydrogen is present in excess.

14. What is the effect of surface area on the reaction rate of solids?

Ans. Finely divided solids, because of the greater surface area available, react more rapidly than do large pieces of the same substances.

For Example:

Aluminium foil reacts slowy with warm sodium hydroxide but in finely divided state it reacts rapidly with even cold aqueous solution of sodium hydroxide evolving hydrogen gas.

$$2Al_{(s)} + 2NaOH_{(aq)} + 6H_2O_{(l)} \longrightarrow 2NaAl(OH)_{4\,(aq)} + 3H_{2\,(g)}$$

15. Give an everyday example of the surface area affect.

Ans. Small pieces of wood burn much more rapidly than a large piece of wood because of the increased surface area available for the fire.

16. Why do chemical reactions proceed faster at higher temperatures?

Ans. As the temperature of reaction is increased, the kinetic energy of the participating reacting particles also increases. This, in turn increases the velocities of their movements, as a result the collisions which lead to the occurence of reactions also increase, enhancing the rate of reaction.

17. Define a catalyst.

Ans. Catalyst: A catalyst is a substance which alters the rate of the reaction but it is not consumed during the course of reaction.

18. How does a catalyst speed up a reaction?

Ans. The role of a catalyst is to after the way reaction takes place by substantially lowering its activation energy. When the activation energy is lowered, more and more particles of the reactants will start forming the high energy state and the rate of reactions will increase.

19. What are enzymes?

Ans. Enzymes: Enzymes are biological catalysts. They are basically proticns which helps to speed up specific chemical reactions taking place in our body.

20. Why is the study of reaction rates important in the food industry?

Ans. It helps scientists to determine the optimum conditions for harvesting, storage and transportation of food products by studying the rates of enzymatic reactions, oxidation or microbial growth.

21. How do enzymes affect the ripening of fruits?

Ans. Fruits and vegetables owing to the reactions which involve enzymes. These reactions convert starches into sugars, soften tissues and develop characteristics flavour and clours.

22. How can farmers use kinetics to predict harvesting time?

Ans. With the help of rates of there enzymatic reactions, farmers can predict when the product will reach at its peak quality and ready for harvesting.

For Example: The rate of production of ethene during ripening can be monitored to determine the best time to harvest the fruits.

23. Why does food spoil faster in summer than in winters?

Ans. Hy temperatures in summer increase the rate of enzymatic reactions and microbial growth, leading to rapid degradation of texture, flavour and nutritional value compared to the cooler winter months.

24. How is refrigeration used to prevent food spoilage?

Ans. Refrigeration lowers the temperature, which significantly slows down the rates of oxidation reactions and enzymatic processes that cause food do decay.

25. What kind of biosensors are used to detect glucose in blood?

Ans. Enzyme based bisosensors are used to detect glucose in blood.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ Choose and tick the correct answer from the given choices.

1. **The number of collisions per unit volume of the reaction mixture is called:**
   (a) Collision energy (b) Activation energy
   (c) Collision frequency (d) Collision force
2. **If the reactants possess an energy higher than the activation energy, then the reaction will be:**
   (a) Slow (b) Fast (c) Not affected (d) Instantaneous
3. **Which of the following explains the increase in rate of reaction in the presence of a catalyst?**
   (a) Catalyst provides extra energy to the reactant molecules
   (b) Catalyst provides an alternative pathway which lowers the activation energy.
   (c) Catalyst increases the collision frequency
   (d) Catalyst decreases the collision frequency
4. **Which of the following statements is correct?**
   (a) Collisions with energy equal to or greater than the activation energy lead to reaction.
   (b) Collision frequency is not related to the reaction rate
   (c) All collisions lead to a reaction.
   (d) Collisions with energy less than the activation energy lead to the reaction.
5. **When a reaction proceeds ahead, how the concentrations of reactants and products change?**
   (a) Concentration of reactants increases and that of the products decreases.
   (b) Concentration of reactants decreases and that of the products increases.
   (c) Concentration of both reactants and products decreases.
   (d) Concentration of both reactants and products increases.

Answers

1. (c) 2. (b) 3. (b) 4. (a) 5. (b)

B. Short Answer Questions

17.1 What is a successful collision?

Ans. A successful collision is one that results in the formation of products. For a collisions to be successful, the colliding particles must have the correct orientation and energy equal to or greater than the activation energy.

17.2 How does increase in the temperature increase the rate of a reaction?

Ans. As the temperature of a reaction is increased, the kinetic energy of the participating reacting particles also increases. This, in turn increases the velocities of their

movements. As a result the collisions which lead to the occurrence of reactions also increase, enhanced the rate of reaction.

17.3 Define activation energy.

Ans. Activation Energy:

The minimum energy required to start a chemical reaction is called its activation energy.

17.4 Why does the burning of sulphur proceed slower in air than in pure oxygen?

Ans. The burning of sulphur proceeds slower in air than in pure oxygen. It is because air contains only about 21 % oxygen, while pure oxygen has a much higher concentration, leading to a higher collision frequency between sulphur and oxygen molecules.

17.5 Why a catalyst used in a reaction is preferably taken in the powdered form?

Ans. A catalyst used in a reaction is preferably taken in the powdered form because powdered form increases the surface area, providing more active sites for the reactant molecules to absorb and react, this increasing the reaction rate.

17.6 Why is the rate of a reaction often very fast at the beginning of the reaction?

Ans. The rate of reaction is often very fast of the beginning of the reaction because at the start, the concentration of reactants is greater which means faster rate of reaction and more chance of effective collisions.

17.7 Magnesium does not react with air at room temperature but it reacts very fast at high temperature giving intense white light. Explain.

Ans. At room temperature, magnesium atoms do not have enough energy to break their bonds and start a reaction with the oxygen in the air. When magnesium is heated at high temperature.

Activation Energy:

The heat provides the "starting energy" (activation energy) needed for the reaction to begin.

Chemical reaction:

The magnesium starts to burn rapidly, reacting with oxygen to form magnesium oxide.

Energy Release:

This reaction is very strong and releases a lot energy all at once, giving intense white light.

17.8 What happens to the reactants after they climb the energy hill during a reaction?

Ans. In a chemical reaction, the "energy hill" is the amount of energy reactants must gain to actually change into something new.

Once the reactants reach the top of that hill:

- They reach a very unstable state where their original bonds are broken.
- They immediately "slide down" the other side of the hill. As they do this atoms

rearrange themselves and form new bonds, and turned into products.

17.9 How does a catalyst lower the activation energy of a reaction?

Ans. A catalyst lowers activation energy by providing an alternative reaction pathway with a lower energy barrier, allowing the reaction to occur faster.

17.10 Give any two features of the catalytic action of an enzyme.

Ans. (i) High specificity: An enzyme acts only on a particular substrate.

(ii) Reusability: The enzyme cannot consumed and can be used repeatedly.

C. Constructed Response Questions

17.1 In what different ways you can increase the successful collisions between the particles of the reactants?

Ans. To increase the rate of reaction, you must increase the number of effective collisions. This can be achieved by:

- **Increasing Concentration:**
  Adding more reactant particles into the same volume increases the probability of them hitting each other.
- **Increasing Temperature:**
  This gives particles more kinetic energy. They move faster (increasing collision frequency) and more importantly, a larger percentage of particles will have energy equal to or greater than the activation energy.
- **Increasing Surface Area:**
  For solid reactants, crushing them into a powder exposes more "inner" atoms to the other reactants, allowing more collisions to occur simultaneously.
- **Adding a catalyst:**
  This provides an alternative pathway with a lower activation energy, making it "easier" for collisions to be successful.

17.2 Give an example of a reaction which proceeds with the gain in mass.

Ans. A classic example is the combustion of Magnesium ribbon.

$$2\,Mg_{(s)} + O_{2\,(g)} \longrightarrow 2\,MgO_{(s)}$$

If a ribbon of magnesium is burnt in an open crucible, the mass of the product (MgO) formed will be greater than the reactant (Mg). This increase in mass has occurred due to the reaction of magnesium with oxygen present in air.

17.3 From where do molecules get energy to attain higher energy state?

Ans. Molecules primarily gain energy through molecular collisions. In any sample, particles are moving at different speeds. When they collide, kinetic energy is transferred. If a molecule undergoes several high-energy collisions, it may accumulate enough energy to reach the activated complex state (the top of the energy hill).

Endothermic Reaction:

In an endothermic reaction, this energy is absorbed from the surroundings (heat).

Reaction Mixture:

In a reaction mixture, increasing the external temperature provides the thermal energy that increases the internal energy of the molecules.

17.4 How does the presence of V_2O_5 catalyst lowers the activation energy of the following reaction?

$$2\,SO_{2\,(g)} + O_{2\,(g)} \longrightarrow 2\,SO_{3(g)}$$

Ans. The vanadium (V) oxide (V_2O_5) acts as a heterogeneous catalysts in the contact process. It does not simply "push" the molecules; it provides a new chemical pathway consisting of two smaller steps:

- First, SO_2 reacts with V_2O_5 to form SO_3 and a reduced catalyst (V_2O_4).
- Then the V_2O_4 reacts with O_2 to regenerate the original V_2O_5.

Because each of these individual steps has a lower activation energy than the direct collisions of SO_2 and O_2, the overall reaction proceeds much faster.

17.5 Explain the catalytic action of an enzyme.

Ans. For answer See Q7 (Long Subjective Questions)

17.6 If you desire to stop a reaction going on at 60°C, what action you will take?

Ans. By lowering the temperature, system will cool rapidly. So the reaction rate decreases or stops.

D. Descriptive Questions

17.1 Explain the effect of surface area on the rate of a raection.

Ans. For answer See Q6 (b)

17.2 Describe the main points of the collision theory of reaction rate.

Ans. For answer See Q1

17.3 Discuss the following factors affecting the rate of a reaction:

(a) Effect of concentrations of the reactants.

(b) Effect of temperature at which a reaction is carried out.

Ans. (a) For answer See Q4

(b) For answer See Q5

17.4 How does chemical kinetics play an important role in the food industry?

Ans. For answer See Q9

17.5 Write briefly about the role enzymes play in our body as biological catalysts.

Ans. For answer See Q8

CHAPTER 18 Salts

Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain that salts are ionic compounds formed due to electrostatic attraction between oppositely charged ions (in which the positive ions come from bases and negative ions come from acids).
- Explain why at S.T.P salts are solids with high melting points.
- Describe that under normal conditions, ionic compounds are usually solids with lattice structures.
- Explain why the molten and aqueous solutions of salts are good conductors of electricity by making reference to the idea of mobile ions.
- Describe the general solubility rules for salts, (these are:
  - (a) sodium, nitrate, potassium and ammonium salts are soluble
  - (b) chlorides are soluble except lead and silver
  - (c) carbonates are insoluble except sodium, potassium and ammonium
  - (d) hydroxides are insoluble except sodium, potassium, ammonium and calcium (partially).
- Describe the preparation, separation and purification of soluble salts by reactions of acid with alkali (titration), excess metal, excess insoluble base, excess insoluble carbonate.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: (a) What is neutralization reaction? Give example.

Ans. Neutralization Reaction:

When acids react with bases or alkalis, salts and water are formed. This reaction is called neutralization reaction.

For example: Sodium hydroxide, an alkali, neutralizes hydrochloric acid to form sodium chloride and water.

Equation: $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

(b) Define salt. How salts are formed?

Ans. Salt:

A salt is a chemical combination of positive and negative ions.

Role of Electrostatic Force of Attraction: These oppositely charged ions are then bonded together by the electrostatic force of attraction. These oppositely charged ions are then bonded together by the electrostatic force of attraction.

Strength of the Attraction:

The strength of this attraction depends on the following factors:

- Magnitude of the charges
- Distance between the ions.

Q.2: What is crystal lattice? Explain the formation of sodium chloride crystal.

Ans. Crystal Lattice:

The oppositely charged ions in a salt arrange themselves in a regular and repeating pattern to give a three dimensional network called a crystal lattice.

Properties shown by the ionic compounds:

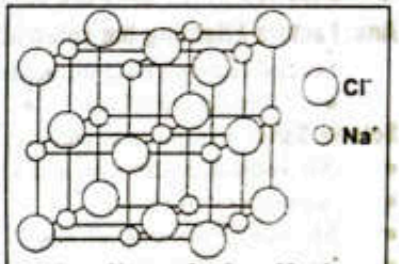
The properties shown by the ionic compounds are due to the preserve of this ordered structure (crystal lattice).

Under ordinary conditions of temperature and pressure the ionic compounds exist as crystalline solids.

Formation of sodium chloride crystal:

In sodium chloride (NaCl), each sodium ion is surrounded by six chloride ions and each chloride ion, in turn, is surrounded by six sodium ions.

- These ions are arranged in the crystal lattice having the shape of a face-centered cube.
- The bigger chloride ions are present at the corners and at the centre of each face of the cube, while the smaller sodium ions occupy the edges of the cube.



Crystal lattice of sodium chloride

Q.3: Discuss why the melting point of ionic compounds are generally very high.

Ans. Strong Electrostatic Forces of Attraction:

Since very strong electrostatic forces of attraction are present between the ions within a crystal lattice, a significant amount of energy is needed to break these forces. This is the reason that the melting points of ionic compounds are generally very high.

Explanation:

During the process of melting the attractive forces break down and let the ions move freely.

The melting points of ionic compounds depend upon the charges present on the ions and their sizes. Higher charges and small ion sizes lead to stronger attractions and hence the higher melting points.

Q.4: Why Ionic compound do not conduct electricity in solid state but in molten state and when dissolved in water they conduct electricity?

Ans. Ionic compounds in Solid state:

Ionic compounds do not conduct electricity in solid state. It is because, in the solid state ions are held together by strong forces of attraction, they are not free to move and, therefore cannot conduct electricity.

Ionic compounds in Molten state: Inoic compounds start conducting electricity in molten state. It is because when ionic compounds are heated to their melting points- their ions became free to move around and hence start conducting electricity

Ionic compounds when dissolved in water :

Inoic compounds also start conducting electricity when they are dissolved in water. It is because, when ionic compounds are dissolved in water, the forces of attraction between ions break down and the ions are again free to move independently.

Ionic compounds - As strong Electrolytes: Ionic compounds serve as a strong electrolytes because they dissociate completely into ions when dissolved in water.

18.4 Soluble and Insoluble Salts

18.5 Preparation of Soluble Salts

Q.5: Describe which salts are soluble in water and which are insoluble.

Ans. Factors Effecting the solubility of A Salt:

Several factors effect the solubility of a salt including:

- The nature of salt
- The Temperature

Soluble Salts: Soluble salts include:

- All sodium, potassium, and ammonium salts.
- All metallic nitrates.
- Most chlorides and sulfates.
- Hydroxides of sodium, potassium and ammonium.
- Calcium hydroxide is only partially soluble in water.

Insoluble salts include:

- All carbonates with the exception of carbonates of sodium, potassium and ammonium.
- Chlorides of silver and lead.
- Sulfates of barium and lead
- Beryllium and magnesium hydroxides

The following table shows the pattern for the solubility of salts in water.

Solubility of salts in water

Salts	Soluble	Insoluble
Salts of sodium, potassium and ammonium and all nitrates	All	None

Chlorides, bromides and iodides	Most soluble	Silver, Lead (II)
Sulphates	Most soluble	Barium, Lead(II), Calcium
Carbonates	Sodium, Potassium, Ammonium	Most insoluble
Hydroxides	Sodium, Potassium, Ammonium, Calcium (partially soluble)	Most insoluble

Q.6: Explain the preparation of soluble salt.

Ans. Reaction of water soluble Acid with water soluble Base

Titration Method: This method is also called a titration method. It involves the reaction of a water soluble acid and a water soluble base.

The acid and base are selected depending on the nature of salt which is to be prepared.

Preparation of Soluble Potassium Nitrate:

For the preparation of soluble potassium nitrate, appropriate volumes of potassium hydroxide and nitric acid are made to react together in a conical flask.

Chemical Reaction

$$KOH_{(aq)} + HNO_{3(aq)} \longrightarrow KNO_{3(aq)} + H_2O_{(l)}$$

The solution present in the conical flask now contains two things:

- The soluble salt
- The water

Transfer the solution to an evaporating dish.

There are two ways to get the water salt:

- Evaporation
- Crystallization

If the salt being prepared is stable towards heat, then evaporate the solution to dryness to get the salt

Alternatively, heat the solution gently until a thin film of crystals is formed on the surface of the solution.

Cool this solution slowly which is now saturated with salt.

Filtration and Dry:

Filter the mixture to get the pure crystals of the salt.

Dry the crystals between the folds of the filter papers.

Q.7: How will you prepare pure crystals of sodium sulphate in the laboratory?

Ans. Preparation of Pure Crystals of Sodium Sulphate:

In the laboratory, we can prepare pure crystals of sodium sulphate by performing the following activities.

(i) Add 50 cm^3 of 1 mol/dm^3 solution of sodium hydroxide in a neat conical flask with the help of a pippet.

(ii) Add a few drops of phenolphthalein indicator to get a pink colour solution.

(iii) Run 1 mol/dm^3 solution of sulphuric acid from the burette into the conical flask until the colour of solution changes from light pink to colourless.

(iv) Note down the volume of sulphuric acid used to neutralize sodium hydroxide.

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O$$

(v) Repeat the experiment taking the same volumes of sodium hydroxide and sulphuric acid but without using the indicator.

(vi) Transfer this neutralized solution to an evaporating dish and heat it gently until one-third of the solution is left.

(vii) Dip a glass rod into this hot solution and take it out.

(viii) If the immersed end of the glass rod turns cloudy, the solution is concentrated enough for crystals to form.

(ix) Cool down the solution for the crystallization to occur completely.

(x) Filter and wash the crystals with a little cold distilled water to remove any soluble impurities and the acid attached.

(xi) Dry the crystals within the fold of filter papers or in an oven.

Q.8: Describe the preparation of soluble salts by reaction of an acid with an insoluble base.

Ans. Preparation of Soluble salts by - Reaction of An Acid with an Insoluble Base:

This is also a neutralization reaction between the soluble acid and an insoluble base. The insoluble base may be an appropriate metal oxide, a metal carbonate or a metal hydroxide.

Selection of Acid and Insoluble Base:

- The acid and the insoluble bare are selected depending upon the salt to be prepared.
- A salt is also formed when an acid reacts with a metal.

Mixing and Stirring: This method involves

- The mixing of the selected acid with the selected base or a metal.
- Constant stirring to ensure that the acid has fully reacted with the base or the metal.

Using an Excess Amount: The insoluble base or the metal should always be added in excess to make sure that all the the acid present has reacted.

Filtering out the Left overs:

Filter the mixture to remove the excess amount of base or the metal.

Evaporation: Evaporate the filtrate to get a saturated solution.

Cooling:

Allow the solution to cool down when pure crystals of the salt will start appearing.

Drying the crystals: Filter and dry the crystals carefully.

Chemical Reactions:

$$Cu(OH)_{2(s)} + 2HCl_{(aq)} \longrightarrow CuCl_{2(aq)} + 2H_2O_{(l)}$$

$$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$$

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Q.9: Discuss how will you prepare pure crystals of zinc sulphate in the laboratory?

Ans. Preparation of pure crystals of Zinc sulphate:

We can prepare pure crystals of zinc sulphate in the laboratory by perforating the following activity.

Materials Pequired:

- A beaker
- An evaporating dish
- Filter paper
- Dilute sulphuric acid
- Small granules of zinc metal

Chemical equation:

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$$

Procedure:

(i) Take about 25 cm^3 dilute sulphuric acid in a beaker and warm it gently.

(ii) Go on adding small granules of zinc metal slowly with constant stirring till the metal starts settling down at the bottom of the beaker.

(iii) Filter the solution to remove undissolved zinc metal and collect the filtrate.

(iv) Evaporate the filtrate in an evaporating dish by gentle heating to concentrate the solution without over heating or boiling.

(v) Cool down the solution slowly and allow the crystals to appear.

(vi) Once all the crystals have formed, carefully filter the mixture to get the crystals.

(vii) Allow the crystals to dry on filter paper.

18.1 Quick Check!

1. How the ions present in NaCl arrange themselves to form a crystal lattice?

Ans. In NaCl, each sodium ion is surrounded by six chloride ions and each chloride ion, in turn, is surrounded by six sodium ions.

These ions are arranged in the crystal lattice having the shape of a face- centered cube.

- The bigger chloride ions are present at the corners and at the centre of each face of the cube.
- The smaller sodium ions occupy the edges of the cube.

2. Do you expect melting point of KCl to be higher or lower than NaCl?

Ans. KCl has a lower melting point than NaCl. This is because the potassium ion (K^+) is larger than the sodium ion (Na^+), resulting in weaker electrastatic forces (lower lattice energy) and easier breaking of bonds. Smaller cations allow for stronger ionic packing, requiring more heat to melt. On the other hand larger ions result in weaker lattice structures.

18.2 Quick Check!

1. Which salts of barium and calcium are soluble in water?

Ans. Salts of Barium Soluble in water: Following salts of Barium are solube in water:

- Barium Nitrate
- Barium chloride

Salts of Calcium Soluble in water: Following salts of calcium are soluble in water:

- Calcium Nitrate
- Calcium chloride

2. How barium sulphate is prepared in the laboratory?

Ans. In the laboratory, barium sulphate is prepared using a process called precipitation.

Method:

(i) Mix two soluble salt solution together one containing barium ions (Live Barium chloride) and one containing sulfate ions (like sadium sulfate)

Reaction: $BaCl_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow BaSO_4 + NaCl$

(ii) The barium sulfate forms as a solid white precipitate because it is insoluble in water.

(iii) Filter the mixture to collect the solid crystals.

INTERESTING INFORMATION:

- Common salt was a valuable commodity in the past. It was even used as Currency
- Copper sulphate is used as a fungicide. Other salts are used in water softening and glass manufacture

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

18.1 Arrangement of Ions in Salts

18.2 Melting Points of Ionic compounds

18.3 Conduction of Electricity by Ionic Compounds

1. **What are the primary products formed when an acid neutralizes a base or an alkali?**
   (a) salt and water (b) salt and hydrogen gas
   (c) salt and a metal (d) Salt and an oxide
2. **In the reaction $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O(l)$, What does NaCl represent?**
   (a) Hydrochloric acid (b) Sodium hydroxide
   (c) sodium chloride (d) Hydrogen oxide
3. **Which force is responsible for bonding the oppositely charged ions together in a salt?**
   (a) Nuclear force (b) Electrostatic force of attraction
   (c) Gravitational force (d) Magnetic force
4. **What is the three dimensional network structure formed by ions in a salt called?**
   (a) Atomic cloud (b) Liquid matrix
   (c) Molecular chain (d) Crystal lattice

5. **Under ordinary conditions of temperatuse and pressure, in what state do ionic compounds exist?**
   (a) Liquid state (b) Crystalline solids (c) Gaseous state (d) Plasma state
6. **In a sodium chloride crystal, how many chloride ions surround each individuals sodium ion?**
   (a) Six (b) Seven (c) Eight (d) Nine
7. **What is the geometric shape of the structure of NaCl lattice?**
   (a) Hexagonal prism (b) Pyramid
   (c) Face centered cube (d) Octa hedron
8. **Where are the smaller sodium ions located in the sodium crystal cube?**
   (a) At the corners of the cube (b) At the center of each face
   (c) In the edges of the cube (d) Floating outside the cube
9. **How was common salt used in the past?**
   (a) As currency (b) As a fuel
   (c) As a source of light (d) As source of radiation
10. **Ionic compounds typically have high melting points of ____ electrostatic forces of attraction are present between the ions.**
    (a) Strong (b) Very strong (c) Weak (d) very weak
11. **The attractive forces break down and let the ions move freely during the process of:**
    (a) Melting (b) Boiling (c) Evaporation (d) Condensation
12. **In which state do ionic compounds Not conduct electricity?**
    (a) Dissolved in water (b) Molten state
    (c) Solid state (d) None of these
13. **Ions are held together by strong forces of attractions in:**
    (a) Liquid state (b) Solid state (c) Gaseous state (d) All of these
14. **Ionic compounds serve as:**
    (a) Weak electrolytes (b) Bad electrolytes
    (c) Good electrolytes (d) Strong electrolytes
15. **Higher charges and smaller ion size lead to stronger attractions and hence.**
    (a) Higher boiling points (b) Lower melting points
    (c) Lower boiling points (d) Higher melting points
16. **The forces of attraction between ions break down and the ions are again free to move independently, when ionic compounds are:**
    (a) In solid state (b) In molten state (c) Dissolved in water (d) a and b both

18.4 Soluble and Insoluble Salts

18.5 Preparation of Soluble Salts

17. **In which state do ionic compounds NOT conduct electricity?**
    (a) Molten State (b) Solid state
    (c) Liquid state (d) Aqueous solution

18. **In which state of matter ions are held together by strong forces of attractions?**
(a) Solid state (b) Liquid state (c) Gaseous state (d) All of these

19. **What happens to the ions in an ionic compound when it is heated to its melting point?**
(a) They become fixed (b) They disappear
(c) They become free to move (d) None of these

20. **When an ionic compound dissolves in water the forces of attraction between its ions:**
(a) Become stronger (b) Break down
(c) Remain the same (d) Completely finish

21. **Ionic compounds serve as strong electrolytes because they _____ completely into ions when dissolved in water.**
(a) Condense (b) Freeze (c) Evaporate (d) Dissociate

22. **According to the solubility rules, which of these groups of salt are always soluble in water?**
(a) All sodium, potassium, and ammonium salts.
(b) Barium and lead sulfates
(c) Silver and lead chlorides (d) All of these

23. **All carbonates are insoluble in water with the exception of carbonates of:**
(a) Sodium (b) Potassium (c) Ammonium (d) All of these

24. **Reaction of water soluble acid with water soluble base is also known as:**
(a) Filtration (b) Crystallization (c) Titration method (d) Evaporation

25. **To prepare soluble Potassium Nitrate (KNO_3), which acid and base should be used in a titration method.**
(a) Hydrochloric acid and Potassium hydroxide
(b) Sulpuric acid and potassium carbonate
(c) Nitric acid and potassium hydroxide (d) Nitric acid and sodium hydroxide.

26. **Which of the following salt is used as a fungicide?**
(a) Magnesium hydroxide (b) Potassium nitrate
(c) Sodium carbonate (d) Copper sulphate

27. **In reaction of an acid with an insoluble base, what is the step taken to remove the excess insoluble base from the mixture?**
(a) Filtration (b) Evaporation (c) Crystallization (d) Stirring

28. **Which of these salts is typically insoluble in water?**
(a) Sodium Carbonate (b) Ammonium Nitrate
(c) Lead sulpate (d) Potassium chloride

29. **Which of the following salts is only partially soluble in water?**
(a) Potassium hydroxide (b) Calcium hydroxide
(c) Ammonium hydroxide (d) Sodium hydroxide

30. **Which indicator is used to neutralize sodium hydroxide with sulphuric acid?**
(a) Methyl orange (b) Phenolphthalein

(c) Litmus (d) a and b both

31. **What colour change indicates that the sodium hydroxide has been neutralized?**
(a) Colourless to pink (b) Pink to colourless
(c) Blue to red (d) Red to colourless

32. **Which type of insoluble base can be used be react with a soluble acid?**
(a) Metal oxide (b) Metal carbonate
(c) Metal hydroxide (d) All of these

33. **If a salt being prepared is stable towards heat, how should it be recovered from the solution?**
(a) Filtration (b) Evaporation to dryness
(c) Cooling (d) Heating

34. **How should pure salt crystals be dried once they are filtered?**
(a) By heating (b) By leaving them in a beaker
(c) Between the folds of filter paper (d) None of these.

ANSWERS

1.	(a)	2.	(c)	3.	(b)	4.	(d)	5.	(b)	6.	(a)	7.	(c)
8.	(c)	9.	(a)	10.	(b)	11.	(a)	12.	(c)	13.	(b)	14.	(d)
15.	(d)	16.	(c)	17.	(b)	18.	(a)	19.	(c)	20.	(b)	21.	(d)
22.	(a)	23.	(d)	24.	(c)	25.	(c)	26.	(d)	27.	(a)	28.	(c)
29.	(b)	30.	(b)	31.	(b)	32.	(d)	33.	(b)	34.	(c)		

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

18.1 Arrangement of Ions in Salts

18.2 Melting Points of Ionic compounds

18.3 Conduction of Electricity by Ionic compoumds

1. **What is a neutralization reaction?**

Ans. When acids neutralize bases or alkalis, salts and water are formed. This reaction is called neutralization.

2. **Write the balanced chemical equation for the neutralization reaction.**

Ans. $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

3. **Define the term salt**

Ans. Salt: A salt is a chemical combination of positive and negative ions.

4. **What is formed when an acid neutralizes a base or an alkali?**

Ans. Salt and water are formed when an acid neutralizes a base or an alkali

5. What force bonds the ions in a salt?

Ans. Electrostatic force of attraction bonds positive and negative ions in a salt.

6. What two factors determine the strength of attraction in a salt?

Ans. The strength of attraction in a salt depends on the following two factors:

- Magnitude of the charges
- Distance between the ions

7. What is the regular, repeating three-dimensional network of ions called?

Ans. The regular, repeating three dimensional network of ions is called a crystal lattice.

8. In what state do ionic compounds exist under ordinary conditions of temperature and pressure?

Ans. Under ordinary conditions of temperature and pressure the ionic compounds exist as crystalline solids.

9. What is the specific shape of the sodium chloride (NaCl) lattice?

Ans. The specific shape of the sodium chloride (NaCl) lattice is a face - centered cube.

10. How many chloride ions surround each sodium ion?

Ans. Six chloride ions surround each sodium ion.

11. Which ion is larger sodium or choride?

Ans. Chloride (Cl^-) ion is larger.

12. Where are the chloride ions located in the face centered cube of sodium chloride?

Ans. In the face - centered cube of sodium chloride, the bigger chloride ions are present at the corners and at the centre of each face of the cube.

13. Where are the sodium ions located in the face- centered cube of sodium chloride?

Ans. In the face - centered cube of sodium chloride, the smaller sodium ions occupy the edges of the cube.

14. How was the salt used as a commodity in the past?

Ans. Common salt was a valuable commodity in the past. It was used as currency.

15. Why do ionic compounds generally have very high melting points?

Ans. Ionic compounds generally have very high melting points because very strong electrstatic forces of attraction are present between the ions writhin a crytal lattice.

16. Why do ionic compounds need a significant amount of energy?

Ans. Since very strong electrostatic forces of attraction are present between the ions within a crystal lattice, a significant amount of energy is needed to break these forces.

17. What does happen to the ions during the process of melting?

Ans. During the process of melting, the electrostatic forces of attraction between the ions break down and let the ions move freely.

18. Upon which two factors do the strength of the melting points in ionic compounds depend?

Ans. The melting points of ionic compounds depend upon the two factors.

- The charges present on the ions
- The sizes of the ions

19. How do ionic charges and size affect the melting points?

Ans. Higher charges and smaller ion sizes lead to stronger attractions and hence the higher melting points.

20. Why do ionic compounds not conduct electricity in the solid state?

Ans. Ionic compounds do not conduct electricity in the solid state. It is because, in the solid state ions are held together by strong forces of attraction, they are not free to move and, therefore cannot conduct electricity.

21. Under what conditions do ionic compounds conduct electricity?

Ans. Ionic compounds conduct electricity in two states.

- In molten state
- When they are dissolved in water

22. Why do ionic compunds start conducting electricity in molten state?

Ans. Ionic compounds start conducting electricity in molten state. It is because, when ionic compounds are heated to their melting points.

23. Why do ionic compounds conduct electricity when they are dissolved in water?

Ans. Ionic compounds start conducting electricity when they are dissolved in water. It is because, when ionic compounds are dissolved in water, the forces of attraction between ions break down and the ions are again free to move independenly.

24. Discus why are ionic compounds considered strong dectrolytes?

Ans. Ionic compounds serve as a strong electrolytes because they dissociate completely into ions when dissolved in water.

18.4 Soluble and Insoluble salts

18.5 Preparation of soluble salts

25. Why do ionic compounds serve as strong electrolytes?

Ans. Ionic compounds serve as strong electrolyte because they dissociate completely into ions when dissolved in water.

26. Mention two factors that effect the solubility of a salt.

Ans. Nature of salt and the temperature are the two factors that effect the solubility of a salt.

27. What do soluble salts include?

Ans. Soluble salts include:

- All sodium, potassium, and ammonium salts.

- All metallic nitrates.
- Most chlorides and sulfates
- Hydroxides of sodium, potassium and ammonium
- Calcium hydroxide is only partially soluble in water.

28. What do insoluble salts include?

Ans. Insoluble salts include:

- All carbonates with the exception of carbonates of sodium, potassium and ammonium.
- Chlorides of silver and lead.
- Sulphates of barium and lead
- Beryllium and magnesium hydroxides.

29. What happens to ions when an ionic compound dissolves in water?

Ans. When ionic compounds are dissolved in water, the forces of attraction between ions break down and the ions are again free to move independently.

30. What is a common use of copper sulphate?

Ans. Copper sulphate is used as a fungicide.

31. What is the titration method?

Ans. It is a method used to prepare a salt by reaction of water soluble acid with water soluble base.

32. Which reactants are used to prepare soluble potassium nitrate?

Ans. Appropriate volumes of potassium hydroxide (KOH) and nictric acid (HNO_3) are reacted together in a conical flask.

33. Is a salt formed when an acid reacts with a metal?

Ans. Yes, a salt is formed when an acid reacts with a metal.

34. Why is the insoluble base or the metal added in excess in neutralization reaction?

Ans. The insoluble base or the metal should always be added in excess in neutratization reaction to make sure that all the acid present has reacted.

35. How do you confirm a solution is "Concentrated enough" for crystals to form?

Ans. Dip a glass rod into the neutralized solution and take it out. If the immersed end of the glass rod turns cloudy, the solution is concentrated enough for crystals to form.

36. What colour change indicates that the sodium hydroxide has been neutralized?

Ans. If a solution changes from light pink to colourless it indicates that the sodium hydroxide has been neutralized.

37. What are the products when KOH reacts with HNO_3?

Ans. KNO_3 and H_2O are the products when KOH reacts with HNO_3.

38. Which indicator is used to neutralize sodium hydroxide with sulphuric acid?

Ans. Phenolphthalein is used to neutralize sodium hydroxide with sulphuric acid

39. How is excess amount of the base or the metal remove from the mixture?

Ans. Filter the mixture to remove the excess amount of the base or the metal.

40. How should pure salt crystals be dried once they are filtered?

Ans. Once they are filtered, dry the crystals between the folds of the filter papers.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Which base is not soluble in water?
(a) KOH (b) $Mg(OH)_2$ (c) NaOH (d) Na_2CO_3

2. The shape of the crystal of NaCl is:
(a) Cubic (b) Hexagonal (c) Rombic (d) Trigonal

3. Which salts are always soluble in water?
(a) Chlorides (b) Sulphates (c) Nitrates (d) Carbonates

4. Which salt will be formed when marble pieces react with dilute nitric acid?
(a) Sodium nitrate (b) Calcium nitrate
(c) Potassium nitrate (d) Magnesium nitrate

5. Water insoluble salt is:
(a) Calcium sulphate (b) Sodium sulphate
(c) Potassium sulphate (d) Magnesium sulphate

Answers

1. (b) 2. (a) 3. (c) 4. (b) 5. (a)

B. Short Answer Questions

18.1. Which factors are responsible for the strength of electrostatic forces between ions?

Ans. The strength of electrostatic forces between ions depends on the nature of the salt, which includes.

- The charge of the ions
- The size of the ions

18.2 Is lead (II) chloride soluble in water? Give comments.

Ans. Generally, most chlorides are soluble, however, lead (II) chloride is an exception. It is considered insoluble in cold water, though it can become slightly more soluble if the water is heated.

18.3 Which lead salts are insoluble in water?

Ans. Following lead salts are insoluble in water:

- Lead chloride

- Lead sulfate
- Lead carbonate

18.4 Name two insoluble carbonates.

Ans. Two insoluble carbonates are:

- Calcium carbonate
- Barium carbonate

18.5 What is a crystal lattice?

Ans. The oppositely charged ions in a salt arrange themselves in a regular and repeating pattern to give a three dimensional network called a crystal lattice.

C. Constructed Response Questions

18.1 Why are melting points of ionic salts generally very high?

Ans. Ionic salts have high melting points because they are held together by very strong electrostatic forces between the positive and negative ions.

To melt the salt, you must provide enough heat energy to break these powerful attractions throughout the entire crystal lattice. Because these bonds are so strong, a very high temperature is needed to pull the ions apart.

18.2 Why ionic salts exist in solid state?

Ans. Ionic salts exist as solids because the oppositely charged ions sodium (Na^+) and chloride(Cl^-) attract each other so strongly that they pack together in a fixed, repeating 3D pattern called a crystal lattice.

In this state, the ions are not free to move around, they are locked in place by the surrounding ions, which makes the substance a rigid solid at room temperature.

18.3 How will you prepare calcium sulphate in the laboratory?

Ans. Preparation of calcium sulphate in the Laboratory: Since calcium sulphate is an insoluble salt, it is prepared using a precipitation reaction.

Method:

(i) Mix a solution of a soluble calcium salt (like calcium chloride, $CaCl_2$) with a solution of a soluble sulfate (like sodium sulfate, Na_2SO_4)

(ii) The calcium ions and sulfate ions will swap partners to form solid calcium sulfate.

Reaction: Filter the mixture to collect the solid $CaSO_4$ (the precipitate), wash it with distilled water, and dry it.

18.4 Compare the melting points of $NaCl$ and $MgCl_2$.

Ans. The melting point of magnesium chloride ($MgCl_2$) is higher than that of Sodium chloride ($NaCl$)

Charge power: A magnesium ion (Mg^{2+}) has a + 2 charge, while a sodium ion (Na^+) has a +1 charge

Force of Attraction: Because the magnesium ion has a higher charge, it attracts the negative chloride ions much more strongly than the sodium ion does.

Result: Stronger attraction means more energy is required to break the bond, resulting in a higher melting point for $MgCl_2$.

18.5 How would you prepare pure crystals of copper sulfate in the laboratory?

Ans. Copper sulfate is a soluble salt, so it is prepared by reacting an acid with an insoluble base.

Method

(i) Add excess copper (II) oxide powder to warm dilute sulphuric acid.

(ii) Filter the solution to remove the extra, unreacted copper oxide.

(iii) Evaporate the filtrate (Copper sulfate solution) until it is saturated.

(iv) Allow it to cool slowly so that large, pure blue crystals of copper sulfate form.

D. Descriptive Questions

18.1 Explain the formation of sodium chloride crystal?

Ans. For answer see Q 2

18.2 Explain the methods of preparation of two soluble salts.

Ans. For answer see Q 6 and Q 8

18.3 How are the following salts prepared?

K_2SO_4, $CuCl_2$, $CaCl_2$

Ans. Preparation of K_2SO_4: Potassium sulfate (K_2SO_4) is a soluble salt and is typically prepared through a titration method.

Reactants: Patassium hydroxide (KOH) and sulfuric acid (K_2SO_4).

Method

(i) A known volume of KOH is titrated against K_2SO_4 using an indicator (like phenolphthalein) to find the exact neutralization point.

(ii) Once the point is found, the experiment is repeated without the indicator to get a pure solution.

(iii) The water is then evaporated to leave behind K_2SO_4 crystals

Reaction

$$2KOH_{(aq)} + 2H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O(l)$$

Preparation of $CuCl_2$: Copper (II) chloride is a soluble salt prepared by reaction of an acid with a soluble base.

Reactants:

Copper (II) oxide and dilute hydrochloric acid (HCl).

Method:

(i) Add excess copper (II) oxide powder to a known volume of warm dilute hydrochloric acid.

(ii) Stir the mixture until no more oxide reacts, ensuring all the acid has been

neutralized.

(iii) Filter the mixture to remove the unreacted copper oxide.

(iv) Heat the filterate in an evaporating dish until the crystallization point is reached.

(v) Allow it to cool to form crystals, then filter and dry them between filter paper.

Reaction:

$$CuO_{(s)} + 2HCl_{(aq)} \longrightarrow CuCl_{2(aq)} + H_2O_{(\ell)}$$

Preparation of $CaC\ell_2$: $CaC\ell_2$ is a soluble salt prepared by reacting an acid with an insoluble carbonate.

Reactants:

Calcium carbonate ($CaCO_3$) and dilute Hydrochloric acid ($HC\ell$).

Method:

(i) Add excess calcium carbonate to dilute hydrochloric acid in a beaker.

(ii) Wait for the effervescence to stop, which indicates that all the acid has reacted.

(iii) Filter the solution to remove the left over calcium carbonate.

(iv) Evaporate the filterate to concentrate the solution.

(v) Cool the solution to allow $CaC\ell_2$ crystals to form then collect and dry them.

Reaction:

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$$

18.4 Describe which salts are soluble in water and which are insoluble.

Ans. Salts that are generally soluble in water:

(i) All nitrates (NO_3^-) e.g., $NaNO_3$, KNO_3

(ii) All salts of alkali metals e.g., Na^+, Li^+ Salts

(iii) All ammonium salts (NH_4^+) e.g. NH_4Cl.

Salts that are generally insoluble in water:

(i) Most carbonates (CO_3^{2-}) e.g., $CaCO_3$, $MgCO_3$

(ii) Most hydroxides (OH^-) e.g., $Al(OH)_3$, $Pb(OH)_2$

(iii) Most phosphates (PO_4^{3-}) e.g., $Ca_3(PO_4)_2$, $Mg_3(PO_4)_2$

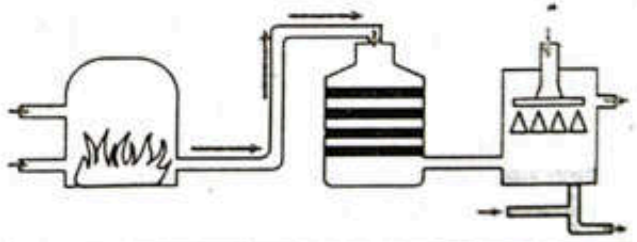
CHAPTER 19

Nitrogen and Sulphur

Student Learning Outcomes

After studying this chapter, students will be able to:

- Recognize that atmospheric oxides of nitrogen (NO and NO_2) can react with unburned hydrocarbons to form peroxyacetyl nitrate, PAN, which is a component of photochemical smog.
- Describe the role of NO and NO_2 in the formation of acid rain both directly and in their catalytic role in the oxidation of atmospheric sulphur dioxide.
- State the symbol equation for the production of ammonia in the Haber process, $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$
- State the sources of the hydrogen (methane) and nitrogen (air) in the Haber process.
- State the typical conditions in the Haber process as 450°C, 20000kPa/20 atm and an iron catalyst.
- State the symbol equation for the conversion of sulphur dioxide to sulphur trioxide in the Contact process, $2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$
- State the sources of the sulphur dioxide (burning sulphur or roasting sulphide ores) and oxygen (air) in the Contact process.
- State the typical conditions for the conversion of sulphur dioxide to sulphur trioxide in the Contact process as 450°C, 200kPa/atm and a vanadium(V) oxide catalyst Oxides.
- Describe the amphoteric oxides as oxides that react with acids and bases to produce a salt and water.
- Classify oxides as acidic, including SO_2 and CO_2, basic, including CuO and CaO, or amphoteric, limited to Al_2O_3 and ZnO, related to metallic and non-metallic character.
- Properties of metal
- Identify the general chemical properties of metals, limited to their reactions with dilute acids, cold water, steam and oxygen.
- Arrange metals in order of reactivity given relevant information.



Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

19.1 Ammonia

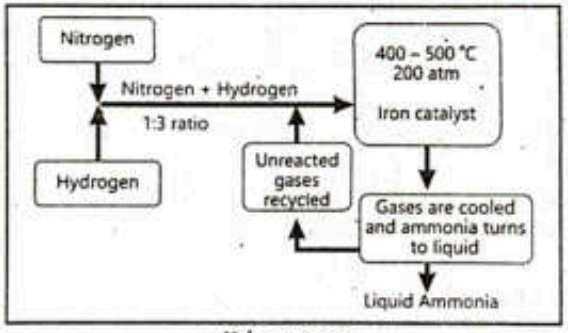
Q.1: Explain the production of ammonia on industrial scale.

Ans. Haber Process:

Ammonia is produced industrially by Haber process discovered by a German Chemist F.J. Haber. In this process, a mixture of nitrogen and hydrogen, in the ratio of 1:3 by volume is heated at 400-500°C under 200 atmospheric pressure and in the presence of catalyst Fe/Al_2O_3 to give ammonia.

$$N_{2(g)} + 3H_{2(g)} \underset{\text{Catalyst}}{\overset{400\text{-}500\ ^\circ C}{\rightleftharpoons}} 2NH_{3(g)}$$

The equilibrium mixture obtained in the above reaction contains 35% ammonia by volume. This mixture is cooled by refrigeration coils where ammonia gas changes to liquid ammonia at –33.4 °C and is removed from the mixture. The other components of the mixture, hydrogen and nitrogen gases, are then recycled back into the reaction chamber.



Haber process

Q.2: How nitrogen and hydrogen used in Haber process are obtained?

Ans. Source of Nitrogen:

One of the raw materials used for the production of ammonia is nitrogen gas and it is obtained by the fractional distillation of air. For this purpose, first of all carbon dioxide present in air is removed and the air is subjected to about 200 atmospheric pressure. This compressed air is then cooled and allowed to pass through a spiral jet. While escaping through this jet, the air suffers sudden expansion and its temperature is decreased. This process of compression and The liquid air is then fractionally distilled. Since the boiling point of nitrogen is less than oxygen, nitrogen evaporates first at -196°C leaving behind the oxygen. The separated nitrogen is reliquified and stored in

specially designed cylinders.

Source of Hydrogen:

The second raw material, hydrogen, is produced by heating methane in the limited amount of oxygen that is not enough to completely oxidize methane to carbon dioxide and water. With less oxygen available, the reaction products contain primarily hydrogen and carbon monoxide and a relatively small amount of carbon dioxide. The carbon monoxide obtained is then reacted with water to form carbon dioxide and more hydrogen gas.

$$CH_{4(g)} + H_2O_{(g)} \longrightarrow CO_{(g)} + 3H_{2(g)}$$
$$CO_{(g)} + H_2O_{(g)} \longrightarrow CO_{2(g)} + H_{2(g)}$$

Q.3: Describe the contact process for the production of sulphuric acid.

Ans. Contact Process:

Sulphuric acid is one of the most important chemical compounds known. It is very commonly used in the laboratory and almost every manufacturing process makes use of this acid directly or indirectly at some stage.

Sulphuric acid is prepared industrially by the contact process. The process involves the following steps.

Preparation of Sulphur dioxide gas:

Sulphur dioxide gas is produced either by burning elemental sulphur in air or roasting a sulphur ore, iron pyrite, in excess of air.

$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$
$$4FeS_{2(s)} + 11O_{2(g)} \longrightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

Sulphur dioxide produced above is then passed through purifying chambers and sprayed with steam. This process removes dust impurities as well as arsenic compounds present in the gas. This step is important because arsenic compounds poison the catalyst used later on. The moist gases (SO_2 and O_2) are then dried by passing through a drying tower in which concentrated sulphuric acid is being sprayed. Oxygen used in this reaction is obtained by the fractional distillation of air.

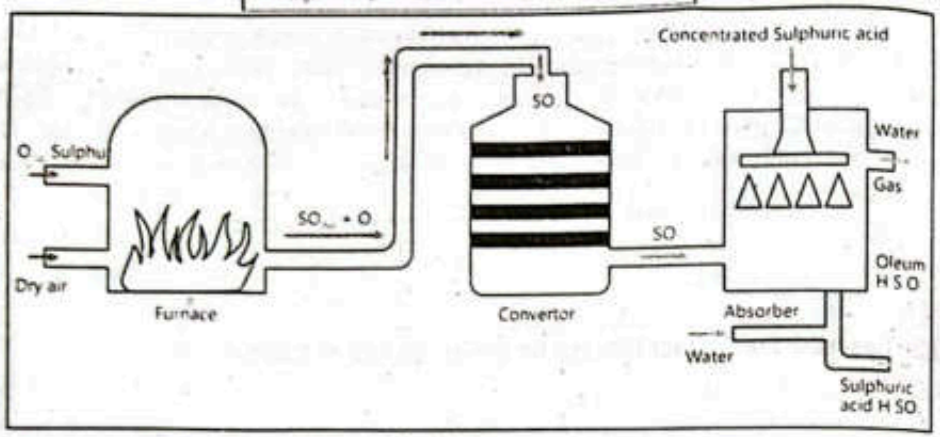
Oxidation of Sulphur dioxide:

The clean and dry gases (SO_2 and O_2) are then passed over vanadium (V) oxide catalyst at 450°C and 2-3 atmospheric pressure through a contact chamber. Although the reaction is reversible yet under these conditions 98% SO_2 gas is converted to SO_3.

$$2SO_{2(g)} + O_{2(g)} \underset{\text{2-3 atomsphere}}{\overset{V_2O_5\ 450\ ^\circ C}{\longrightarrow}} 2SO_{3(g)}$$

Sulphur trioxide gas formed in the contact chamber is then absorbed into 98% sulphuric acid to give oleum.

$$SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)} \text{ oleum}$$



Contact process

The oleum is then mixed with an appropriate amount of water to produce sulphuric acid with desired concentration.

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

19.3 Oxides

19.4 Metals

Q.4: Explain the formation and properties of acidic and basic oxides.

Ans. Oxides

Binary compounds of elements with oxygen are called oxides. Oxygen shows an oxidation state of –2 in there oxides.

Metal Oxides: Metal oxides are commonly basic and amphoteric.

Non-metallic oxides: Non-metallic oxides are acidic in nature.

Formation of Basic and Acidic Oxides: Both basic and acidic oxides are formed when metals and non-metals are heated respectively in the presence of air or oxygen.

Metal oxides are typically ionic compounds in which electrons are transferred from metals to oxygen.

Non-metal oxides are covalent compounds where electrons are shared between non-metals and oxygen atoms.

Properties of Basic Oxides: Oxygen reacts with metals to give oxides which when dissolved in water produce hydroxides. They change red litmus blue. When treated with acids they give salts.

$$O_{2(g)} + 4Na_{(s)} \longrightarrow 2Na_2O_{(s)}$$
$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$

$$O_{2(g)} + 2Ca_{(s)} \longrightarrow 2CaO_{(s)}$$
$$CaO_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)}$$

$$O_{2(g)} + 2Cu_{(s)} \longrightarrow 2CuO_{(s)}$$
$$CuO_{(s)} + 2HCl_{(aq)} \longrightarrow CuCl_{2(aq)} + H_2O_{(l)}$$

Properties of Acidic Oxides: Oxygen combines with non metals (S, C, N) to give acidic oxides. These oxides react with water to give acids which turn blue litmus red.

$$O_{2(g)} + S_{(s)} \longrightarrow SO_{2(g)}$$
Sulphur dioxide
$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(l)}$$
Sulphurous Acid

$$O_{2(g)} + C_{(s)} \longrightarrow CO_{2(g)}$$
$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$
Carbonic Acid

Acidic oxides react with bases to give salts.

$$SO_{2(g)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_3 + H_2O$$
Sodium sulphite
$$CO_{2(g)} + Ca(OH)_{2(aq)} \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$$

Q.5: What are neutral oxides? Explain the formation and properties of amphoteric oxide?

Ans. Neutral Oxides:

Neutral oxides are those oxides which on contact with water produce neither an acid nor a base. Their aqueous solutions have no action on blue or red litmus paper. Examples are carbon monoxide (CO), nitric oxide (NO) and nitrous oxide (N_2O).

Amphoteric Oxide:

Amphoteric oxides are usually formed when oxygen reacts with less electropositive metals.

$$O_{2(g)} + 2Zn_{(s)} \longrightarrow 2ZnO_{(s)}$$
$$3O_{2(g)} + 4Al_{(s)} \longrightarrow 2Al_2O_{3(s)}$$

These oxides behave both as an acid and a base. Zinc oxide and aluminium oxide behave as bases in the presence of an acid.

$$ZnO_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_2O_{(l)}$$
$$Al_2O_{3(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_2O_{(l)}$$

These oxides behave as acids in the presence of an alkali.

$$ZnO_{(s)} + 2NaOH_{(aq)} + H_2O_{(l)} \longrightarrow \underset{\text{Sodium zincate}}{Na_2Zn(OH)_{4(aq)}}$$

$$Al_2O_{3(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \longrightarrow \underset{\text{Sodium aluminate}}{2NaAl(OH)_{4(aq)}}$$

These oxides are insoluble in water and have no action on litmus paper.

Q.6: Give reaction of metals with cold water, steam, oxygen and dilute acids.

Ans. Metals: Nearly three fourth elements shown in the periodic table are called metals. Metals have a tendency to lose electrons and form cations.

Reaction of metals with cold water:

Most of the elements present in the first and second group of the periodic table react vigorously with cold water producing their respective hydroxides and hydrogen gas.

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$$

$$2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$$

Magnesium, however, reacts with cold water slowly giving magnesium hydroxide and hydrogen gas.

$$Mg_{(s)} + H_2O_{(l)} \longrightarrow Mg(OH)_{2(s)} + H_{2(g)}$$

Reactions of metals with steam: The more reactive the metal, the more readily it reacts with steam. Reactive metals like lithium, sodium, potassium and calcium react violently with steam and the reaction can be dangerous.

Beryllium and aluminum react with steam at high temperatures (around 700°C) to give their respective oxides and hydrogen.

$$Be_{(s)} + H_2O_{(g)} \longrightarrow BeO_{(s)} + H_{2(g)}$$

Magnesium, iron and Zn have a moderate reaction with steam producing their respective oxides and hydrogen gas.

$$Mg_{(s)} + H_2O_{(g)} \longrightarrow MgO_{(s)} + H_{2(g)}$$

Reactions of metals with Oxygen: Metals react with oxygen to give metal oxides. The ease of reaction and the type of oxide which is formed, depends upon the reactivity of metals and the conditions used.

Sodium burns in air with yellow flame producing both sodium oxide and sodium per oxide.

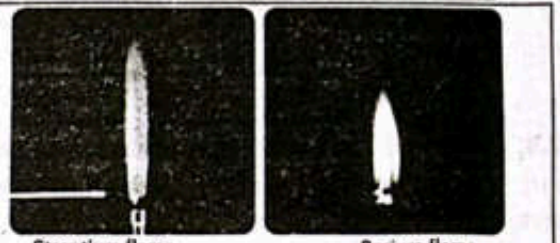
$$4Na_{(s)} + O_{2(g)} \longrightarrow 2Na_2O_{(s)}$$

$$2Na_{(s)} + O_{2(g)} \longrightarrow Na_2O_{2(s)}$$

Magnesium, calcium, strontium and barium burn in oxygen with colour of the flame characteristic to each metal giving their respective oxides.

$$Ca_{(s)} + O_{2(g)} \longrightarrow 2CaO_{(s)}$$

Metal	Colour of flame
Mg	Intense white flame
Ca	White flame with a tinge of red
Sr	Crimson flame
Ba	A pale green flame



Strontium flame Barium flame

Reactions of metals with dilute acids: The more reactive the metal the more vigorous is its reaction with dilute acids. Sodium and potassium are very dangerous and react violently with dilute acids giving their respective salts and hydrogen gas.

$$2Na_{(s)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_{2(g)}$$

All group 2 elements react with dilute acids giving their salts and hydrogen gas. The reaction generally becomes more vigorous as we move down the group.

$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

19.5 Reactivity Series of Metals

19.6 Role of Oxides of Nitrogen in Spreading Air Pollution

Q.7: Write a note on the reactivity series of metals.

Ans. Reactivity Series of Metals:

Based on their reactions with water and acids, the metals can be arranged in decreasing order of their reactivities. Such an arrangement is called the reactivity series of metals.

According to this reactivity series, calcium and metals above it react with cold water to give metal hydroxides and hydrogen gas. The metals below calcium do not react with cold water, instead they react with steam to give metal oxides and hydrogen gas.

Only metals above hydrogen will be able to liberate H_2 upon reacting with dilute acids. Unreactive metals below hydrogen do not react with dilute acids. The more reactive the metal, the more vigorous its reaction will be with dilute acids. Similarly reactive metals, like potassium and sodium, react with oxygen easily whereas the less reactive metals like silver, copper and iron react with oxygen much more slowly.

Reactivity Series of Metals
Most Reactive
k
Na
Li
Ba
Sr
Ca
Mg
Al
C
Mn
Zn
Fe
H
Cu
Ag
Au
Least Reactive

The metals at the top of the series are powerful reducing agents since they are easily oxidized. However, the reducing ability of metals decreases going down the series.

$$Zn_{(s)} + CuSO_{4\,(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

Q.8: Describe the role of nitrogen in the formation of PAN and the acid rain.

Ans. Role of Nitrogen in the formation of PAN and the Acid Rain:

Primary Pollutants: The primary pollutants in the atmosphere include oxides of nitrogen, sulphur and carbon and various hydrocarbons etc.

Secondary Pollutants: These primary pollutants are then converted into secondary pollutants through various reactions going on in the atmosphere. The main secondary pollutants are ozone, per oxyacetyl nitrate (PAN), sulphuric acid etc. All these compounds are toxic and their concentration in the atmosphere must be controlled.

Harmful oxides of Nitrogen: Oxides of nitrogen which are harmful when present in the atmosphere include NO and NO_2, collectively represented by NO_x. They are generated in the atmosphere through both natural and man-made sources.

Natural Sources of NO_x: Natural sources for the production of NO_x include electrical discharges during lightning which can cause atmospheric nitrogen and oxygen to react forming nitric oxide. This nitric oxide is rapidly converted into nitrogen dioxide by oxygen present in air.

$$N_{2(g)} + O_{2\,(g)} \xrightarrow{\text{Electric arc}} 2NO_{(g)}$$
$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2\,(g)}$$

Man-Made Sources of NO_x: Combustion of fossil fuels in vehicles, various industrial processes and electricity power plants are the main man-made sources which generate NO in the atmosphere. Apart from these, agricultural activities and fertilizers also contribute to NO_x emission.

Emission of (NO_x) and (VOCs) in the Atmosphere: Heavy traffic during morning and evening hours together with industrial processes emit a huge amount of oxides of nitrogen (NO_x) and most volatile organic compounds (VOCs) in the atmosphere.

Production of (PAN): Ultraviolet radiation present in sunlight interacts with the oxides of nitrogen and VOCs through a complex series of chemical reactions to produce secondary pollutants like ozone, aldehydes and peroxyacetyl nitrate (PAN).

Formation of Acid Rain: Oxides of nitrogen are also responsible for the formation of another type of pollutant called acid rain. Especially NO reacts with water and other chemicals presents in air, to produce vapours of nitric acid and nitrous acid.

$$2NO_{2\,(g)} + H_2O_{(l)} \longrightarrow HNO_{3(g)} + HNO_{2\,(g)}$$

These acidic vapours then mix with water vapours present in air and fall to earth as acid rain.

Oxides of nitrogen (NO_x) can also act as catalyst to convert, another primary pollutant, sulphur dioxide present in air, to sulphuric acid which is another major component of acid rain.

$$2SO_{2\,(g)} + O_{2\,(g)} \xrightarrow{\text{Oxides of nitrogen}} 2SO_{3(g)}$$
$$SO_{3(g)} + H_2O_{(g)} \longrightarrow H_2SO_{4\,(g)}$$

Acid rain has a pH less than 5.6. Acid rain is damaging for the ecosystem, it can corrode materials and can lead to respiratory problems.

19.1 Quick Check!

1. Why is ammonia gas turned into a liquid after its production?

Ans. Ammonia is turned into a liquid (at approximately -33.4°C) to easily separate it from the mixture of unreacted nitrogen and hydrogen remain as gases, allowing them to be recycled back into the reaction chamber to increase efficiency.

2. Why high pressure is maintained in the production of ammonia?

Ans. Since the formation of ammonia involves 4 moles of reactants turning into 2 moles of product, maintaining a high pressure of 200 atm forces the equilibrium to the right, significantly increasing the yield of ammonia.

19.2 Quick Check!

1. How SO_2 is prepared from FeS_2?

Ans. Sulphur dioxide (SO_2) is prepared by roasting iron pyrite, in excess of air.

The chemical reaction is:

$$4FeS_{2(s)} + 11O_{2(g)} \longrightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

2. Why SO_2 and oxygen are purified before they react to produce SO_3.

Ans. The gases must be purified to remove dust, impurities as well as arsenic compounds present in the gas. This step is important because arsenic compounds poison the catalyst (vanadium (v) oxide) (V_2O_5), used later on.

19.3 Quick Check!

1. Why lead oxide is called an amphoteric oxide?

Ans. Lead oxide is called an amphoteric oxide because it can react with both acids and strong bases to form salts and water, demonstrating both acidic and basic characteristics.

2. Why non-metals form covalent oxides?

Ans. Non-metals have high electronegativites. When they react with oxygen (also a non-metal), they share electrons to reach stability rather than transferring them, resulting in covalent bonds.

19.4 Quick Check!

1. Write the equation for the reaction between Ba and H_2O.

Ans. $Ba + 2H_2O \longrightarrow Ba(OH)_2 + H_2$

2. How do aluminum and zinc react with water?

Ans. Aluminum and Zinc do not react with cold water due to a protective oxide layer on their surface. However, they react with steam at high temperatures to form their respective oxides and hydrogen.

19.5 Quick Check!

1. Which will react faster with HCl, Zn or Fe?

Ans. Zinc (Zn) will react faster with HCl because it is placed higher than Iron (Fe) in the reactivity series, making it more reactive.

2. Name one metal which will displace Zn from its salt.

Ans. Any metal above Zinc (Zn) in the series, such as magnesium (Mg), Aluminum (Al), or sodium (Na), will displace Zinc from its salt.

19.6 Quick Check!

1. What are the harmful effects of oxides of nitrogen on human health?

Ans. (i) Oxides of nitrogen can lead to severe respiratory problems, including inflammation of the airways, coughing, and wheezing.

(ii) They also contribute to the formation of secondary pollutants like ozone and PAN, which are toxic to humans.

2. How do oxides of nitrogen pollute environment?

Ans. Oxides of nitrogen pollute the environment by:

- Acting as catalyst to form acid rain (Contributing to sulphuric acid formation).
- Reacting with water to form nitric acid rain.
- Contributing to the formation of smog and secondary pollutants like ozone and peroxyacetyl nitrate (PAN) in the presence of sunlight.

INTERESTING INFORMATION

- 13% of total nitrogen fixation in the environment is contributed by the Haber process.
- Air pollution is responsible for about seven to eight million deaths annually. It is a significant risk to child health.
- Water is an amphoteric substance. It can act as both an acid and a base, depending on the other substance it reacts with.
- Sulphuric acid is called the "king of chemicals" because it is used in almost every industry.
- If two pieces of uncoated metal touch in space, they become permanently stuck together. It does not happen on Earth because the atmosphere puts a thin layer of oxide between the surfaces which acts as a barrier preventing adhesion.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

19.1 Ammonia

19.2 Sulphuric Acid

1. What is the ratio by volume of nitrogen to hydrogen used in the Haber process?

(a) 1:1 (b) 1:3 (c) 3:1 (d) 2:3

2. Which catalyst is used in the synthesis of ammonia?

(a) Vanadium (v) oxide (b) Platinum
(c) Iron with Al_2O_3 (d) Nickel

3. At what temperature is nitrogen separated from liquid air during fractional distillation?

(a) –196°C (b) –33.4°C (c) 450°C (d) 0°C

4. Which of these is a raw material for the production of hydrogen in the Haber process?

(a) Iron pyrite (b) Carbon dioxide (c) Methane (CH_4) (d) Sulphur

5. What is the chemical formula of oleum?

(a) H_2SO_4 (b) SO_3 (c) $H_2S_2O_7$ (d) $H_2S_2O_8$

6. Which catalyst is employed in the contact process for the oxidation of SO_2?

(a) Iron (b) Magnesium
(c) Vanadium (V) oxide (d) Copper

7. What percentage of the total nitrogen fixation in the environment is contributed by the Haber process?

(a) 80% (b) 13% (c) 98% (d) 35%

8. Which compound is known as the "king of chemicals"?

(a) Ammonia (b) Nitric acid (c) Methane (d) Sulphuric acid

9. The roasting of Iron Pyrite (FeS_2) produces which gas?

(a) SO_2 (b) NH_3 (c) CO_2 (d) H_2

10. What pressure is typically maintained in the Haber process?

(a) 100 atm (b) 200 atm (c) 300 atm (d) 400 atm

11. What is the primary use of the Ammonia produced globally?

(a) Plastics (b) Refrigerants (c) Explosives (d) Fertilizers

19.3 Oxides

19.4 Metals

12. Which type of oxide is formed when oxygen reacts with a non-metal like sulphur or carbon?

(a) Basic oxide (b) Acidic oxide
(c) Neutral oxide (d) Amphoteric oxide

13. What is the characteristic flame colour of Barium (Ba) when it burns in oxygen?

(a) Intense white (b) Crimson (c) Pale green (d) White with red

14. It is an example of a neutral oxide.

(a) ZnO (b) Na_2O (c) CO (d) Al_2O_3

15. Which metal produces a crimson flame when burned?

(a) Calcium (b) Strontium (c) Magnesium (d) Potassium

16. Which of the following metals reacts most violently with dilute acids?

(a) Sodium (b) Zinc (c) Iron (d) Magnessium

17. It is an amphoteric substance.

(a) Water (b) Carbon dioxide
(c) Sodium hydroxide (d) Hydrochloric acid

19.5 Reactivity Series of Metals

19.6 Role of Oxides of Nitrogen in Spreading Air Pollution

18. Which gas is rapidly converted into nitrogen dioxide (NO_2) by oxygen in the air?

(a) Nitric oxide (NO) (b) Nitrous oxide (N_2O)
(c) Ammonia (NH_3) (d) Nitrogen (N_2)

19. Peroxyacetyl nitrate (PAN) is formed by the reaction of sunlight with NO_x and.

(a) Carbon dioxide (b) Volatile organic compounds
(c) Water vapour (d) Oxygen

20. Which metal cannot displace hydrogen from dilute acids?

(a) Iron (Fe) (b) Zinc (Zn) (c) Lead (Pb) (d) Gold (Au)

Answers

1.	(b)	2.	(c)	3.	(a)	4.	(c)	5.	(c)	6.	(c)	7.	(b)
8.	(d)	9.	(a)	10.	(b)	11.	(d)	12.	(b)	13.	(c)	14.	(c)
15.	(b)	16.	(a)	17.	(a)	18.	(a)	19.	(b)	20.	(d)		

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

19.1 Ammonia

19.2 Sulphuric Acid

1. What are the main industrial uses of ammonia?

Ans. Ammonia is primarily used to manufacture nitrogenous fertilizers (about 80%), such as urea. It is also used in the production of plastics, pharmaceuticals, and as a refrigerant.

2. Who discovered Haber process for the production of ammonia?

Ans. Haber process was discovered by a German chemist F.J. Haber for the production of ammonia.

3. What are the optimum conditions for the Haber process?

Ans. The conditions are a temperature of 400-500°C under 200 atmospheric pressure, and the presence of catalyst Fe/Al_2O_3.

4. State the balanced chemical equation for the synthesis of ammonia.

Ans. $N_{2(g)} + 3H_{2(g)} \xrightleftharpoons[\text{Catalyst}]{400\text{-}500\ ^\circ C} 2NH_{3(g)}$

5. How is nitrogen obtained for the Haber process?

Ans. Nitrogen for the Haber process is obtained from the fractional distillation of liquid air. Since the boiling point of nitrogen is less than oxygen, nitrogen evaporates first at −196°C leaving behind the oxygen. The separated nitrogen is reliquified and

stored in specially designed cylinders.

6. How much nitrogen fixation in the environment is contributed by the Haber process?

Ans. 13% of total nitrogen fixation in the environment is contributed by the Haber process.

7. How is sulphuric acid prepared industrially?

Ans. Sulphuric acid is prepared industrially by the contact process.

8. Why must SO_2 and O_2 be purified before entering the contact chamber?

Ans. They must be purified to remove dust and arsenic compounds, as there impurities can poison the catalyst used later on.

9. Why is sulphuric acid called the "king of chemicals"?

Ans. Sulphuric acid is called the "king of chemicals" because it is used in almost every industry.

10. What catalyst and conditions are used to convert SO_2 to SO_3?

Ans. A vanadium (V) oxide (V_2O_5) catalyst is used at a temperature of 450°C and 2-3 atmospheric pressure to convert SO_2 to SO_3.

19.3 Oxides

19.4 Metals

11. What are oxides?

Ans. Oxides: Binary compounds of elements with oxygen are called oxides.

12. Differentiate between basic and acidic oxides.

Ans. Basic oxides: Usually formed by metals. They dissolve in water to produce hydroxides. They change red litmus blue.

Acidic Oxides: Usually formed by non-metals (S, C, N). They dissolve in water to give acids which turn blue litmus red.

13. What are neutral oxides?

Ans. Neutral Oxides: Neutral oxides are those oxides which on contact with water produce neither an acid nor a base.

Examples: Carbon monoxides (CO), nitric oxide (NO) and nitrous oxide (N_2O).

14. Define amphoteric oxides.

Ans. Amphoteric oxides: Amphoteric oxides are usually formed when oxygen reacts with less electropositive metals. They behave both as an acid and a base. They also behave as acids in the presence of an alkali.

Examples: Zinc oxide (Zn) and Aluminum oxide (Al_2O_3).

15. Give a reaction showing ZnO behaving as a base.

Ans. Zinc oxide (ZnO) behaves as a base the presence of an acid.

$$ZnO_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_2O_{(l)}$$

16. Give a reaction showing Al_2O_3 behaving as an acid.

Ans. When Al_2O_3 reacts with an alkali like (NaOH), It behaves as an acid.

$$Al_2O_{3(s)} + 2NaOH_{(aq)} + 3\,H_2O_{(l)} \longrightarrow 2NaAl(OH)_{4(aq)}$$

17. Water is an amphoteric substance. Comment on it.

Ans. Water is an amphoteric substance. It can act as both an acid and a base, depending on the other substance it reacts with.

18. How do group 1 metals (Na, k) react with cold water?

Ans. They react vigorously with cold water to produce their respective hydroxides and hydrogen gas.

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$$

$$2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$$

19. How does magnesium react with water?

Ans. Magnesium reacts with cold water slowly giving magnesium hydroxide and hydrogen gas.

$$Mg_{(s)} + H_2O_{(l)} \longrightarrow Mg(OH)_{2(s)} + H_{2(g)}$$

20. What are the characteristic flame colours of Mg, Ca, Sr, and Ba?

Ans. Magnesium (Mg): Intense white flame
Calcium (Ca): White flame with a ting of red.
Strontium (Sr): Crimson flame
Barium (Ba): A pale green flame

19.5 Reactivity Series of Metals

19.6 Role of Oxides of Nitrogen in Spreading Air Pollution

21. Which metals can liberate hydrogen gas from dilute acids?

Ans. Only metals placed above hydrogen in the reactivity series can liberate hydrogen gas upon reacting with dilute acids.

22. Which metals react with oxygen easily and which metals react with oxygen slowly?

Ans. Reactive metals, like potassium and sodium, react with oxygen easily whereas the less reactive metals like silver, copper and iron react with oxygen much more slowly.

23. Which metals in the reactivity series are powerful and why?

Ans. The metals at the top of the series are powerful reducing agents since they are easily oxidized.

24. How the reducing ability of metals decreases in the reactivity series?

Ans. The reducing ability of metals decreases going down the series.

25. What does primary pollutants in the atmosphere include?

Ans. The primary pollutants in the atmosphere include oxides of nitrogen, sulphur and carbon and various hydrocarbons.

26. Differentiate between primary and secondary pollutants.

Ans. Primary pollutants: Pollutants emitted directly into the atmosphere are called primary pollutants, such as oxides of nitrogen (NO_x), sulphur and carbon and

various hydrocarbons.

Secondary Pollutants: Secondary pollutants are formed when primary pollutants react in the atmosphere, such as ozone (O_3), peroxyactyl nitrate (PAN), and sulphuric acid.

27. How is nitric oxide (NO) produced naturally?

Ans. It is produced during lightening when electrical discharges cause atmospheric nitrogen and oxygen to react.

$$N_{2(g)} + O_{2(g)} \xrightarrow{\text{Electric arc}} 2NO_{(g)}$$

28. What is the role of NO_2 in the formation of acid rain?

Ans. Nitrogen dioxide reacts with water and other chemicals in the air to produce vapours of nitric acid (HNO_3) and nitrous acid (HNO_2), which contribute to acid rain.

29. What are negative impacts of an acid rain?

Ans.
- Acid rain is damaging for the ecosystem.
- It can corrode materials.
- It can lead to respiratory problems.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. The reason for maintaining higher temperature for the production of ammonia is:
(a) activation energy of the reaction is very high.
(b) activation energy of the reaction is very low.
(c) nitrogen and hydrogen are both gases.
(d) at low temperature nitrogen and hydrogen change into liquids.

2. The contact process used for the industrial production of H_2SO_4 is sensitive to the impurities present in SO_2 and O_2 because the impurities:
(a) affect the capability of the catalyst (b) affect the purity of H_2SO_4
(c) do not let SO_2 to react with oxygen
(d) decrease the rate of reaction appreciably

3. Which of the following oxides is neutral in character?
(a) Al_2O_3 (b) SO_2 (c) CO_2 (d) NO

4. Sodium is considered more reactive than magnesium because:
(a) It is more electropositive than magnesium
(b) It reacts with water slowly. (c) It is present in second group
(d) It is the less metallic

5. Secondary pollutants present in the atmosphere are:
(a) Oxides of nitrogen (b) Oxides of Sulphur

(c) Ozone and PAN (d) Oxides of Carbon

6. **SO_3 is absorbed in H_2SO_4 rather than H_2O during the production of sulphuric acid because:**
   (a) SO_3 does not react with H_2O
   (b) Reaction of SO_3 with H_2O is highly exothermic producing mist of H_2SO_4 which is difficult to condense.
   (c) It gives better yield of H_2SO_4
   (d) reaction of SO_3 with H_2O can cause explosion.

7. **Oxides formed when oxygen reacts with metals:**
   (a) Acidic (b) Basic
   (c) Both basic and amphoteric (d) Neutral

8. **Major components of acid rain are:**
   (a) H_2SO_4 and HNO_3 (b) H_2SO_3 and HNO_2
   (c) H_2SO_4 and HCl (d) Acetic acid and HNO_3

Answers

1. (a) 2. (a) 3. (d) 4. (a) 5. (c) 6. (b) 7. (b) 8. (a)

B. Short Answer Questions

19.1 How is nitrogen obtained from air?

Ans. Nitrogen is obtained by the fractional distillation of liquid air. Since the boiling point of nitrogen is less than oxygen, nitrogen evaporates first at −196°C leaving behind the oxygen. The separated nitrogen is reliquified and stored in specially designed cylinders.

19.2 How is hydrogen produced from methane?

Ans. Hydrogen is produced by heating methane in the limited amount of oxygen that is not enough to completely oxidize methane to carbon dioxide and water. With less oxygen available, the reaction products contain primarily hydrogen and carbon monoxide and a relatively small amount of carbon dioxide. The carbon monoxide obtained is then reacted with water to form carbon dioxide and more hydrogen gas.

$$CH_{4(g)} + H_2O_{(g)} \longrightarrow CO_{(g)} + 3H_{2(g)}$$

$$CO_{(g)} + H_2O_{(g)} \longrightarrow CO_{2(g)} + H_{2(g)}$$

19.3 Which conditions are used to oxidize SO_2 to SO_3?

Ans. In the contact process, the oxidation occurs at 450°C, a pressure of 2-3 atmosphere, in the presence of a catalyst vanadium (V) oxide (V_2O_5).

19.4 Why CO_2 is called an acidic oxide while CO is called a neutral oxide?

Ans. Carbon dioxide (CO_2) is an acidic oxide because it dissolves in water to form carbonic acid (H_2CO_3) and reacts with bases to form salts.

On the other hand carbon monoxide (CO) is a neutral oxide because it does not react with acids or bases and has no effect on litmus paper.

19.5 How do magnesium and calcium differ with each other towards their reactions with water?

Ans. Calcium reacts vigorously with cold water to produce calcium hydroxide and hydrogen.

$$Ca_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(s)} + H_{2(g)}$$

Magnesium reacts with cold water slowly giving magnesium hydroxide and hydrogen gas.

$$Mg_{(s)} + H_2O_{(l)} \longrightarrow Mg(OH)_{2(s)} + H_{2(g)}$$

19.6 How are the reactivities of metals determined?

Ans. The relative reactivates of metals are determined by comparing how vigorously they react with water, dilute acids and oxygen. Metals are then arranged in decreasing order of their reactivity.

19.7 Which secondary pollutants are produced by oxides of nitrogen?

Ans. Oxides of nitrogen (NO_x) react with other compounds and sunlight to produce ozone (O_3), peroxyacetyl nitrate (PAN), sulphuric acid and acid rain.

C. Constructed Response Questions

19.1 Why ammonia is regarded as an important chemical?

Ans. Ammonia (NH_3) is considered one of the most important chemical for several reasons.

- **Agriculture:** About 80% of the ammonia produced world-wide is used to manufacture nitrogenous fertilizers, such as urea and various ammonium salts. These are essential for increasing crop yields to feed the global population.
- **Industrial Applications:** Ammonia is a key raw material in the production of plastics and pharmaceuticals.
- **Refrigeration:** Due to its thermodynamic properties, ammonia is widely used as an industrial refrigerant.
- **Nitrogen Fixation:** The Haber process, which produces ammonia, contributes to 13% of the total nitrogen fixation in the environment.

19.2 How SO_2 present in the atmosphere is converted to SO_3?

Ans. In the atmosphere, the conversion of sulphur dioxide (SO_2) to sulphur trioxide (SO_3) does not happen efficiently on its own; it requires a catalyst.

- **Catalyst Role:** Oxides of nitrogen (NO_x) present in the air act as catalysts for this reaction.
- **Reaction:** $2SO_{2(g)} + O_{2(g)} \xrightarrow{NO_x} 2SO_{3(g)}$
- **Impact:** Once SO_3 is formed, it reacts with water vapour in the air to produce sulphuric acid (H_2SO_4), which is a major component of acid rain.

19.3 The burning of fossil fuels in a car engine is responsible for the production of oxides of nitrogen. Explain.

Ans. The burning of fossil fuels in a car engine is responsible for the production of oxides of nitrogen is discussed below.

- **High Temperature Environment:** Inside a car engine, the combustion of fossil fuels creates extremely high temperatures.
- **Thermal Reaction:** This intense heat provides the necessary activation energy

for atmospheric nitrogen (N_2) and oxygen (O_2) to react directly.

- **Sequence:** They first form nitric oxide (NO), which then rapidly reacts with more oxygen in the air to form nitrogen dioxide (NO_2).
- **Equation:** $N_{2(g)} + O_{2(g)} \xrightarrow{\text{High Temp}} 2NO_{(g)}$

19.4 The metals present at the top of the reactivity series are regarded as more reactive than those present at the bottom. Comment on this statement.

Ans. Reactivity of Metals: The reactivity of a metal is defined by its ability to lose electrons and form positive ions.

Reactivity Series of Metals: Based on their reactions with water and acids, the metals can be arranged in decreasing order of their reactivities. Such an arrangement is called the reactivity series of metals.

Top of the Series: Metals like potassium (K) and sodium (Na) are at the top because they are highly electropositive.

They lose their valence electrons very easily and react vigorously with water, oxygen and acids.

Reducing Agents: Because they are easily oxidized (lose electrons), metals at the top are considered powerful reducing agents.

Bottom of the Series: Metals like silver (Ag) and gold (Au) are at the bottom because they are very stable and do not lose electrons easily, making them "least reactive".

19.5 How fossil fuels produce SO_2?

Ans. Sulphur dioxide is a by-product of energy production and industrial processes.

- **Impurities:** Most fossil fuels, particularly coal and heavy oils, naturally contain small amounts of sulphur compounds as impurities.
- **Combustion:** When these fuels are burned (combusted) in power plants, factories, or home heating systems, the sulphur reacts with oxygen.
- **Reaction:** $S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$
- **Ore Roasting:** Additionally, roasting sulphide ores like iron pyrite (FeS_2) in excess air also releases large quantities of SO_2.

D. Descriptive Questions

19.1 Explain the production of ammonia on industrial scale.

Ans. For answer see Q1

19.2 Describe the contact process for the production of sulphuric acid.

Ans. For answer see Q3

19.3 Explain the formation and properties of acidic and basic oxides.

Ans. For answer see Q4

19.4 Differentiate between first and second group metals based on their reactivities with oxygen and water.

Ans. For answer see Q6

19.5 Describe the role of oxides of nitrogen in the formation of PAN and the acid rain.

Ans. For answer see Q8

CHAPTER 20 Water

Student Learning Outcomes

After studying this chapter, students will be able to:

- Investigate chemical tests for the presence of water using anhydrous copper (II) sulphate.
- Explain how to test the purity of water using melting point and boiling point.
- Distinguish between Distilled water and tap water with their applications in practical chemistry.
- State that water from natural sources may contain useful and harmful substances. (Some examples include:
  - **a.** Dissolved oxygen **b.** metal compounds **c.** plastics
  - **d.** sewage **e.** harmful microbes **f.** nitrates from fertilizers
  - **g.** phosphates from fertilizers and detergents
- Recognize that some naturally occurring substances in water are potentially harmful (some examples include:
  - **a.** some metal compounds that are toxic
  - **b.** some plastics that harm aquatic life
  - **c.** sewage that contains harmful microbes which cause disease
  - **d.** nitrates and phosphates that lead to deoxygenation of water and damage to aquatic life (details of the eutrophication process are not required)
- Explain the treatment of the domestic water supply: (some examples of this includes:
  - **a.** sedimentation and filtration to remove solids.
  - **b.** Use of carbon to remove tastes and odours
  - **c.** Chlorination to kill microbes
- Describe various water-borne diseases and the steps that can be taken to avoid them
- Identify the negative effects of water pollutants on life and the ways to avoid them.
- Explain water scarcity as an important issue faced by Pakistan and the ways in which it can be resolved.
- State that urea, ammonium salts and nitrates are used as fertilizers.
- Explain the use of NPK fertilizers to provide the elements nitrogen, phosphorus and potassium for improved plant growth.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

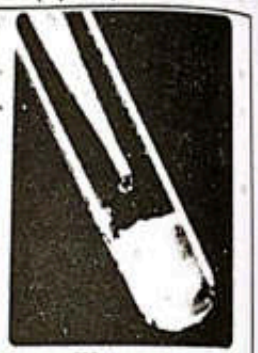
20.1 Water

20.2 Purity of Water

Q.1: Describe a chemical test for water using anhydrous copper (II) sulphate.

Ans. Test for water:

Testing water is important for food and pharmaceutical industries where the presence of water can affect the product quality and safety.



Water test

Hydrated copper (II) sulphate:

Hydrated copper (II) sulphate ($CuSO_4.5H_2O$) is a chemical compound. It is used as a sensitive indicator for the presence of water. It is blue in colour but when it is heated, it loses water molecules to become anhydrous copper (II) sulphate, which is white in colour.

Observation:

A drop of water on anhydrous sample of copper (II) sulphate changes its colour from white to blue.

$$\underset{\text{White}}{CuSO_4} + 5H_2O \rightleftharpoons \underset{\text{Blue}}{CuSO_4.5H_2O}$$

Sensitivity:

It is a very sensitive test and can detect even a small amount of water.

Q.2: What two physical constants can be used to determine if a sample of water is pure?

Ans. Physical Constant:

A physical constant is a quantity with a fixed numerical value that is universal in nature and does not change.

Boiling point and melting point are the physical constant. They can be used to determine if a sample of water is pure.

Pure water boils at 100°C and freezes at 0°C under standard conditions of temperature and pressure. The impurities present in water will change both these physical constants.

Checking purity of water by determining its boiling point:

The purity of a sample of water can be checked by determining its boiling point at STP. If it boils at 100°C it is pure sample of water. The presence of impurities in water will slightly increase its boiling point.

Checking purity of water by determining its melting point:

Another test check the purity of water is to determine melting point of the sample. For this purpose, cool the sample of water until it freezes. Observe and record the temperature at which the ice begins to melt. If its melting point is 0°C it is pure water. A melting point below 0°C suggests the presence of impurities in the sample.

Conclusion:

The impurities present in water raise the boiling point but lowers the melting point. Both these constants are specific to standard conditions. At high altitudes or lower pressure, these values will change.

20.3 Difference between distilled water and tap water

20.4 Substances present in water obtained from natural sources

Q.3: Explain difference between distilled water and tap water.

Ans. Tap Water:

Source: Water which is supplied to our homes, shops and offices comes through taps and is readily available for any usage. This water may either come from rivers, lakes and ponds or from underground sources.

Composition: Tap water contains minerals like salts of calcium and magnesium depending upon the source from where it is obtained. It also contains chlorine and fluoride salt which are mixed with it during treatment.

Conductivity: It is a conductor of electricity due to the presence of free ions from dissolved minerals.

pH: Its pH has the range of 6.5 to 8.5 depending upon its source.

Distilled Water:

Source: Water obtained after the process of distillation is called distilled water.

Composition: Distilled water contains only water molecules without any bacteria, ions, gases or other contaminants.

Conductivity: It is a bad conductor of electricity due to absence of ions.

pH: Its pH is 7

Q.4:(a) Discuss dissolved oxygen as a useful substance present in water obtained from natural sources.

Ans. Dissolved Oxygen-Useful Substance:

Oxygen enters the natural water from the atmosphere through the process of diffusion. It is also produced by aquatic plants and algae in the process called photosynthesis.

This absorbed oxygen is then used by the aquatic organisms including fish to breathe and survive. The health and diversity of an ecosystem directly depends upon the amount of dissolved oxygen in a water body.

(b) How do harmful microbes enter in sources of fresh water and affect its quality?

Ans. Harmful Microbes:

Both surface and ground water which are vital sources of fresh water can be contaminated by various human activities.

- Harmful microorganisms like bacteria, viruses and parasites enter into natural water through human and animal wastes, land fills, agricultural runoff and waste water from industries.
- Sewage from waste water treatment plants or from faulty septic tanks can release pathogens directly into nearby water body.

Effects: Microbes can cause such infectious diseases as dysentery, typhoid, hepatitis and cholera.

Q.5(a) How do heavy metals and their compounds enter in natural water and affect its quality?

Ans: Heavy metals and their compounds:

Heavy metals like lead, mercury, cadmium, and chromium and their compounds can enter in natural water through many routes.

- Waste water from factories may contain heavy metals and their compounds, which are eventually released into rivers and other water bodies.
- Mining operations and use of fertilizers and pesticides can contaminate both ground and surface water with heavy metals and their compounds.

Effects: Heavy metals and their compounds not only damage vital organs like liver and kidney, they can also lead to neurological problems. Arsenic and cadmium are known to increase the risk of certain cancers.

(b) Discuss plastics as harmful substances present in water and its effects.

Ans. Plastics:

Very small particles of plastics called micro plastics are present in both tap and bottled water. These tiny particles can enter water through wastewater, rainwater when it carries plastic debris to water sources, and by degradation of plastic waste.

Effects: Plastic tiny particles have been found in some human organs like lungs and blood. These particles can disturb the immune and reproductive systems.

Q.6: How do nitrates and phosphates enter in natural water and affect its quality?

Ans. Nitrates and phosphates :

- Nitrates and phosphates enter natural water through weathering of rocks.
- They can also enter in water through human sources such as agriculture fertilizers, detergents and industrial wastewater.

Effects:

- Nitrates and phosphates are eventual nutrients for plant and animal life. However, if amounts of these compounds exceed a limit they can affect the quality of water and cause eutrophication.

- The excessive amounts of these nutrients cause algae and other aquatic plants to grow excessively. This overgrowth of algae, in turn, can decrease the dissolved oxygen level in water which is not only harmful for aquatic life but can also disrupt the entire ecosystem.

20.5 Treatment of domestic water supply
20.6 Effects of pollutants present in water

Q.7. How domestic water supply can be made fit for drinking?

Ans. Treatment of domestic water supply:

Three types of impurities are mostly present in water obtained from natural sources.

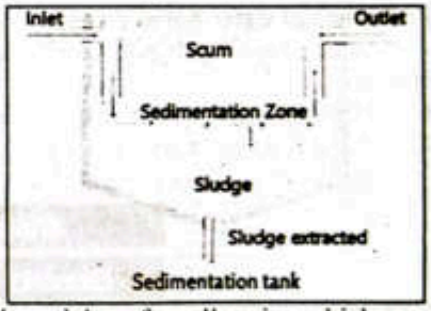
(i) Dissolved impurities
(ii) Suspended impurities
(iii) Microorganisms

In order to remove these impurities different methods are applied which include sedimentation, filtration, distillation and treatment with liquid chlorine etc.

(i) Sedimentation:

Insoluble impurities present in natural water include soil, pieces of plants and other organic matter and sand. These impurities are bigger in size and are often removed by the process called sedimentation.

Method: In this process water obtained from natural sources is pumped into sedimentation tanks where water is allowed to stand for a few hours. The suspended particles present in water settle down at the bottom of the tank due to gravity and form a layer of sendiment. The cleaner water at the top can then be extracted for the next stage.



(ii) Filtration:

This process is used to remove suspended particles of smaller size which are generally not removed in the sedimentation process. For this purpose water is allowed to trickle through layer of sand and gravel filters which trap these solid particles.

(iii) Chlorination:

Water must be sterilized before humans can use it.

Method: For this purpose all harmful bacteria and other microbes, must be killed. Mostly a small amount of liquid chlorine is added which has the power to kill all these germs.

(iv) Removal of odours:

Water is passed through powdered activated carbon in the form of charcoal to remove tastes and odours. Activated carbon removes a wide range of organic compounds responsible for taste and odour through absorption. Odour can also be removed by

exposing water to air in a process called aeration.

Q.8: How can we control the harmful effects of pollutants present in water?

Ans. Controlling the harmful effects of pollutants present in water:

Water Pollutants can disrupt aquatic ecosystems through eutrophication and destruction of habitats. Polluted water can also lower crop yields and contaminate food sources.

Harmful effects due to water pollution can be controlled by taking a number of steps:

(i) Sewage and industrial wastewater should be treated before it is discharged into water bodies.
(ii) Plastics must be reused or recycled to minimize their production.
(iii) Chemical cleaners, fats or oils and grease should never be thrown down the drain.
(iv) Minimize the use of pesticides and fertilizers in agriculture.
(v) General public should be made aware of the harmful effects of water pollution through public campaigns.
(vi) Implement and enforce laws for the strict control of all types of water pollution.

Q.9: What measures should be taken to avoid water-borne diseases?

Ans. Water-borne Diseases:

The World Health Organization (WHO) has estimated that 80% of the sickness and diseases in the world are caused by polluted water and lack of sanitation. Water-borne diseases include cholera, typhoid, malaria, nausia and leprosy.

Prevention of water-borne disease:

Water-borne diseases can be avoided if we strictly follow the following instructions.

1. Drink clean water after removing impurities and boiling to kill the germs.
2. Practice hygiene by keeping your body especially hands clean. Ensure proper sanitation facilities are available.

20.7 Water scarcity in Pakistan

20.8 Elements essential for plant growth

Q.10. Write a note on water scarcity in Pakistan

Ans. Geographical location of Pakistan:

Our world is divided into different regions depending upon the annual rainfall which they receive every year. Pakistan is included in a semi-arid region and hence receives a low rainfall annually.

Regional Rainfall Distribution:

- Northern Pakistan including Punjab generally receives rainfall within the range 250-600 mm per year mostly during monsoon season.
- In southern Pakistan precipitation is scarce, below 200mm per year.

Key Factors Driving Water Scarcity:

Pakistan, at present, is facing a severe water scarcity crisis due to a number of

different factors such as:

- Less rainfall
- Flood irrigation
- Depleting aquifers
- Growth in population
- Climate change
- Poor water management

Future Challenges:

If the current situation continues then Pakistan could face very serious challenges in coming years.

Suggestions:

The problem can be addressed by taking a number of steps which are as follows:

(i) Collecting rain water especially during monsoon season by constructing water reservoirs and other water storage facilities.
(ii) Using better crop irrigation techniques.
(iii) Taking appropriate measures to face effects of climate change.
(iv) Effective management of water resources.

Q.11: Discuss the elements essential for plant growth.

Ans. Elements essential for plant growth:

Plants need nutrients from the soil for a healthy growth.

Classification of essential elements:

The elements essential for the plant growth can be classified as:

- Micro-nutrients
- Macro-nutrients

Micro-nutrients (Trace elements):

The nutrients which are required in a very small amount for the growth of plants are called micro-nutrients. These include boron, copper, iron, manganese, zinc, molybdenum and chlorine.

Requirement: Only minute amounts of these elements are needed for healthy plant growth and it may be dangerous to add too much quantity because they are poisonous in larger quantities. These are generally required in quantities ranging from 6 grams to 200 grams per acre.

Macro-nutrients: The nutrients which are required in a large amount for the growth of plants, are called macro-nutrients. These include nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, carbon, hydrogen and oxygen.

Requirement: These are generally required in quantities ranging from 5kg to 200kg per acre.

20.9 Fertilizers

20.10 Classification of fertilizers

Q.12: What are fertilizers? Mention the essential qualities of a good fertilizer.

Ans. Fertilizers:

Fertilizers are the substances added to the soil to make up the deficiency of essential elements like nitrogen, phosphorus and potassium (NPK) required for the proper growth of plants.

Importance of fertilizers:

- Fertilizers enhance the natural fertility of the soil
- Fertilizers also provide the chemical elements taken up from soil by the previous crops.

Essential qualities of a good fertilizer:

The essential requisites of a good fertilizer are:

(i) The nutrient elements present in it must be readily available to the plants.
(ii) It must be fairly soluble in water so that it thoroughly mixes with the soil.
(iii) It should not be injurious to plants.
(iv) It should be inexpensive.
(v) It must be stable so that it is available for a longer time to the growing plants.
(vi) It should not alter the pH of the soil.
(vii) By rain or water, it should be converted into a form, which the plant can absorb easily.

Q.13: Discuss the classification of fertilizers.

Ans. Classification of fertilizers: Fertilizers are classified into nitrogen, phosphorus and potassium which they provide to the soil. This classification gives the following types of fertilizers.

(i) Nitrogenous fertilizers (ii) Phosphatic fertilizers
(iii) Potassium fertilizers

Q.14: What are the main functions of nitrogenous, phosphorus and potassium fertilizers?

Ans. Nitrogenous Fertilizers: These fertilizers supply nitrogen to the plants or soil.

Importance of Nitrogen:

- Nitrogen is required during the early stage of plant growth for the development of stem and leaves.
- It is the main constituent of proteins, imparts green colour to the leaves.
- Nitrogen enhances the yield and quality of the plants.

Examples of Nitrogenous Fertilizers:

Some examples of nitrogenous fertilizer are:

- Ammonium sulphate
- Calcium cyanamide
- Ammonium nitrate
- Ammonium phosphate
- Ammonium chloride
- Ammonia
- Urea

Urea: Urea is a high quality nitrogenous fertilizer. It contains about 46% nitrogen and is the most concentrated solid nitrogen fertilizer. It is the most widely used nitrogen fertilizer in Pakistan.

Ammonium Nitrate: Ammonium nitrate is a useful fertilizer for many crops except paddy rice because the microbial bacteria in flooded fields decompose it to nitrogen gas. It is also used in combination with limestone. It is hygroscope in nature.

Phosphatic Fertilizers: These fertilizers provide phosphorous to the plant or soil.

Importance of Phosphorous:

- Phosphorus is required to stimulate early growth and to accelerate the seed and fruit formation during the later stages of growth.
- It also increases resistance to diseases.

Types of Phosphatic Fertilizers: The various phosphatic fertilizers have different compositions, due to which they have different solubilities. The two most important water soluble fertilizers are:

- Super phosphate (calcium super phosphate) $Ca(H_2PO_4)_2$.
- Triple phosphate (diammonium-phosphate $(NH_4)_2\,HPO_4$.

Potassium Fertilizers: These fertilizers provide potassium to the plant or soil.

Importance of Potassium:

- Potassium is required for the formation of starch, sugar and fibrous materials of the plant.
- They increase resistance to diseases.
- They make the plants strong by helping in healthy root development.
- They also help in ripening of seeds, fruits and cereals.
- They are especially useful for tobacco, coffee, potato and corn.

Examples of Potassium Fertilizers: Some common examples of potassium fertilizers are:

- Potassium chloride
- Potassium sulphate
- Potassium nitrate

20.1 Quick Check!

1. How purity water can be checked by determining its freezing point?

Ans. To check the purity of water by determining its freezing point cool the sample of water until it freezes. Observe and record the temperature at which the ice-begins to melt. If its melting point is 0 °C, it is pure water. A melting point below 0°C suggests the presence of impurities in the sample.

20.2 Quick Check!

1. Why tap water is a conductor of electricity whereas distilled water is not?

Ans. Tap water is a conductor of electricity due to presence of free ions from dissolved minerals. On the other hand distilled water is a bad conductor of electricity due to absence of ions.

20.3 Quick Check!

1. Which pollutants are harmful for aquatic life?

Ans. Following pollutants are harmful for aquatic life:

- Microorganisms like bacteria viruses, and parasites.
- Heavy metals like lead, mercury, cadmium and chromium and their compounds.

2. How to identify if water is polluted?

Ans. We can identify if water is polluted by:

- **Appearance:** if the water looks cloudy or has an unusual colour (like green due to algae or brown due to soil), the water is polluted.
- **Smell:** clean water is odourless. It water smells like rotten eggs, chemicals or sewage, it is likely polluted.
- **Biological signs:** The presence of a lot of dead fish, floating debris and foam, a thick layer of green scum (algae) on the surface makes it polluted.

20.4 Quick Check!

1. How can we conserve water at home?

Ans. We can conserve water at home by following the steps given below:

- Turn of the tap while brushing teeth or soaping our hands.
- Take shorter showers.
- Fix leaky pipes and dripping taps.
- Run the washing machine or dishwasher when they are completely full.
- Collect rainwater in buckets or tanks to use for gardening or washing cars.
- Collect the water that drips from the air conditioner and use it for mapping floors, watering plants etc.

20.5 Quick Check!

1. Which is the most concentrated solid nitrogen fertilzer?

Ans. Urea is the most concentrated solid nitrogen fertilizer.

INTERESTING INFORMATION

Biofertilizers are environment friendly. They provide the soil essential nutrients as well as microbes required for the growth of plants. Biofertilizers improve soil health and structure. They also increase biodiversity and reduce the need for harmful chemicals. They also prevent soil degradation.

THINGS TO KNOW

Water from different sources requires different treatment methods.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

20.1 Water

1. What is the colour of hydrated copper (II) sulphate?
(a) White (b) Blue (c) Yellow (d) Green

2. What is the colour of anhydrous copper (II) sulphate?
(a) Brown (b) White (c) Green (d) Blue

3. When blue hydrated copper (II) sulphate is heated, it becomes:
(a) Copper oxide (b) Copper metal
(c) Sulphate oxide (d) Anhydrous copper (II) sulphate

4. Anhydrous copper (II) sulphate turns from white to blue when it comes into contact with:
(a) Water (b) Oil (c) Acid (d) Base

20.2 Purity of Water

5. Under standard conditions, pure water boils at:
(a) 0°C (b) 50°C (c) 80°C (d) 100°C

6. Under standard conditions, pure water freezes at:
(a) 100°C (b) 80°C (c) 50°C (d) 0°C

7. The presence of impurities in a water sample will cure its boiling point to:
(a) Decrease slightly (b) Increase slightly
(c) Remain the same (d) Drop to 0°C

8. If a water sample has a melting point below 0°C, it suggests:
(a) The presence of impurities (b) The water is pure
(c) The water is boiling (d) None of these

20.3 Difference between distilled water and tap water

20.4 Substances present in water obtained from natural sources

9. Why is tap water a good conductor of electricity?
(a) Because it contains bacteria (b) Because it has a pH 6.5 to 8.5
(c) Because it is obtained from rivers
(d) Due to the presence of free ions from dissolved minerals

10. Distilled water is the water that is obtained after:
(a) Filtration (b) Chlorination (c) Distillation (d) Sedimentation

11. What is the typical pH range of tap water?
(a) 6.5 to 8.5 (b) 1.0 to 4.0 (c) 9.0 to 12.0 (d) Exactly 7.0

12. The pH of pure distilled water is:
(a) 9.5 (b) 5.5 (c) 6.5 (d) 7.0

13. How does oxygen primarily enter the natural water from the atmosphere?
(a) Through evaporation (b) Through diffusion
(c) Through precipitation (d) Through condensation

14. By which of the following process aquatic plants and algae produce oxygen in water?
(a) Respiration (b) Fermentation (c) Decomposition (d) Photosynthesis

15. What does the health and diversity of an aquatic ecosystem directly depend upon?
(a) The amount of dissolved oxygen (b) The salt concentration
(c) The depth of water (d) All of these

16. Which sources of water can be contaminated by human activities?
(a) Surface water only (b) Ground water only
(c) Both surface and ground water (d) Rain water only

17. Which of the following are examples of harmful microbes?
(a) Bacteria (b) Viruses (c) Parasites (d) All of these

18. **What are common sources for pathogens entering water bodies?**
(a) Human and animal wastes (b) Land fills and agricultural runoff
(c) Waste water from industries (d) All of these

19. **The bacterial contents can cure such infectious diseases as dysentery and:**
(a) Typhoid (b) Hepatitis (c) Cholera (d) All of these

20. **Heavy metals and their compounds contaminate both ground and surface water through:**
(a) Mining operations (b) Industrial waste
(c) Fertilizers and pesticides (d) All of these

21. **Which vital organs are primarily damaged by heavy metals?**
(a) Head and lungs (b) Skin and bones (c) Liver and kidney (d) Brain and heart

22. **What type of health problem can heavy metals cure besides organ damage?**
(a) Respiratory problems (b) Neurological problems
(c) Digestive problems (d) Skeletal problems

23. **Very small particles of plastics are called:**
(a) Micro plastics (b) Microbes (c) Heavy metals (d) Nitrates

24. **Micro plastics are present in:**
(a) Tap water (b) Bottled water
(c) Both tap and bottle water (d) None of these

25. **Which human organs have been found to contain tiny plastic particles?**
(a) Brain and lungs (b) Lungs and blood
(c) Bones and muscles (d) Skin and hair

26. **Micro plastics can enter water through:**
(a) Waste water (b) Degradation of plastic waste
(c) Rain water carries plastic debris (d) All of these

27. **Nitrates and phosphates enter natural waters through:**
(a) Weathering of rocks (b) Evaporation
(c) Volcanic eruptions (d) Photosynthesis

20.5 Treatment of domestic water supply

20.6 Effects of pollutants present in water

28. **How many types of impurities are mostly present in water obtained from natural sources?**
(a) Two (b) Three (c) Four (d) Five

29. **What method is used to remove impurities from domestic water?**
(a) Sedimentation and filtration (b) Distillation and chlorination
(c) Both (a) and (b) (d) None of these

30. **Insoluble impurities present in natural water are removed through the process of:**
(a) Chlorination (b) Cooling (c) Filtration (d) All of these

31. **Which process involves allowing water to stand for a few hours so suspended particles settle due to gravity?**
(a) Filtration (b) Aeration (c) Sedimentation (d) Chlorination

32. **It is the water-borne disease that often causes blindness, particularly among children in developing countries.**
(a) Malaria (b) Trachoma (c) Typhoid (d) Leprosy

33. **It is a liver disease.**
(a) Nausea (b) Cholera (c) Hepatitis (d) Typhoid

20.7 Water scarcity in Pakistan

20.8 Elements essential for plant growth

34. **Depending upon the annual rainfall, Pakistan is included in region called:**
(a) Arid (b) Wet equatorial
(c) Semi-arid (d) Tropical monsoon

35. **In southern Pakistan, precipitation is below:**
(a) 100 mm per year (b) 200 mm per year
(c) 300 mm per year (d) 400 mm per year

36. **Northern Pakistan including Punjab generally receives rainfall within the range:**
(a) 150-300 mm per year (b) 150-400 mm per year
(c) 250-500 per year (d) 250-600 mm per year

37. **Which of the following is not a macro-nutrients?**
(a) Copper (b) Nitrogen (c) Phosphorous (d) Potassium

38. **Which of the following is not a micro-nutrients?**
(a) Iron (b) Manganese (c) Molybdenum (d) Oxygen

39. **Micro-nutrients are generally required in quantities ranging from 6 grams to:**
(a) 100 grams per ace (b) 200 grams per acre
(c) 300 grams per acre (d) 400 grams per acre

40. **Macro-nutrients are generally required in quantities ranging from 5 kg to:**
(a) 100 kg per acre (b) 200 kg per acre (c) 300 kg per acre (d) 400 kg per acre

41. **Which of the fertilizers supply nitrogen to the plants or soil?**
(a) Phosphorous (b) Magnesium (c) Nitrogen (d) Calcium

42. **It is an example of nitrogen fertilizer.**
(a) Ammonium chloride and urea (b) Calcium super phosphate
(c) Potassium chloride (d) Potassium nitrate

43. Which of the following is a high quality nitrogenous fertilizer?
(a) Ammonium nitrate (b) Calcium cyanamide
(c) Urea (d) Ammonia

44. Ammonium nitrate is a useful fertilizer for many crops except:
(a) Maize (b) Wheat (c) Potato (d) Paddy rice

45. Ammonium nitrate contains about:
(a) 36% nitrogen (b) 46% nitrogen (c) 56% nitrogen (d) 66% nitrogen

46. Which of the most widely used nitrogen fertilizer in Pakistan?
(a) Calcium cyanamide (b) Ammonium phosphate
(c) Urea (d) Ammonium chloride

47. It is required for the formation of starch, sugar and the fibrous material of the plants.
(a) Phosphorus (b) Potassium (c) Nitrogen (d) Both (a) and (b)

48. Potassium fertilizers help in ripening of:
(a) Seeds (b) Fruits (c) Cereals (d) All of these

49. Which of the following fertilizers are especially useful for tobacco, coffee, potato and corn?
(a) Potassium (b) Nitrogenous (c) Phosphatic (d) Ammonium

50. Potassium chloride, potassium sulphate and potassium nitrate are some common examples of:
(a) Nitrogenous fertilizers (b) Potassium fertilizers
(c) Phosphatic fertilizers (d) None of these

51. There fertilizers supply nitrogen to the plants or soil.
(a) Phosphatic fertilizers (b) Potassium fertilizers
(c) Nitrogenous fertilizers (d) Bio fertilizers

52. Which of the following provide phosphorus to the plants or soil?
(a) Nitrogenous fertilizers (b) Phosphatic fertilizers
(c) Bio fertilizers (d) Nitrogenous fertilizers

53. The function of bio fertilizers is:
(a) They increase biodiversity
(b) They reduce the need for harmful chemicals
(c) They prevent soil degradation (d) All of these

Answers

1.	(b)	2.	(b)	3.	(d)	4.	(a)	5.	(d)	6.	(d)	7.	(b)
8.	(a)	9.	(d)	10.	(c)	11.	(a)	12.	(d)	13.	(b)	14.	(d)
15.	(a)	16.	(c)	17.	(d)	18.	(d)	19.	(d)	20.	(d)	21.	(c)
22.	(b)	23.	(a)	24.	(c)	25.	(b)	26.	(d)	27.	(a)	28.	(b)

29. (c)	30. (c)	31. (c)	32. (b)	33. (c)	34. (c)	35. (b)
36. (d)	37. (a)	38. (d)	39. (b)	40. (b)	41. (c)	42. (a)
43. (c)	44. (d)	45. (b)	46. (c)	47. (b)	48. (d)	49. (a)
50. (b)	51. (c)	52. (b)	53. (d)			

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

20.1 Water

20.2 Purity of Water

1. Describe the chemical test used to identify the presence of water.
Ans. Add a drop of water on anhydrous sample of copper (II) sulphate. If water is present, the white powder will turn blue.

2. What is the colour of hydrated copper (II) sulphate ($CuSO_4 . 5H_2O$)?
Ans. The colour of hydrated copper (II) sulphate ($CuSO_4 . 5H_2O$) is blue.

3. What is colour of copper (II) Sulphate?
Ans. Copper (II) sulphate is white in colour.

4. Name the compound used to chemically test for the presence of water.
Ans. Anhydrous copper (II) sulphate is the compound used to chemically test for the presence of water.

5. Write the chemical equation for the water test using copper (II) sulphate.
Ans. $\underset{\text{White}}{CuSO_4} + 5H_2O \rightleftharpoons \underset{\text{Blue}}{CuSO_4 . 5H_2O}$

6. What are the physical constants of pure water at standard pressure?
Ans. Boiling point and melting point are the physical constants of pure water at standard pressure.

7. How do impurities affect the boiling point of water?
Ans. The presence of impurities will slightly increase its boiling point.

8. How do impurities affect the melting point of water?
Ans. The presence of impurities will decrease the melting point of water.

9. How can you check if a water sample is chemically pure?
Ans. By measuring its boiling point or melting point. If it boils exactly at 1000°C and melts exactly of 0°C at STP, it is pure.

10. Are the boiling and melting points of water constant under all conditions?
Ans. No, these constants are specific to standard conditions. At high altitudes or lower pressure, these values will change.

20.3 Difference between distilled water and tap water

20.4 Substances present in water obtained from natural sources

11. What are the common sources of tap water?

Ans. Tap water comes from rivers, lakes and ponds or from underground sources.

12. Which minerals are typically found in tap water?

Ans. Tap water contains minerals like salts of calcium and magnesium.

13. What is the pH range of tap water?

Ans. The pH of tap water ranges from 6.5 to 8.5 depending on its source.

14. Define distilled water.

Ans. Water obtained after the process of distillation is called distilled water.

15. Describe two-step process of distillation.

Ans. Two-step process of distillation are heating and condensation.

- In the first step, the water is heated to get steam.
- In the second step, the steam is condensed back into liquid water.

16. What substances are removed during the distillation process?

Ans. Distillation effectively removes all the dissolved minerals, microorganisms and contaminants from water leaving behind only pure water.

17. Why is distilled water used in laboratories medical procedures and pharmaceutical industry?

Ans. It is because the purity of distilled water ensures accurate scientific measurements, sterilization of medical equipment's and to prevent corrosion.

18. What is the pH of distilled water?

Ans. The pH of distilled water is 7.

19. Is distilled water ideal for drinking?

Ans. Although it is safe to drink but it may not have the necessary minerals needed for the body.

20. What are natural sources of water?

Ans. Natural sources of water are rivers, lakes and aquifers.

21. How does oxygen enter natural water?

Ans. Oxygen enters the natural water from the atmosphere through the process of diffusion.

22. Why is dissolved oxygen important for aquatic ecosystems?

Ans. Aquatic organisms including fish need dissolved oxygen to breathe and survive. The health and diversity of an ecosystem directly depends upon the amount of dissolved oxygen in a water body.

23. Which harmful substances are present in water obtained from natural sources?

Ans. Some harmful substances present in water obtained from natural sources are:

- Harmful microbes
- Nitrates and phosphates
- Heavy metals and their compounds
- Plastics

24. Name some infectious diseases caused by bacterial content in water.

Ans. The bacterial contents can cause such infectious diseases as dysentery, typhoid, hepatitis and cholera.

25. Give some examples of heavy metals.

Ans. Lead, mercury, cadmium and chromium are some examples of heavy metals.

26. Which vital organs are damaged by heavy metals and their compounds present in water?

Ans. Heavy metals and their compounds present in water not only damage vital organs like liver and kidney. They can also lead to neurological problems.

27. Which heavy metals are known to increase the risk of certain cancers?

Ans. Arsenic and cadmium are known to increase the risk of certain cancers.

28. What are micro plastics?

Ans. Very small particles of plastics are called micro plastics.

29. How do micro plastics enter water?

Ans. Micro plastics can enter water through waste water, rainwater when it carries plastic debris to water sources, and by degradation of plastic waste.

30. What are harmful effects of micro plastics on humans?

Ans. Micro plastics have been found in some human organs like lungs and blood. These particles can disturb the immune and reproductive systems.

31. How do nitrates and phosphates enter natural waters?

Ans.

- Nitrates and phosphates enter natural waters through weathering of rocks.
- They can also enter in water through human sources such as agriculture fertilizers, detergents and industrial wastewaters.

32. What is eutrophication?

Ans. Eutrophication: Eutrophication is the name of the process which starts in a water body containing excess of phosphorous and nitrogen nutrients.

20.5 Treatment of domestic water supply

20.6 Effects of pollutants present in water

33. Which types of impurities are mostly present in water obtained from natural sources?

Ans. Three types of impurities are mostly present in water obtained from natural sources. These impurities include:

- Dissolved impurities
- Suspended impurities
- Microorganisms

34. Which methods are applied in order to remove impurities present in water sources?

Ans. In order to remove impurities present in water sources include following methods:

- Sedimentation
- Filtration

- Chlorination
- Removal of odours

35. Which insoluble impurities are present in natural water?

Ans. Insoluble impurities present in natural water include soil, pieces of plants and other organic and sand. These impurities are bigger in size.

36. What is sedimentation?

Ans. Sedimentation: It is the process where water is allowed to stand in sedimentation tanks for a few hours so that large, suspended particles settle at the bottom of the tanks due to gravity.

37. What is filtration?

Ans. Filtration is a process used to remove suspended particles of small size which are generally not removed in the sedimentation process.

38. How does the filtration process work?

Ans. For filtration, water is allowed to trickle through layers of sand and gravel filters which trap the solid particles that were not removed during sedimentation.

39. What is the purpose of chlorination?

Ans. The purpose of chlorination is to sterilize the water by killing harmful bacteria and other microbes before humans use it.

40. How is chlorination performed?

Ans. Chlorination is performed by adding a small amount of liquid chlorine to the water, which has the power to kill all harmful bacteria and other microbes.

41. What is aeration?

Ans. Aeration: Aeration is a process of exposing water to air to help remove odours of the water.

42. Which things are affected by water pollution?

Ans. Water pollution affects human health, ecosystems, aquatic organisms and industries that are dependent on good water quality.

43. What is the affect of polluted water on agriculture?

Ans. Polluted water can lower crop yields and contaminate food sources.

44. How should sewage and industrial wastewater be managed?

Ans. Sewage and industrial wastewater should be treated before it is discharged into water bodies.

45. How should household chemicals, fats and oils be disposed off?

Ans. Chemical cleaners, fats or oils and grease should never be thrown down the drain.

46. What agricultural practice can help to reduce water pollution?

Ans. Minimizing the use of pesticides and fertilizers in agriculture reduces the amount of harmful runoff entering natural waters.

47. How should the general public be made aware of the harmful effects of water pollution?

Ans. General public should be made aware of the harmful effects of water pollution through public campaigns.

48. How can the government help control all types of water pollution?

Ans. Government can implement enforce laws for the strict control of all types of water pollution.

20.7 Water scarcity in Pakistan

20.8 Elements essential for plant growth

49. Upon what our world is divided into different regions?

Ans. Our world is divided into different regions depending upon the annual rainfall which they receive every year.

50. In which region of the world is Pakistan included?

Ans. Pakistan is included in a semi-arid region of the world.

51. Why is Pakistan included in semi-arid region of the world?

Ans. Pakistan is included in semi-arid region of the world because it receives a low rainfall annually.

52. How much rainfall does northern Pakistan including Punjab generally receive?

Ans. Northern Pakistan including Punjab generally receives rainfall with the range 250-600 mm per year mostly during monsoon season.

53. What is rainfall range in southern Pakistan?

Ans. In southern Pakistan the rainfall range is below 200 mm per year.

54. How are essential plant nutrients classified?

Ans. Essential plant nutrients are classified into two categories:

- Micro-nutrients (Trace elements)
- Macro-nutrients

55. Differentiate between micro-nutrients and macro-nutrients.

Ans.

Micro-nutrients	Macro-nutrients
The nutrients which are required in a very small amount for the growth of plants are called micro-nutrients.	The nutrients which are required in a large amount for the growth of plants, are called macro-nutrients.
Examples: Boron, copper, iron, manganese, zinc, molybdenum and chlorine.	**Examples:** Nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, carbon, hydrogen and oxygen.

20.9 Fertilizers

20.10 Classification of fertilizers

56. What are fertilizers?

Ans. Fertilizers: Fertilizers are the substances added to the soil to make up the deficiency of essential (NPK) required for the proper growth of plants.

57. What are the main functions of fertilizers?

Ans. i. Fertilizers enhance the natural fertility of the soil.

ii. They provide the chemical elements taken up from soil by the previous crops.

58. What physical stability characteristics should a good fertilizer have during storage?

Ans. It should be stable and not absorb moisture or set into hard, stony materials with time.

59. How are fertilizers classified?

Ans. Fertilizers are classified according to the nature of the elements like nitrogen, phosphorous and potassium which they provide to the soil.

60. Name different types of fertilizers.

Ans. Different types of fertilizers are:

- Nitrogenous fertilizers
- Phosphatic fertilizers
- Potassium fertilizers

61. Why do nitrogenous fertilizers supply to the plants or soil?

Ans. Nitrogenous fertilizers supply nitrogen to the plants or soil.

62. What is the role of nitrogen in plant growth?

Ans. Nitrogen is required during the early stage of plant growth for the development of stem and leaves. It is the main constituent of proteins, imports green colour to the leaves and enhance the yield and quality of the plants.

63. Which is a high quality nitrogenous fertilizer?

Ans. Urea is a high quality nitrogenous fertilizers.

64. How much nitrogen does urea contain?

Ans. Urea contains about 46% nitrogen.

65. Why is ammonium nitrate not suitable for paddy rice?

Ans. Ammonium nitrate is not suitable for paddy rice because the microbial bacteria in flooded fields decompose it to nitrogen gas.

66. What is nature of ammonium nitrate?

Ans. Ammonium nitrate is hygroscope in nature.

67. What do phosphetic fertilizers provide to the plants or soil?

Ans. Phosphetic fertilizers provide phosphorus to the plants or soil.

68. What is the importance of phosphorus for plants?

Ans.

- Phosphorus is required to stimulate early growth and to accelerate the seed and fruit formation during the later stages of growth.
- It also increases resistance to diseases.

69. Why do phosphatic fertilizers have different solubilities?

Ans. The various phosphatic fertilizers have different compositions, due to which they have different solubilities.

70. Name two important water-soluble phosphatic fertilizers.

Ans. The two most important water-soluble phosphatic fertilizers are:

- Super phosphate (calcium super phosphate) $Ca(H_2PO_4)_2$
- Triple phosphate (diammonium-phosphate $(NH_4)_2 HPO_4$.

71. Give some common examples of potassium fertilizers.

Ans. Some common examples of potassium fertilizers are:

- Potassium chloride
- Potassium sulphate
- Potassium nitrate

72. What are bio fertilizers?

Ans. Bio fertilizers: Bio fertilizers are environmental friendly substances that provide the soil essential nutrients as well as microbes required for the growth of plants.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. The pH of distilled water is:

(a) 6.5 (b) 8.5 (c) 7 (d) 7.5

2. The unpleasant odour in water can be removed by:

(a) adding chlorine (b) treating it with activated charcoal
(c) sedimentation (d) filtration

3. The source of harmful microbes in natural water:

(a) human and animal wastes (b) fertilizers used for crops
(c) industrial waste-water (d) microbes in rocks

4. Which gases are dissolved in natural water from the atmosphere through diffusion?

(a) O_2 and CO_2 (b) N_2 and CO_2 (c) O_2 and N_2 (d) O_2, and CO_2

5. The fertilizer harmful to paddy rice is:

(a) Super phosphate (b) Ammonium nitrate
(c) Urea (d) Potassium sulphate

6. Fertilizers which increase the resistant of plants towards diseases and make plants strong by healthy root development are:

(a) Nitrogenous fertilizers (b) Phosphate fertilizers
(c) Potassium fertilizers (d) Magnesium fertilizers

Answers

1. (c) 2. (b) 3. (a) 4. (d) 5. (b) 6. (c)

B. Short Answer Questions

20.1 Name two methods to check the purity of water.

Ans. We can check the purity of water by determining its melting point and boiling point.

Boiling Point: Pure water boils at 100°C and freezes at 0°C under standard conditions of temperature and pressure.

Melting Point: Pure water freezes at exactly 0°C at standard atmospheric pressure. If there is any impurities present in water, the boiling point will increase and the

freezing point will decease.

20.2 What is the main difference between tap water and distilled water?

Ans. The main difference between tap water and distilled water is that, tap water is a conductor of electricity due to the presence of free ions from dissolved minerals. While distilled water is a bad conductor of electricity due to absence of ions.

20.3 How water is distilled in the laboratory?

Ans. In the laboratory, water is distilled by the process of distillation which comprises two steps, i.e; heating and condensing.

Heating: Impure water is heated in a flask until it turns into steam.

Condensing: The steam paves through a condenser, turning back into liquid (pure water), that is collected in a separate receiver.

20.4 Name useful and harmful substances present in water.

Ans. Useful substances present in water: Dissolved oxygen (essential for aquatic life) and essential minerals like calcium, magnesium and sodium.

Harmful substances present in water: Microorganisms (like bacteria, viruses and parasites), heavy metals (like lead, mercury cadmium and chromium and their compounds), nitrates and phosphates.

20.5 How would you remove harmful bacteria and other microbes present in water?

Ans. We can remove harmful bacteria and other microbes present in water by two methods:

- Boiling
- Chlorination

Boiling: Boiling water for at least 1-3 minutes kills the harmful bacteria and microbes.

Chlorination: Adding a small amount of chlorine or chlorine tablets in the water can kill all germs.

20.6 What is the difference between sedimentation and filtration?

Ans.	Sedimentation	Filtration
	It is a process used to remove insoluble bigger sized impurities present in natural water. It is done by allowing water to stand for a few hours. The suspended particles present in water settle down at the bottom of the tank due to gravity.	It is a process used to remove suspended particles of smaller size by using a filter. It is done by allowing water to trickle through a layer of sand and gravel filters which trap there solid particles.

20.7 Name any three water-borne diseases.

Ans. Water-borne diseases: Three water-borne diseases are:

- Typhoid
- Cholera
- Malaria

20.8 Why fertilizers containing nitrogen element are added into the soil?

Ans. Fertilizers containing nitrogen element are added into the soil because, nitrogenous fertilizers supply nitrogen to the plant or soil.

20.9 What is trachoma disease?

Ans. Trachoma: Trachoma is a water-borne disease that often causes blindness. This disease is particularly prevalent among babies and children in developing countries.

C. Constructed Response Questions

20.1 Describe the negative effects of using plastics in every day life.

Ans. Negative effects of using plastics in everyday life:

- **Contamination of water sources:**

Tiny plastic particles (micro plastics) enter water through wastewater, rainwater carrying plastic debris, and the degradation of plastic waste.

- **Presence in Human Organs:**

Recent findings show there tiny particles have been found in human lungs and blood.

- **Health Disruptions:**

Micro plastics can disturb vital internal systems, specifically the immune and reproductive systems.

- **Environmental Impact:**

Reusing and recycling plastics is necessary to minimize production and their harmful environmental footprint.

20.2 Explain one method to remove dissolved impurities present in water.

Ans. Distillation: Distillation is a highly effective method for removing dissolved impurities.

The process involves:

- Heating
- Condensation
- Collection

Heating: The water is heated until it turns into steam (vapor). Dissolved solid impurities do not evaporate and are left behind in the original container.

Condensation: The steam is then condensed (cooled) in a condenser, where it turns back into pure liquid water.

Collection: The resulting distilled water is collected in separate tank. It is free of dissolved minerals and microorganisms.

20.3 Why urea is regarded as a good nitrogenous fertilizer?

Ans. Urea is regarded as a good nitrogenous fertilizer because:

- It contains about 46% nitrogen.
- It is highly soluble in water and is easily absorbed by plants.
- It is generally non-acidic and does not damage the soil pH as much as some other fertilizers.
- It is easy to store, transport, and apply in both solid and spray forms.

20.4 Why Pakistan is facing a severe shortage of water?

Ans. Pakistan is facing a severe shortage of water because of following factors:

Climate change: Rising temperatures are melting glaciers too fast, while this causes floods now, it means our rivers will eventually run dry once the ice is gone. It also makes rainfall patterns very unpredictable.

Population Growth: Pakistan's population is growing very fast. We have the same amount of water we had years ago, but now three are millions more people who need water for drinking, bathing and cooking.

Flood Irrigation: A lot of water is used in agriculture in Pakistan. Farmers use too much water by "flooding" their whole field. This wastes a lot of water that just evaporates in the sun.

Depleting Aquifers: We are pumping out groundwater (from aquifers) using tube wells much faster than the rain can refill them. This causes the water table to drop, making it harder and more expensive to find clean water.

Poor Water Management: Pakistan does not have enough large dams to save or store water. When it rains a lot during the rainy season (Monsoon), most of that fresh water just flows away into the sea. This means we cannot save or store water for the dry month when we need it most.

D. Descriptive Questions

20.1 How domestic water supply can be made fit for drinking?

Ans. For answer see Q7.

20.2 Which measures should be taken to avoid water-borne disease?

Ans. For answer see Q9.

20.3 What are fertilizers? Mention the essential qualities of a good fertilizer.

Ans. For answer see Q12.

20.4 What are the main functions of nitrogenous, phosphatic and potassium fertilizers?

Ans. For answer see Q14.

20.5 How can you avoid the negative effects of pollutants present in water?

Ans. For answer see Q8.

CHAPTER 21 Organic Chemistry

Student Learning Outcomes

After studying this chapter, students will be able to:

- Describe organic molecules as either straight-chained, branched or cyclic.
- State that a structural formula is an unambiguous description of the way the atoms in molecules are arranged, including $CH_2=CH_2$, CH_3CH_2OH, CH_3COOCH_3
- Identify and draw structural formulae for molecules.
- Interpret general formulae of compounds in the same homologous series including alkanes, alkenes, alkynes, alcohols and carboxylic acids.
- Define structural isomers as compounds with the same molecular formula, but different structural formulae, including C_4H_{10} as $CH_3CH_2CH_2CH_3$ and $CH_3CH(CH_3)CH_3$ and C_2H_8 as CH $CH_2CH = CH_2$ and $CH_3CH=CHCH_3$.
- Identify a functional group as an atom or group of atoms that determine the chemical properties of a homologous series including that for alcohols, aldehydes, ketones, phenols, carboxylic acids, amine, esters, and amide.
- Describe the general characteristics of homologous series. These can include:
  - **a.** Having the same functional group
  - **b.** Having the same general formula
  - **c.** Differing from one member to the next by a CH_2 - Unit.
  - **d.** Displaying a trend in physical properties.
  - **e.** Sharing similar chemical properties
- State that a saturated compound has molecules in which all carbon-carbon bonds are single bonds.
- State that an unsaturated compound has molecules in which one or more carbon-carbon bonds are not single bonds.
- Name and draw the structural and displayed formulae of unbranched alkanes, alkenes, alcohols, and carboxylic acids. (Include but-1-ene and but-2-ene, propan-1-ol, propan-2- ol, butan-1-ol and butan-2-ol.
- State the type of compound present given the chemical name ending in - ane, -ene, -yne, - ol, or -oic acid or from a molecular, structural or displayed formula.
- Name and draw the displayed formulae of the unbranched esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2 Classifications of Organic Compounds + Structural Formula

Q.1: What is an organic compound? How organic compound are classified based on the type of carbon chain present in them?

Ans. Organic Compound:

An organic compound is chemical compound primarily compound of carbon atoms that are covalently bonded to each other or the other elements. Apart from carbon, majority of organic compounds also contain hydrogen. Other elements which may also be present include oxygen, nitrogen, sulphur and halogens etc.

Classifications of Organic Compounds:

There are millions of organic compounds. It is practically not possible to study each individual compound. To facilitate their study, organic compounds are classified into various groups and sub-groups. They may be broadly classified into the following classes:

(i) Open chain or Acyclic compounds.
(ii) Closed chain or Cyclic (or ring) compounds

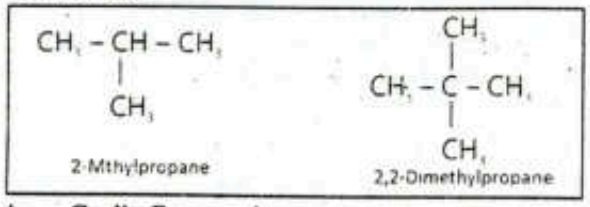
(i) Open Chain orAcyclic Compounds:

This type of compounds contains an open chain of carbon atoms. The chains may be branched or non-branched (straight chain). Open chain compounds alongwith certain cyclic compounds are also called aliphatic compounds.

Straight chain (or non-branched) compounds:

$CH_3-CH_2-CH_2-CH_3$	$H_2C=CH-CH_2-H_2$	$CH_2-CH_2-CH_2-CH_2-OH$
Butane	But-1-ene	Butan-1-ol

Branched chain compounds:



(ii) Closed Chain or Cyclic Compunds:

These compounds contain one or more closed chains (cyclic) of atoms and are known as closed chain or ring compounds.

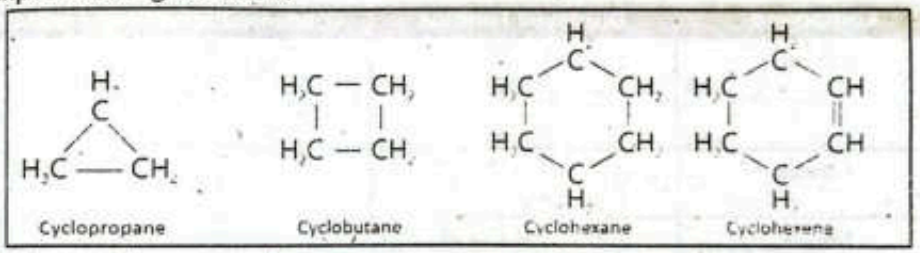
When the ring contains carbon atoms only, the compounds are called carbocylic compounds. However, if the ring contains other atoms alongwith carbon atoms, the

compounds are called heterocyclic compounds. Carbocyclic compounds are further classified as;

(i) Alicyclic compounds (ii) Aromatic compounds

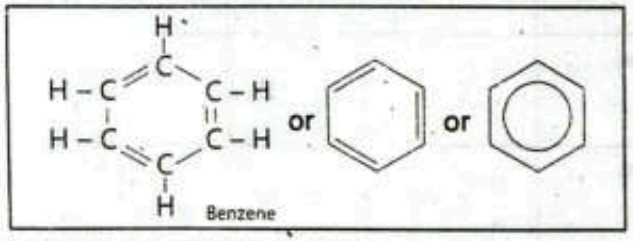
(i) Alicyclic compounds:

The carbocyclic compounds which contain a ring of three or more carbon atoms and resemble aliphatic compounds are called alicyclic compounds. The saturated alicyclic hydrocarbons have the general formula C_nH_{2n}. A few typical alicyclic compounds are given below.



(ii) Aromatic compounds:

Aromatic compounds are of many types. The simplest among them are those which contain one benzene ring. A benzene ring has six carbon atoms with three alternate double and single bonds. These bonds are usually shown in the form of a circle. Some other cyclic compounds having alternate double bonds are also included in aromatic compounds.



Q.2: Explain structural formula giving examples.

Ans. Structural Formula:

The structural formula of a compound shows the arrangement of atoms and bonds present in that compound.

Explanation:

It gives enough information to understand the structure of a molecule clearly. While showing the arrangement of atoms in a molecule, it is usual to omit most of the single covalent bonds present in the molecule. Only important bonds such as double and triple bonds are shown. Identical groups present in the molecules can be bracketed together while some other groups are also shown using brackets.

There are various ways of drawing the structural formula of organic compounds and the students should familiarize with all of them.

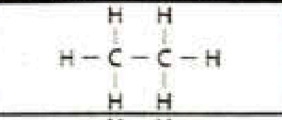
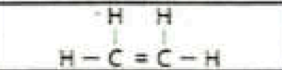
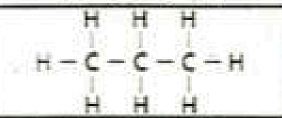
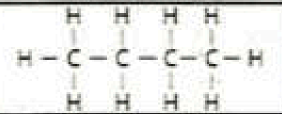
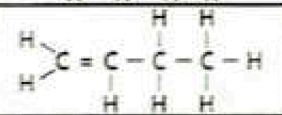
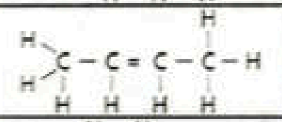
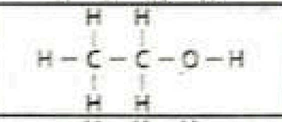
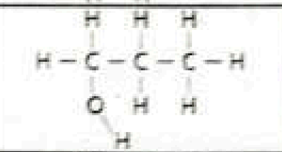
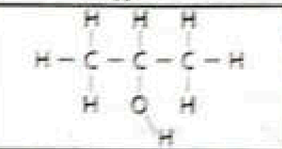
Displayed Formula or Full Structural Formula:

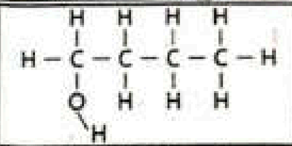
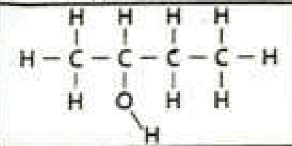
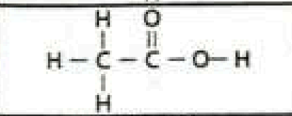
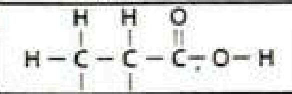
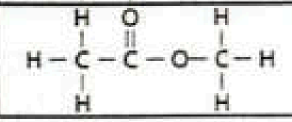
This formula shows the detailed structure of a molecule showing the relative position of atoms, the number and type of bonds between them. The bonds are represented by lines.

Condensed Structural Formula:

This formula still uses lines between bonded atoms, but it omits the carbon to hydrogen bonds.

Condensed Structural Formulae

Compound	Displayed Formula	Condensed Structural Formula
Ethane		$CH_3 - CH_3$
Ethene		$CH_2 = CH_2$
Ethyne	$H - C \equiv C - H$	$HC \equiv CH$
Propane		$CH_3 - CH_2 - CH_3$
Butane		$CH_3 - CH_2 - CH_2 - CH_3$
But-1-ene		$CH_2 = CH - CH_2 - CH_3$
But-2-ene		$Ch_3 - CH = CH - CH_3$
Ethanol		$CH_3 - CH_2 - OH$
Propanol		$CH_2 - CH_2 - CH_3$ | OH
Propan-2-ol		$CH_3 - CH - CH_3$ | OH

Compound	Displayed Formula	Condensed Structural Formula
Butanol		$CH_2 - CH_2 - CH_2 - CH_3$ | OH
Butan-2-ol		$CH_3 - CH - CH_2 - CH_3$ | OH
Ethanoic acid		O ‖ $CH_3 - C - OH$
Propanoic acid		O ‖ $CH_3 - CH_2 - C - OH$
Methyl ethanoate		O ‖ $CH_3 - C - O - CH_3$

21.3 + 21.4 + 21.5 Homologous Series + Isomerism + Functional Group

Q.3: Write down five characteristics of a homologous series.

Ans. Homologous Series:

Organic compounds have been classified into various families. Each family contains closely related organic compounds, as their structure and chemical properties are similar. The different families are known as homologous series.

Characteristics of a Homologous Series:

The common characteristics of the members of a homologous series are:

(i) All the members of the series can be represented by a general formula. For example, the general formula for the series of saturated hydrocarbons called alkanes is C_nH_{2n+2} where n represents the number of carbon atoms present in a member. The general formula of some other families are given below.

Series	General Formula
Alkenes	C_nH_{2n}
Alkynes	C_nH_{2n-2}
Alcohols	$C_nH_{2n+1}OH$
Carboxyl acids	$C_nH_{2n+1}COOH$

(ii) Successive members of the series differ by CH_2 group and 14 units in their relative molecular masses.

(iii) Different members in a family have common functional group e.g. all the members

of carboxylic acid family have -COOH group as the functional group.

(iv) The members in any particular family have almost identical chemical properties due to the presence of the same functional group.

(v) The physical properties such as melting point, boiling point, density and solubility show a regular change with the increase in the molecular masses.

(vi) All members of a series can be prepared by similar methods.

Q.4: Write a detailed note on isomerism.

Ans. Isomerism:

Two or more compounds having the same molecular formula but different structural formulae and properties are said to be isomers and the phenomenon is called structural isomerism.

Simplest Hydrocarbon:

The simplest hydrocarbon to have structural isomers is butane (C_4H_{10}).

Hydrocarbons not showing Isomerism:

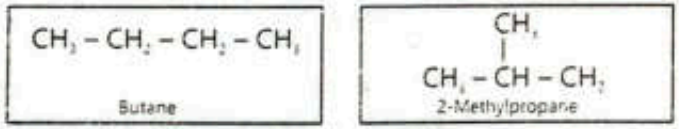
Methane, ethane and propane do not show the phenomenon of isomerism because each exists in one structural form only.

Same Molecular Formula:

If we study the structural formula of butane or other higher hydrocarbons of the alkane family, we will observe that it is possible to arrange the atoms present in the molecule in more than one way to satisfy all valencies. This means that it is possible to have two or more different arrangements for the same molecular formula.

Example:

Butane molecule can have two different arrangements as represented by the following structural formulae:



Support by on Experimental Evidence:

This fact has been supported by an experimental evidence that there are two compounds with different physical properties but with the same molecular formula of C_4H_{10}.

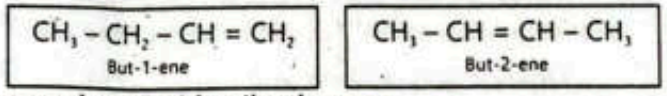
Relationship between Carbon Atoms and Isomers:

As the number of carbon atoms in a hydrocarbon increases, the number of possible isomers increase very rapidly. The five carbon compounds, pentane, has three isomers. When the number of carbon atoms increases to thirty, the number of isomers are over four billions.

Structural Isomerism in Unsaturated Hydrocarbons:

Structural isomerism is not confined to saturated hydrocarbons only. In fact, all

classes of organic compounds and their derivatives show the phenomenon of structural isomerism.



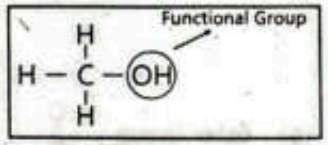
Q.5: Discuss some important functional groups.

Ans. Functional Group:

A functional group may be defined as an atom or group of atoms that determines the characteristic properties of an organic compound.

Example:

The family of alcohols have its characteristic properties due to the presence of -OH (hydroxyl) group, called the functional group of alcohols.

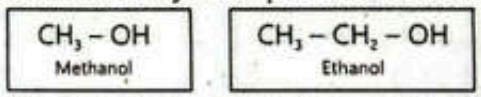


Important Functional Groups:

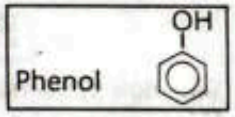
Some important functional groups are described below.

(a) Hydroxyl group (–OH):

This group is present in the family of compounds called alcohols.



If hydroxyl (– OH) group is attached to benzene ring the compound is a member of a series which is named as phenols.



(b) Aldehyde Group $(-\overset{O}{\overset{\|}{C}}-H)$:

This group is present in the family of compounds called carboxylic acids.

Methanal or Formaldehyde $H-\overset{O}{\overset{\|}{C}}-H$ Ethanal or Acetaldehyde $CH_3-\overset{O}{\overset{\|}{C}}-H$

(c) Ketone Group $(\begin{matrix}R\\R\end{matrix}\!\!>C=O$ **where R is an alkyl group):**

The homologous series which contains a ketonic functional group is called ketones.

Propanone or Acetone $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

Butanone $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

(d) Carboxyl Group $(-\overset{O}{\overset{\|}{C}}-OH)$:

This group is present in the family of compounds called carboxylic acids.

Methanoic acid or Formic acid $H-\overset{O}{\overset{\|}{C}}-OH$

Ethanoic acid or Acetic acid $CH_3-\overset{O}{\overset{\|}{C}}-OH$

(e) Amino Group ($-NH_2$):

This group is present in a series of compounds called amines.

Formamide $H-\overset{O}{\overset{\|}{C}}-NH_2$

Acetamide $CH_3-\overset{O}{\overset{\|}{C}}-NH_2$

(g) Ester Group $\left(-\overset{O}{\overset{\|}{C}}-OR\right)$:

Ester group is present in a family called carboxylic esters.

Methyl ethanoate or Methyl acetate $CH_3-\overset{O}{\overset{\|}{C}}-OCH_3$

Ethyl ethanoate or Ethyl acetate $CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5$

21.6 Naming Organic Compounds

Q6. How systematic way of naming organic compounds was introduced?

Ans. Historical Naming of Organic compounds:

The early organic chemists prepared many organic compounds and gave them names which are called common or trivial names.

These names are quite often used because they are very simple and easy to use.

Need of a New system:

Due to existence of a large number of organic compounds and their complexity, it is not possible to give common name to every compound individually.

Introduction of the IUPAC System of Nomenclature:

To deal with this problem, the International Union of Pure and Applied Chemistry (IUPAC) has introduced a systematic way of naming organic compounds called IUPAC nomenclature.

Q7. What are Alkanes. How an organic compound is named according to IUPAC system of Nomenclature.

Ans. Hydrocarbons:

The organic compounds containing carbon and hydrogen only are called hydrocarbons.

Saturated Hydrocarbons:

The hydrocarbons in which all the four valencies of carbon are utilized using single bonds only are called saturated hydrocarbons or alkanes.

Unsaturated hydrocarbons:

The hydrocarbons containing at least one double or triple bond are called unsaturated hydrocarbons.

Carbon Atoms in Saturated Hydrocarbons:

The saturated hydrocarbons or alkanes may contain one or more carbon atoms and they may have a straight chain or a branched chain.

Methane (CH_4):

Methane (CH_4) is the simplest member of saturated hydrocarbons.

Root	No. of Carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8
Non-	9
Dec-	10

Naming of an Organic Compound According IUPAC system:

According to IUPAC system of nomenclature, the entire name of an organic compound has three parts.

1. **Root:** It tells us the number of carbon atoms in the longest continuous chain present in the molecule. The roots up to ten carbon atoms are shown in Table 21.2.
2. **Suffix:** It is added after the root and tells us about the class of organic compound.
3. **Prefix:** It is indicated before the root and tells us about the group or groups attached to the longest chain.

Molecular Formulae, Displayed Formulae or Condensed Structural Formulae"

The molecular formua, the displayed formulae or the condensed structural foomulae of some alkanes are given in Table given below:

Formulae of Alkanes

Methane	CH_4	$H-\overset{H}{\overset{\|}{C}}-H$ $\quad\quad H$
Ethane	C_2H_6 CH_3-CH_3	$H-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-H$ $\quad\quad H\quad H$
Propane	C_3H_8 $CH_3-CH_2-CH_3$	$H-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-H$ $\quad\quad H\quad H\quad H$
Butane	C_4H_{10} $CH_3-(CH_2)-CH_3$	$H-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-\overset{H}{\overset{\|}{C}}-H$ $\quad\quad H\quad H\quad H\quad H$
Pentane	C_5H_{12}	$CH_3-CH_2-CH_2-CH_2-CH_3$

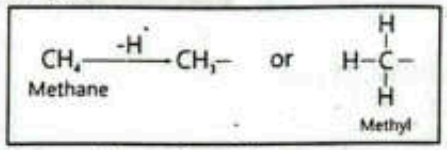
Hexane	C_6H_{14}	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$
Heptane	C_7H_{16}	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
Octane	C_8H_{18}	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
Nonane	C_9H_{20}	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$
Decane	$C_{10}H_{22}$	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

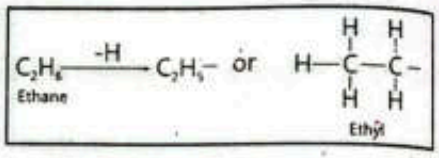
Q.8: How is Alkyl Group formed?

Ans. Alkyl Group:

An alkyl group is functional group which is formed when an alkane molecule loses one of its many hydrogen atoms.

Example:





Representation of an Alkane:

An Alkane is represented by R–H.

Representation of an Alkyl Group:

An Alkyl group is represented by R–.

Q9. Name the following compound to explain the IUPAC System.

$CH_3-CH_2-CH_2-CH_3$

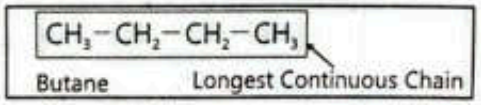
Ans. To explain the IUPAC system, let us name the following compound.

$CH_3-CH_2-CH_2-CH_3$

a) Identify the longest continuous chain present in the compound.

b) Identify the class of organic compound.

The organic compound contains four carbon atoms in the longest continuous carbon chain and it belongs to the family of hydrocarbons called Alkanes. The root is, therefore, But- and the suffix -ane is added to this. The organic compound will, thus, be given the name Butane.



Q.10: What are Alkenes. How are Alkenes named using IUPAC System?

Ans. Alkenes:

Hydrocarbons containing at least one carbon to carbon double bond are called Alkenes.

Alkenes are named in the same way as alkanes except the suffix used is -ene. The rules for naming alkenes are as follows.

1. Count the number of carbon atoms in the longest continuous chain that contains both the carbon atoms of the double bond.
2. Number the chain starting from the end nearest to the double bond carbon atom.
3. Write the root, then position of double bond and finally the suffix -ene. Examples of alkenes are as follows:

$CH_2=CH_2$ Ethene	$CH_3-CH=CH_2$ Propene
$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2-\overset{4}{C}H_3$ But-1-ene	$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_3$ But-2-ene
$CH_2=CH-CH_2-CH_2-CH_3$ Pent-1-ene	$CH_3-CH=CH-CH_2-CH_3$ Pent-2-ene

Q.11: Give IUPAC rules for naming alcohols.

Ans. Alcohols:

Monohydroxy derivatives of alkanes are also called alcohols.

General Formula:

General formula for alcohol is ROH.

Naming Alcohols:

According to IUPAC system, alcohols are named observing the following rules.

(i) The longest chain of carbon atoms containing the hydroxyl group is taken as a parent hydrocarbon. The ending 'e' of alkane is replaced by 'ol'.

(ii) The longest carbon chain is numbered, starting from the end where carbon atom attached with hydroxyl group gets the lowest possible number.

(iii) The position of hydroxyl group is indicated by a number placed before the -ol.

Names and condensed formulae of some simple alcohols:

Names and condensed formulae of some simple alcohols are given in the Table given below:

Names and formulas of Alcohols

Alcohol	CH_3OH	CH_3CH_2OH	$\overset{3}{C}H_3-\overset{2}{C}H_2-\overset{1}{C}H_2-OH$
Common Name	Methyl Alcohol	Ethyl Alcohol	Propyl alcohol
IUPAC Name	Methanol	Ethanol	Propan-1-ol
Alcohol	$\overset{1}{C}H_3-\overset{2}{C}H(OH)-\overset{3}{C}H_3$	$CH_3-CH_2-CH_2-CH_3$ (OH)	$CH_3-CH(OH)-CH_2-CH_3$
Common Name	Iso-Propyl Alcohol	n-Butyl Alcohol	Sec-Butyl Alcohol
IUPAC Name	Propan-2-ol	Butan-1-ol	Butan-2-ol

Q.12: What are Carboxylic acids. How are they named by IUPAC system?

Ans. Carboxylic Acids:

Organic compounds containing a carboxyl group (-COOH) as a functional group

are called carboxylic acids. They are also commonly called fatty acids because some carboxylic acids are obtained from fats. They are represented by the general formula RCOOH.

General Formula:

They are represented by the general forula RCOOH.

IUPAC Names of Carboxylic Acids:

The IUPAC names of carboxylic acids are derived from the names of alkanes containing the same number of carbon atoms as the acid. The ending 'e' of the alkane name is replaced by '-oic' acid.

The common and IUPAC names of some common carboxyiic acids are shown in Table given below:

Names of Carboxylic Acids

Carboxylic Acids	HCOOH	CH_3COOH	CH_3CH_2COOH	CH_3CH_2COOH
Common Name	Formic acid	Acetic acid	Propionic acid	Butyric acid
IUPAC Name	Methanoic acid	Ethanoic acid	Propanoic acid	Butanoic acid

Q.13: What are Esters? Give some common and IUPAC names of Esters.

Ans. Esters:

Esters are sweet smelling compounds.

Uses of Esters:

They are commonly used as flavouring agents in certain food items.

General Formula:

They are represented by a general formula RCOOR.

Preparation of Esters: Esters can be prepared by reacting an alcohol with a carboxylic acid in the presence of an acid catalyst.

$$\underset{\text{Propanoic acid}}{CH_3CH_2COOH} + \underset{\text{Ethanol}}{CH_3\text{-}CH_2\text{-}OH} \rightleftharpoons^{H^+} \underset{\text{Ethyl Propanoate}}{CH_3CH_2COOCH_2CH_3} + H_2O$$

Common and IUPAC Names of Esters:

Common and IUPAC names of esters are shown in Table given below:

Common Names of some Esters

Esters	CH_3COOCH_3	$CH_3COOCH_2CH_3$	$HCOOCH_2CH_3$
Common Name	Methyl acetate	Ethyl acetate	Ethyl formate
IUPAC Name	Methyl ethanoate	Ethyl ethanoate	Ethyl methanoate
Esters	$CH_3CH_2COOC_2H_5$	$CH_3CH_2COOCH_3$	$CH_3CH_2CH_2COOCH_3$
Common Name	Ethyl Propionate	Methyl Propionate	Methyl butyrate
IUPAC Name	Ethyl propanoate	Methyl propanoate	Methyl butanoate

21.1 Quick Check!

1. What is the difference between cyclohexane and benzene?

Ans. Cyclohexane

It is an alicyclic compound with single bonds between carbon atoms (C_6H_{12}).

Benzene

It is an aromatic compound with alternate double and single bonds in a six carbon ring (C_6H_6).

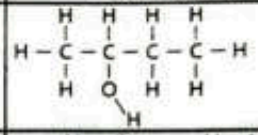
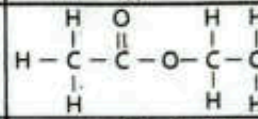
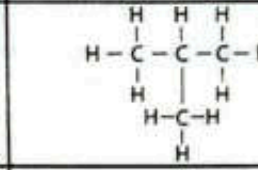
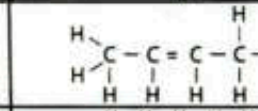
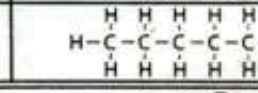
2. Give the examples of branched chain compounds.

Ans. (i) 2 – Methyl propane (ii) 2,2 – Dimethylpropane

21.2 Quick Check!

1. Write down the displayed and condensed formulae of butan-2-ol, ethyl ethanoate, 2-methylpropane, but -2-ene and pentane.

Ans.

Compound	Displayed Formula	Condensed Structural
Butan-2-ol		$CH_3-\underset{\displaystyle OH}{\underset{\vert}{CH}}-CH_2-CH_3$
Ethyl ethanoate		$CH_3-\overset{\displaystyle O}{\overset{\Vert}{C}}-O-CH_2-CH_3$
2–Methyl propane		$CH_3-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_3$
But – 2 – ene		$CH_3-CH=CH-CH_3$
Pentane		$CH_3-CH_2-CH_2-CH_2-CH_3$

21.3 Quick Check!

1. Write down the molecular formula of a carboxylic acid having three carbon atoms.

Ans. The general formula for a carboxylic acid is C_nH_{2n+1} COOH. For a molecule with a total of three carbon atoms, one carbon is already part of the functional group (– COOH), so we let n = 2 for the alkyl group.

Name = Propanoic acid

Molecular Formula = $C_3H_6O_2$

Condensed Formula = $CH_3-CH_2-\overset{\displaystyle O}{\overset{\Vert}{C}}-OH$

2. Write down the molecular formula of an alcohol containing four carbon atoms.

Ans. The general formula of an alcohol is $C_nH_{2n+1}OH$. For a molecule with four carbon atoms, we let $n = 4$

Name = Butanol (Specifically 1 – Butanol)
Molecular Formula = $C_4H_{10}O$
Condensed Formula = $CH_3 - CH_2 - CH_2 - CH_2 - OH$

21.4 Quick Check!

1. How phenols are different from alcohols?

Ans. Both phenols and alcohols contain the hydroxyl group (– OH) but they differ based on the structure they are attached to:

Attachment of (– OH) in Alcohols

In alcohols the group (– OH) is attached to an aliphatic carbon atom (a chain - like structure, e.g., $CH_3 - CH_2 - OH$).

Attachment of (– OH) in phenols

In phenols, the group (– OH) is directly attached to a carbon atom of an aromatic benzene ring.

e.g: 

2. What is common between the formula of aldehydic and ketonic functional groups.

Ans. Aldehyde and ketone functional groups both contain the carbonyl group (C = O)

Aldehyde: In aldehyde, it is at the end of the chain $(-\overset{O}{\overset{\|}{C}}-H)$

Examples

- Methanal or Formaldehyde $(H-\overset{O}{\overset{\|}{C}}-H)$
- Ethanal or Acetaldehyde $(CH_3-\overset{O}{\overset{\|}{C}}-H)$

Ketone:

In ketone, it is between two carbon atoms $(\begin{matrix}R\\R\end{matrix}\!\!>\!C=O)$

Examples

- Propanone or Acetone $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$
- Butanone $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

21.5 Quick Check!

1. Name the following compounds according to IUPAC system of normenclature.

(i) $CH_3-CH_2-CH_2-CH_2-CH_3$ **(ii)** $CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

(i) $CH_3-CH_2-CH_2-CH_2-CH_3$

Ans. Number of carbons: 5
Root Name: Pent –
Suffix: – ane (since it is a saturated hydrocarbon)
IUPAC Name: Pentane

(ii) $CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

Ans. Number of carbons: 7

Root Name: Hept –
Suffix: – ane (since it is a saturated hydrocarbon)
IUPAC Name: Heptane

21.6 Quick Check!

- **Condensed structural formulae of some organic compounds are given below. Write down the names of their families.**

Ans.

(i) $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$ **Ans:** Family Name = Alcohol

(ii) $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$ **Ans:** Family Name = Ketone

(iii) $CH_2=\underset{\displaystyle CH_3}{\underset{|}{C}}-CH_3$ **Ans:** Family Name = Alkene

(iv) $\underset{\displaystyle COOH}{\underset{|}{CH_2}}-CH_2-CH_3$ **Ans:** Family Name = Carboxylic Acid

(v) C_3H_6 **Ans:** Family Name = Alkene (Propene)

(vi) C_5H_{12} **Ans:** Family Name = Alkane (Pentane)

(vii) $H-\overset{O}{\overset{\|}{C}}-H$ **Ans:** Family Name = Aldehyde

(viii) $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-O-CH_2-CH_3$ **Ans:** Family Name = Ester

INTERESTING INFORMATION

Organic chemistry plays a vital role in developing new materials with specific properties, such as polymers and drugs.

INTERESTING INFORMATION

The ability of carbon atom to form four bonds creates an almost infinite variety of molecules which make organic chemistry very useful.

INTERESTING INFORMATION

The common names of carboxylic acids are derived from the sources from which they were first isolated. Formic acid was first isolated from red ants. The Latin word formic means ant. Similarly acetic acid was isolated from vinegar. The Latin word for vinegar is acetum.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2 Classifications of Organic Compounds + Structural Formula

1. **Organic chemistry is primarily defined as the study of compounds containing which two elements?**
   (a) Hydrogen and Oxygen (b) Carbon and Nitrogen
   (c) Carbon and Oxygen (d) Carbon and Hydrogen
2. **Which of the following is considered as an inorganic carbon compound for historical reasons?**
   (a) Benzene (b) Ethane
   (c) Calcium Carbonate (d) Methane
3. **What is another name for open chain organic compounds?**
   (a) Aromatic compounds (b) Alicyclic compounds
   (c) Heterocyclic compounds (d) Acyclic compounds
4. **A compound with a continuous series of carbon atoms without any branch is called a:**
   (a) Branched chain compound (b) Aromatic compound
   (c) straight chain compound (d) Cyclic compound
5. **Cyclic compounds containing only carbon atoms in the ring are called:**
   (a) Acyclic compounds (b) Homocyclic compounds
   (c) Aliphatic compounds (d) Heterocyclic compounds
6. **What is the general formula for saturated alicyclic hydrocarbons?**
   (a) C_nH_2n (b) C_nH_{2n-2} (c) C_nH_{2n+2} (d) C_nH_n
7. **Which molecule is a common example of an aromatic compound containing six carbons and alternate double bonds?**
   (a) Cyclo butane (b) Benzene (c) Propane (d) Cyclohexane
8. **A formula that shows the relative position of every atom and all bonds represented by lines is called a/an:**
   (a) Empirical formula (b) Condensed structural formula
   (c) displayed structural formula (d) Molecular formula
9. **Condensed structural formula of Ethane is:**
   (a) $CH_3 - CH_3$ (b) $CH_2 = CH_2$ (c) $HC \equiv CH$ (d) $CH_3 - CH_2 - CH_3$
10. **Condensed structural formula of But-2-ene is:**
    (a) $CH_3 - C - OH$ (b) $CH_3 - CH_2 - CH_2 - CH_3$
    (c) $CH_3 - CH = CH - CH_3$ (d) $CH_2 = CH - CH_2 - CH_3$

21.3 + 21.4 + 21.5 Homologous series + Isomerism + Functional Group

11. **What is the general formula for the Alkynes series?**
    (a) C_nH_{2n+2} (b) C_nH_{2n-2} (c) C_nH_{2n+1} (d) C_nH_{2n}
12. **Which of these hydrocarbons does Not show structural isomerism?**
    (a) Pentane (b) Butane (c) Hexane (d) Propane
13. **The functional group (–OH) attached to an alkyl group identifies which family?**
    (a) Alde hydes (b) Alcohols (c) Ethers (d) Phenols
14. **Which functional group is present in both Aldehydes and ketones?**
    (a) Amino group (b) Carbonyl group (c) Carboxyl group (d) Hydroxyl group
15. **Which is the name of the simplest aldehyde also known as formaldehyde?**
    (a) Propanone (b) Ethanal (c) Methanol (d) Methanal
16. **It is a compound containing a Nitrogen atom in its functional group.**
    (a) Methyl ethanoate (b) Methyl amine
    (c) Acetone (d) Phenol
17. **What is the specific functional group for Ester?**
    (a) $-CHO$ (b) $-COOR$ (c) $CO-NH_2$ (d) $-NH_2$
18. **Which of the following is the formula for Acetone (Propanone)?**
    (a) $CH_3 - CO - CH_3$ (b) $CH_3 - CHO$
    (c) $CH_3 - COOH$ (d) $CH_3 - NH_2$
19. **If a hydroxyl (–OH) group is attached to a benzene ring, the compound is a member of:**
    (a) Phenols (b) Alcohols (c) Ketones (d) Esters
20. **Successive members of a homologous series differ in molecular mass by how many units?**
    (a) 12 units (b) 16 units (c) 2 units (d) 14 units

21.6 Naming Organic Compounds

21. **Which part of the IUPAC name indicates the number of carbon atoms in the longest continuous chain?**
    (a) Infix (b) Root (c) Prefix (d) Suffix
22. **What is the IUPAC root for a compound containing seven carbon atoms?**
    (a) Non – (b) Hept – (c) Hex – (d) Oct –
23. **An alkyl group is formed when an alkane loses how many hydrogen atoms?**
    (a) Four (b) Two (c) Three (d) One
24. **What is the correct IUPAC name for $CH_3 - CH_2 - CH_2 - CH_3$?**
    (a) Ethane (b) Pentane (c) Butane (d) Propane
25. **What is the IUPAC name for "Isopropyl Alcohol"?**
    (a) Propane – 2 – ol (b) Ethanol
    (c) Butan – 2 – ol (d) Propan – 1 – ol

26. Esters are prepared by the reaction between:
(a) A ketone and an Aldehyde (b) An Alcohol and a carboxylic acid
(c) An Alkane and an Alkene (d) An Amine and an Alcohol

27. What is the common name for Ethanoic acid?
(a) Butyric acid (b) Acetic acid (c) Propionic acid (d) Formic acid

28. The root 'Prop – ' corresponds to how many carbon atoms?
(a) 2 (b) 3 (c) 4 (d) 5

Answers

1.	(d)	2.	(c)	3.	(d)	4.	(c)	5.	(b)	6.	(a)	7.	(b)
8.	(c)	9.	(a)	10.	(c)	11.	(b)	12.	(d)	13.	(b)	14.	(b)
15.	(d)	16.	(b)	17.	(b)	18.	(a)	19.	(a)	20.	(d)	21.	(b)
22.	(b)	23.	(d)	24.	(c)	25.	(a)	26.	(b)	27.	(b)	28.	(b)

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2 Classifications of Organic Compounds + Structural Formula

1. Define Organic Chemistry.

Ans. Organic Chemistry: Organic Chemistry is defined as that branch of chemistry in which we study compounds of carbon and hydrogen (hydrocarbons) and their derivatives.

2. What are organic compounds?

Ans. Organic Compound: An organic compound is a chemical compound primarily composed of carbon atoms that are covalently bonded to each other to other elements. A part from carbon, majority of organic compounds also contain hydrogen.

3. Why are carbon oxides and carbonates studied in inorganic chemistry despite containing carbon?

Ans. Carbon oxides and carbonates are studied as inorganic compounds for historical and conventional reasons, as their properties align more closely with inorgonic substances.

4. How are organic compounds broadly classified?

Ans. Organic compounds are classified into two main groups:
(i) Open chain or Acyclic compounds
(ii) Closed chain or Cyclic (or ring) compounds

5. Distinguish between straight chain and branched chain compounds.

Ans. Straight chain: Carbon atoms are linked in a continuous series (e.g; n-Butane).
Branched chain: There is at least one "branch" or side chain of carbon atoms

attached to the main chain (e.g; 2-Methylpropane)

6. What are Aliphatic compounds?

Ans. Aliphatic Compounds: Open chain compounds along with certain cyclic compounds are called aliphatic compounds.

7. Define Homocyclic (carbocyclic) compounds.

Ans. Carbocyclic Compounds: These are cyclic compounds where the ring contains carbon atoms only.
(i) Alicyclic compounds (ii) Aromatic compounds

8. What are Carbocyclic compounds further classified?

Ans. Carbocyclic compounds are further classified as:
(i) Alicyclic compounds (ii) Aromatic compounds

9. What are alicyclic compounds? Give their general formula and examples.

Ans. Alicyclic compounds: The carbocyclic compounds which contain a ring of three or more carbon atoms and resemble aliphatic compounds are called alicyclic compounds.
General Formula: C_nH_{2n}
Examples: Cyclopropene, Cyclobutane, Cyclohexane, Cyclohexene

10. What are aromatic compounds?

Ans. Aromatic compounds: These are cyclic compounds which contain one benzene ring. A benzene ring has six carbon atoms with three alternate double and single bonds.

11. Define Heterocyclic compounds.

Ans. Heterocyclic compounds: Cyclic compounds in which the ring contains other atoms along with carbon atoms (such as nitrogen, oxygen or sulphur) are called heterocyclic compounds.

12. What is a structural formula?

Ans. Structural Formula: The structural formula of a compound shows the arrangement of atoms and bonds present in that compound.

13. Define Displayed (Full) structural formula.

Ans. Displayed (Full) Structural Formula: This formula shows the detailed structure of a molecule showing the relative position of atoms, the number and type of bonds between them. The bonds are represented by lines.

14. What is condensed structural formula?

Ans. Condensed Structural Formula: This formula still uses lines between bonded atoms, but it omits the carbon to hydrogen bonds.

21.3 + 21.4 + 21.5 Homologous Series + Isomerism + Functional Group

15. Define the term homologous series.

Ans. Homologous series: Organic compounds have been classified into various families. Each family contains closely related organic compounds, as their structure

and chemical properties are similar. The different families are known as homologous series.

16. What is isomerism?

Ans. Isomerism: Two or more compounds having the same molecular formula but different structural formulae and properties are said to be isomers and the phenomenon is called structural isomerism.

17. Which is the simplest hydrocarbon to have structural isomers?

Ans. The simplest hydrocarbon to have structural isomers is butane (C_4H_{10}).

18. Why do Methane, Ethane and Propane not show isomerism?

Ans. Methane, Ethane and Propane do not show the phenomenon of isomerism because each exists in one structural form only.

19. Name the two structural isomers of Butane (C_4H_{10}).

Ans. Two structural isomers of Butane (C_4H_{10}) are:

- n – Butane (straight chain)
- 2 – Mathyl propane (Branched chain)

20. Name the two structural isomers of Butene (C_4H_8).

Ans. Two structural isomers of Butene (C_4H_8) are:

- But-1-ene
- But-2-ene

21. How many isomers do pentane has?

Ans. Pentane has three isomers.

22. Define functional group.

Ans. Functional Group: A functional group may be defined as an atom or group of atoms that determines the characteristic properties of an organic compound.

For Example: The family of alcohols have its characteristic properties due to the presence of –OH (hydroxyl) group, called the functional group of alcohols.

23. Distinguish between Alcohols and phenols.

Ans. Alcohols and phenols both contain the Hydroxyl group (–OH).

Alcohols: In alcohols, the hydroxyl group is attached to an alkyl group (e.g. Methanol).

Phenols: In phenols, the hydroxyl group is directly attached to a benzene ring.

24. Give one example of an Amide group Compound.

Ans. Formamide $H-\overset{\overset{O}{\|}}{C}-NH_2$ (or) Acetamide $CH_3-\overset{\overset{O}{\|}}{C}-NH_2$

21.6 Naming Organic Compounds

25. How are IUPAC names of alcohols derived?

Ans. The ending '– e' of the parent alkane is replaced by '– ol'.

Example: Methane becomes Methanol

26. From what formic acid was first isolated?

Ans. Formic acid was first isolated from red ants.

27. What does formica mean?

Ans. The latin word Formica means ant.

28. From what acetic acid was isolated?

Ans. Acetic acid was isolated from vinegar.

29. What is the Latin word for vinegar?

Ans. The Latin word for vinegar is acetum.

30. What are Esters and what are they used for?

Ans. Esters: Esters are sweet smelling compounds.

Use: They are commonly used as flavouring agents in certain food items.

31. How is an Ester prepared?

Ans. An Ester can be prepared by reacting an alcohol with a carboxylic acid in the presence of an acid catalyst.

$$CH_3CH_2COOH + CH_3-CH_2OH \xrightleftharpoons{H^+} CH_3CH_2COOCH_2CH_3 + H_2O$$

32. How do you name a Carboxylic acid in the IUPAC system?

Ans. Replace the ending '–e' of the alkane with '–oic acid'.

Example: Ethane becomes Ethanoic acid.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Choose the correct IUPAC name for the compound $HC-\overset{\overset{CH_2}{\|}}{C}-CH_3$

(a) But-3-ene (b) But-1-ene (c) But-2-ene (d) Butene

2. Select a branched chain compound.

(a) $CH_2=CH-CH_2-CH_3$ (b) $CH_3-\overset{\overset{CH_2}{|}}{C}=CH-CH_3$

(c) $CH_2=C-CH-CH_3$ (d) $CH_3=CH=CH_2-CH_3$

3. Which is the displayed formula of ethanol?

(a) C_2H_5OH (b) CH_3-CH_2-OH

(c) $H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-OH$ (d) $H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-O-H$

4. Identify the aldehydic functional group among the following:

(a) $-\overset{\overset{O}{\|}}{C}-OH$ (b) $-\overset{\overset{O}{\|}}{C}-$ (c) $-OH$ (d) $-\overset{\overset{O}{\|}}{C}-H$

5. Select the general formula of alkyne family.

(a) C_nH_{2n+1} (b) C_nH_{2n} (c) C_nH_{2n-2} (d) C_nH_{2n-1}

6. How many structural isomers will be there for a saturated hydrocarbon having five carbon atoms?

(a) 2 (b) 3 (c) 4 (d) 5

7. **Which ester among the following will be called ethylpropanoate?**

(a) $CH_3-\overset{O}{\overset{\|}{C}}-OCH_3$ (b) $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-OCH_3$

(c) $CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5$ (d) $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-OC_2H_5$

8. **Which functional group is present in alkenes?**

(a) No Functional group (b) Carbon - carbon triple bond

(c) Carbon - carbon double bond (d) Carbon-carbon single bond

Answers

1. (b) 2. (b) 3. (d) 4. (d) 5. (c) 6. (b)
7. (d) 8. (c)

B. Short Answer Questions

21.1 What is the difference between saturated and unsaturated hydrocarbons?

Ans. Saturated Hydrocarbons: The hydrocarbons in which all the four valencies of carbon are utilized using single bonds only are called saturated hydrocarbons or alkanes.

Unsaturated Hydrocarbons: The hydrocarbons containing at least one double or triple bond are called unsaturated hydrocarbons.

21.2 Write down the structural formula of Butan-2-ol.

Ans. The structural formula of Butan-2-ol is: $CH_3-\underset{OH}{\underset{|}{CH}}-CH_2-CH_3$

21.3 Why is ethylamine $CH_3-CH_2-NH_2$ called an organic compound?

Ans. Ethylamine ($CH_3-CH_2-NH_2$) is called an organic compound because it is a derivative of a hydrocarbon where a hydrogen atom is replaced by an amino group ($-NH_2$).

21.4 Write down the formula of an ester called ethyl methanoate.

Ans. The formulae of an ester called ethyl methanoate is as follows: $HCOCH_2CH_3$.

21.5 Define structural isomerism.

Ans. Structural Isomerism: Two or more compounds having the same molecular formula but different structural formulae and properties are said to be isomers and the phenomenon is called structural isomerism.

21.6 Give IUPAC name to $CH_3-CH_2-CH_2-CH_3$

Ans. The IUPAC name for $CH_3-CH_2-CH_2-CH_3$ is Butane (4 carbons in a straight saturated cain)

21.7 What is common in carboxyl group, amide functional group and ester functional group?

Ans. The common feature in the carboxyl group amide functional group and ester

functional group is the carbonyl goup (C = O).

All three groups contain a carbon atom double - bonded to an oxygen atom.

C. Constructed Response Questions

21.1 Why the members of a homologous series have similar chemical properties?

Ans. The members of a homologous series have similar chemical properties due to the prerence of the same functional group. Because the reactive part of the molecule is identical across the series, they under go the same types of chemical reactions.

21.2 How are the properties of 2–methyl propane different from n-butane, both containing the same number of carbon atoms?

Ans. Even though both share the molecular formula C_4H_{10}, they are structural isomers, meaning their atoms are bonded in different arrangements.

- **n-butane** is a stright - chain alkane. It has a larger surface area, leading to stronger intermolecular forces. This results in a higher boiling point (–0.5 °C).
- **2-methylpropane (isobutane)** is a branched chain alkane. Branching makes the molecule more spherical, decreasing its surcface area and weakening the intermolecular forces. This results in a lower boiling point (– 11.7 °C).

21.3 Write down the structural formulae of isomers shown by satruated hydrocarbon containing five carbon atoms.

Ans. A saturated hydrocarbon with five carbon is pentane (C_5H_{12}). It has three structural isomers:

i. **n – pentane:** $CH_3-CH_2-CH_2-CH_2-CH_3$

ii. **Isopentane (2 – methyl butane):** $CH_3-CH(CH_3)-CH_2-CH_3$

iii. **Neopentane (2,2 – dimethyl propane):** $(CH_3)_4C$ $\quad CH_3-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_3$

21.4 Write down the structural formula of the isomers shown by butene.

Ans. Butene (C_4H_8) exhibits isomerism based on the position of the double bond and the arrangement of the carbon skeleton:

i. **1-Butene:** The double bond is between the first and second carbon. $CH_2=CH-CH_2-CH_3$.

ii. **2-Butene:** the double bond in the centre. $CH_3-CH=CH-CH_3$

iii. **Isobutylene (2 – methyl propene):** A branched structure with a double bond. $CH_2=C(CH_3)-CH_3$

21.5 Explain the difference among functional group present in aldehyde, ketone and carboxylic acid.

Ans. All three contain the carbonyl group (C = O), but they differ in whatelse is attached to that carbon:

- **Aldehyde:** The carbonyl carbon is bonded to at least one hydrogen atom. It is

always located at the end of a carbon chain.

General Formula: R – CHO

- **Ketone:** The carbonyl carbon is bonded to two other carbon atoms. It is always located inside the carbon chain.

  General Formula: R – CO – R′
- **Carboxylic Acid:** The carbonyl carbon is bonded to hydroxyl group (–OH). This combination is called a carboxyl group.

  General Formula: R – COOH

D. Descriptive Questions

21.1 What is an organic compound? How organic compounds are classified based on the type of carbon chain present in them?

Ans. For answer see Q1

21.2 Explain structural formula giving examples.

Ans. For answer see Q2

21.3 Write down five characteristics of a homologous series.

Ans. For answer see Q3

21.4 Give IUPAC rules for naming alcohols.

Ans. For answer see Q11

21.5 Name the following compounds.

(a) $CH_3 - CH_2 - CH_2OH$ **(b)** $CH_3 - CH_2 - CHO$

(c) $CH_3 - CH_2 - CH_3 - COOH$ **(d)** $CH_3 - CH_2 - CO - O - CH_3$

(a) $CH_3 - CH_2 - CH_2OH$

Ans. Propan – 1 – ol

(b) $CH_3 - CH_2 - CHO$

Ans. Propanal

(c) $CH_3 - CH_2 - CH_3 - COOH$

Ans. Butanoic acid

(d) $CH_3 - CH_2 - CO - O - CH_3$

Ans. Methyl propanoate

CHAPTER 22 Hydrocarbons

Student Learning Outcomes

After studying this chapter, students will be able to:

- State that the bonding in alkenes includes a double carbon-carbon covalent bond and that alkenes are unsaturated hydrocarbons.
- Describe the manufacture of alkenes by the cracking of large alkane molecules using a high temperature and a catalyst.
- Describe the reasons for the cracking of large alkane molecules.
- Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine and $KMnO_4$.
- Describe the properties of alkenes in terms of addition reactions with: bromine or aqueous bromine
  - hydrogen in the presence of a nickel catalyst
  - steam in the presence of an acid catalyst and draw the structural or displayed formulae of the products
- Describe, using symbol equations, preparation of alkenes by elimination reaction in halogenoalkanes and alcohols.
- Identify alkynes as hydrocarbons containing triple carbon-carbon covalent bond and that alkynes are unsaturated hydrocarbons.
- Describe the use of ethyne as fuel for welding and in artificially ripening fruits.
- Describe separation of petroleum into useful fraction by fractional distillation.
- Describe how the properties of fractions obtained from petroleum change from the bottom to the top of the fractionating column, limited to:
  - decreasing chain length
  - higher volatility
  - lower boiling points
  - lower viscosity
- Name the uses of the fractions as:
  - refinery gas fraction for gas used in heating and cooking
  - gasoline/petrol fraction for fuel used in cars
  - naphtha fraction as a chemical feedstock
  - kerosene/paraffin fraction for jet fuel
  - diesel oil/gas oil fraction for fuel used in diesel engines.
  - fuel oil fraction for fuel used in ships and home heating systems
  - lubricating oil fraction for lubricants, waxes and polishes
  - bitumen fraction for making roads
- Name fossil fuels; coal, natural gas and petroleum

- Name methane as main constituent of natural gas
- State that petroleum is a mixture of hydrocarbons, compounds containing hydrogen and carbon only

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

22.1 Alkenes **22.2 Important Reactions of Alkenes** **22.3 Alkynes**

Q.1: What are alkenes. How are they prepared?

Ans. Alkenes:

Alkenes are unsaturated hydrocarbons containing one or more carbon double bond. They have Alkenes are also called olefins. The have general formula for alkenes is C_nH_{2n}.

Uses of alkenes: Alkenes are widely used in the synthesis of various products, like plastics and fuels.

Preparation of Alkenes: Alkenes may be prepared either by:

- Dehydration of alcohols
- Dehydrohalogenation of alkyl halides.
- Cracking of aikanes

- **By Dehydration of Alcohols:** Dehydration means removal of water molecule.

Dehydration of alcohols is carried out with a dehydrating agent like concentrated sulphuric acid.

$$\underset{\text{Ethanol}}{CH_3-CH_2-OH} \xrightarrow[H_2SO_4]{180^\circ C} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

- **By Dehydrohalogenation of Alkyl Halides:**

In dehydrohalogenation a molecule of hydrogen halide (HX) is removed from a molecule of alkyl halide.

Dehydrohalogenation of alkyl halides is done with potassium hydroxide dissolved in ethanol.

$$\underset{\text{Chloroethane}}{CH_3-CH_2Cl} + KOH \xrightarrow[\text{Alcohol}]{180^\circ C} \underset{\text{Ethene}}{CH_2=CH_2} + KCl + H_2O$$

This is an example of Elimation reactions.

Occurrence of Elimation Reactions: These reactions occur when a molecule is removed from a saturated compound to produce an unsaturated compound.

Q.2: Explain with examples the cracking of alkanes.

Ans. Cracking of alkanes to alkenes:

Cracking: Cracking is a process which is carried out to convert high molecular mass alkanes to lower alkanes and alkenes.

Explanation: The process is carried out by heating alkanes at high temperature in the absence of oxygen and in the presence of Zeolites as catalysts.

Importance of cracking: Cracking is important commercially because it produces:

- **Smaller Alkanes** Which are useful as fuel.
- **Alkenes (ethane and propene)** which are useful starting materials to produce many commercially important chemicals.

For Example: Kerosene oil and diesel oil which contain higher molecular mass alkanes are often cracked to give petrol, alkenes and hydrogen gas.

$$\text{Kerosene oil} \xrightarrow[500^\circ C]{\text{Catalyst}} \text{Petrol} + \text{Alkenes} + \text{Hydrogen gas}$$

$$C_{15}H_{32} \xrightarrow[500^\circ C]{\text{Zeolite}} \underset{\text{Ethene}}{2C_2H_4} + \underset{\text{Propene}}{C_3H_6} + \underset{\text{Octane}}{C_8H_{18}}$$

Q.3: Describe important reactions of alkenes.

Ans. Chemical Reactivity of alkenes: Alkenes are very reactive compounds. The Chemical reactivity of alkenes is due to the presence of carbon-carbon double bond.

Reactions: Alkenes undergo addition reactions.

Addition Reaction: Addition reactions are those reactions in which reactants combine to form a simple new product.

Addition of Hydrogen: Hydrogen is added to alkenes in the presence of nickel metal as a catalyst to give alkanes as the products. This reaction is called catalytic hydrogenation or catalytic reduction.

$$CH_2=CH_2 + H_2 \xrightarrow[150^\circ C,\ 2\ atm.\ pressure]{Ni} \underset{\text{Ethane}}{CH_3-CH_3}$$

Addition of Halogens:

$$CH_2=CH_2 + Br_2 \xrightarrow{CCl_4} \underset{\substack{| \\ Br}}{\overset{\substack{| \\ Br}}{CH_2-CH_2}}$$

1,2 - Dibromoethane

Oxidation with $KMnO_4$: Alkenes can also react with cold and dilute alkaline potassium permanganate to give an important compound called ethylene glycol or ethane–1,2–diol.

$$CH_2 = CH_2 + H_2O + [O] \xrightarrow{KMnO_4} \underset{\underset{OH}{|}}{CH_2} - \underset{\underset{OH}{|}}{CH_2}$$

Ethan-1, 2-diol (Glycol)

Addition of Hydrogen Halides:

Like halogens, hydrogen halides can also be added to a double bond of an alkene. These reactions are known as hydrohalogenation of alkenes.

$$\underset{\text{Ethene}}{CH_2 = CH_2} + \underset{\substack{\text{Hydrogen}\\ \text{Bromide}}}{HBr} \longrightarrow \underset{\text{Bromoethane}}{CH_3 - CH_2Br}$$

Addition of Water (Steam):

Alkenes react with water in the presence of sulphuric acid. The reaction takes place at around 300 °C. This is also called hydration reaction.

$$\underset{\text{But-1-ene}}{H-C=C-C-C-H} + H_2O \xrightarrow[300\ ^\circ C]{H_2SO_4} \underset{\text{Butan-2-ol}}{H-C-C-C-C-H}$$

But-1-ene + Water $\xrightarrow{H_2SO_4}$ Butan-2-ol

Q.4: How we can distinguish between saturated and unsaturated compounds?

Ans. Oxidation with $KMnO_4$:

$$CH_2 = CH_2 + H_2O + [O] \xrightarrow{KMnO_4} \underset{\underset{OH}{|}}{CH_2} - \underset{\underset{OH}{|}}{CH_2}$$

Ethan-1, 2-diol (Glycol)

Both halogenation and oxidation reactions may be used to detect the presence of an alkene. The reddish brown colour of bromine or purple colour of potassium permanganate is rapidly discharged when either two reacts with an alkene. Similarly alkenes also discharge the violet colour of iodine.

- These reaction are not given by saturated compounds or alkanes. Thus they are used to distinguish between saturated and unsaturated compounds (alkenes).

Q.5: Write a detailed note on alkynes.

Ans. Alkynes:

Alkynes are unsaturated hydrocarbons which contain at least one –C ° C – bond. They are represented by the general formula C_nH_{2n-2}.

Naming of Alknes:

Just like alkenes are also named by counting the number of carbon atoms present in the longest continuous chain that contains the triple bond.

$CH \equiv CH$ Ethyne	$CH_3 - C \equiv CH$ Propyne
$CH \equiv C - CH_2 - CH_3$ But-1-yne	$CH_3 - C \equiv C - CH_3$ But 2-yne

Ethyne or Acetylene Gas: The simplest unsaturated hydrocarbon containing triple bond is called ethyne or acetylene gas.

Uses of Acetylene:

For Welding:

It is commonly used for welding and cutting purposes because it produces a large amount of heat when it is ignited in the presence of oxygen or air.

Fig. 22.1: Acetylene torch

$$2CH \equiv CH + 5O_2 \longrightarrow 4CO_2 + 2H_2O + Heat$$

In the acetylene torch, acetylene gas burns in oxygen to produce CO_2 and H_2O. The high temperature of the oxy-acetylene flame speeds up the cutting and welding processes.

Ripening of Green fruits:

Acetylene gas is also used for ripening of green fruits. When solid calcium carbide reacts with moisture present in the air it produces acetylene gas which accelerates the ripening of the green fruits and induces a colour change.

22.4 Sources of organic Compounds

22.5 Refining of Petroleum

Q.6: Identify the major sources from which organic compounds can be obtained.

Ans. Organic Compounds: Organic compound are chemical compounds primarily composed of corbon atoms that are covalently bonded to each other or to other elements.

Sources of Organic Compounds: Organic compounds can be obtained from many sources. Three major sources of organic compounds are:

- Coal
- Petroleum
- Natural gas

Sources of aliphatic Hydrocarbons: Chief sources of aliphatic hydrocarbons are:

Source of Aromatic Hydrocarbons: Coal major source of aromatic hydrocarbons.

Natural gas: Natural gas is a mixture of many hydrocarbon gases, with methane (CH_4) being the largest component.

Petroleum: Petroleum and natural gas are mostly found together, held between the layers of non-porous rocks underground.

Extraction: When a well is drilled through the rock, the gas is released carrying with it some of more volatile liquids.

Collection of liquid Petroleum: After the flow of gases ceases, the liquid petroleum is

taken out with the help of pumps.

Liquid Petroleum: Liquid petroleum is a complex mixture of mainly aliphatic hydrocarbons.

Chemical Diversity of Petroleum: It has been estimated that when petroleum is boiled upto 400 °C, at least 500 compounds can be obtained.

Principal Products of Petroleum Refining: Although the principal products of petroleum refining are various types of fuels, yet a large number of other important chemicals can also be produced from these fuels.

For Example:

Alkenes: Petroleum products produce alkenes which are starting material to prepare plastics.

Benzene: Benzene, an aromatic hydrocarbons, may be produced from n-hexane.

Uses of Benzene: Benzene may be used to produce thousands of useful aromatic compounds like:

- Perfumes
- Drugs
- Dyes
- Photographic developers

Q.7: Describe the fractional distillation of petroleum.

Ans. Refining of Petroleum:

Petroleum in a crude state is a mixture of many hydrocarbons which do not burn easily. To make it useful, petroleum must be separated into different fractions by a process called refining of petroleum.

Fractional Distillation: Refining process involves the fractional distillation of petroleum at about 400 °C whereby it is separated into many useful fractions.

Neutralization: The first step in the refining process is neutralization of the crude oil by washing with acidic or basic solution as required.

Heating: The neutralized oil is then heated in an electric furnace above 400 °C and the resulting gases and vapours are allowed to pass into a tall factionating column.

Fractionating column:

The resulting gases and vapours are allowed to pass into a tall fractionating column

The column has a number of compartments divided into shelves having holes in them. These holes are covered with babble caps.

Refinery Gases:

When the oil is heated, the dissolved gases known as the refinery gases first go at the top of the fractionating column and escape there from the outlet.

Fractions with High Boiling Points:

As the temperature, the vapour start going up in the column where the hydrocarbon fractions which have high boiling points are easily condensed to liquids in the lower part of the column.

Fractions with Lower Boiling Points:

The fraction which have lower boiling point ranges rise up near the top of the column as vapours, which are then condensed into liquid state.

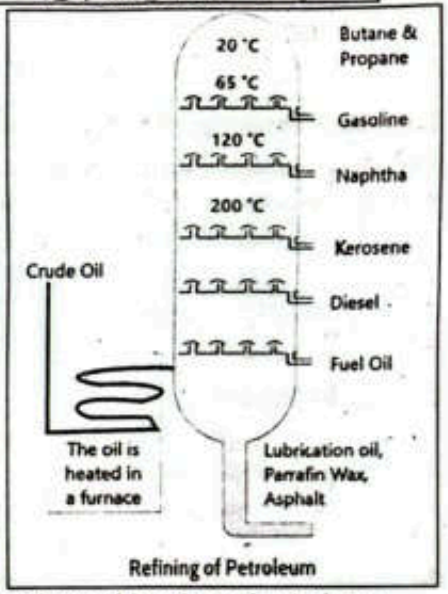
Collection of Condensed Liquid Fractions:

These condensed liquid fractions are collected on the various shelves from where they can be drained of into separate storage tanks.

Redistillation of Fractions:

The fractions thus separated are not without impurities from the other fractions.

They are then redialed to have a better separation of hydrocarbons.



Refining of Petroleum

Q.8: Write names, boiling range, composition and use of fractions of petroleum.

Ans. Fractions of petroleum and their uses.

Name of the Fraction	Appropriate boiling range (°C)	Range of carbon atoms in each Fraction	Uses
Refinery gases	Below 0	1–4	Refinery gases are liquified and sold as fuels for stoves
Gasoline (petrol)	0–65	5–6	Used to drive automobiles
Naphtha	65–170	6–10	It is used as source of many useful hydrocarbons
Kerosene oil	170–250	10–14	It is a fuel used in jet engines.
Diesel oil	250–340	14–19	Used to run cars, buses and trucks
Lubricating oil	340-500	19–35	Used in cars, buses and truck as lubricant, waxes and polishes
Fuel oil	340-500	Above 20	Used in ships and to run power plants

Bitumen	Above 500	Above 35	Used to construct roads and to water proof roofs and pipes.

Q.9: Which properties of petroleum fractions Change with their boiling points?

Ans. Each petroleum fraction contains a mixture of hydrocarbons. They have similar physical properties which depend upon the following factors.

(i) Number of carbon and hydrogen atoms present in the molecule of a fraction.
(ii) Volatility
(iii) Boiling point range
(iv) Viscosity

Effect of Boiling points:

As the boiling points increase, several key properties change in a predictable trend:

Increasing Molecular Masses:

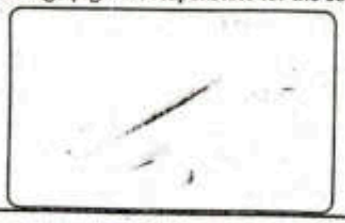
As the number of carbon and hydrogen atoms in the molecule of a hydrocarbons increases so does their molecular masses. As the molecular masses increase, this changes the strength of intermolecular forces between the molecules. Higher the molecular mass of a hydrocarbon stronger the intermolecular forces between its molecules. This fact affects the physical properties of hydrocarbons as well. Lower hydrocarbons have high volatility, low boiling points and lower viscosities. As the chain length increases their properties also show upward trends. So the fractions of the petroleum obtained at the top of the column have high volatilities, lower boiling ranges, lower viscosities and they are highly inflammable.

DO YOU KNOW?

The use of calcium carbide in our country is prohibited because it is known to cause serious health problems like dizziness, vomiting and skin ulcer.

INTERESTING INFORMATION

Alkenes occur abundantly in nature. Ethylene, for example is a plant harmone that induces ripening in fruit. An alkene β-carotene is an orange pigment responsible for the colour of carrots.



Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

22.1 Alkenes | 22.2 Important Reactions of Alkenes | 22.3 Alkynes

1. **Which of the following condition is required for the dehydration of ethanol to produce ethane?**
   (a) Alcoholic KOH at 180°C (b) Dilute H_2SO_4 at 100 °C
   (c) Concentrated H_2SO_4 at 180 °C (d) Nickel-catalyst at 150 °C
2. **Which term describes a reaction where a molecule is removed from a saturated compound to produce an unsaturated compound?**
   (a) Elimination reaction (b) Cracking
   (c) Hydrogenation (d) Catalytic reduction
3. **Which of the following is used as catalyst, in the industrial process of cracking?**
   (a) Nickel (b) Alcohol (c) Sulphuric acid (d) Zeolite
4. **What occurs when ethene is treated with hydrogen gas in the presence of a Nickel (Ni) catalyst at 150 °C?**
   (a) No reaction occurs (b) Ethene is reduced to ethane
   (c) Ethene is converted to etheyne (d) None of these
5. **It is a chemical test used to distinguish between saturated alkanes and unsaturated alkenes.**
   (a) Addition of bromine water (b) Reaction with concentrated H_2SO_4
   (c) Combustion in air (d) Reaction with Nickel catalyst
6. **When an alkene reacts with cold, dilute alkaline potassium permanganate, what happens to the purple colour?**
   (a) It remains unchanged (b) It is rapidly discharged
   (c) It turns deep blue (d) It turns bright red
7. **General formula for alkenes is:**
   (a) CH (b) C_nH_{2n} (c) C_nH_{2n-2} (d) –COOH
8. **Olefins is another name of:**
   (a) Alkynes (b) Alcohols (c) Alkenes (d) Butane
9. **Alkene β–carotene is a pigment of:**
   (a) Green colour (b) Pink colour (c) Yellow colour (d) Orange colour
10. **What is the general formula for alkynes?**
    (a) C_nH_{2n} (b) C_nH_{2n-2} (c) C_nH_n (d) C_nH_{2n+2}

11. **Hydrohalogenation of ethane with hydrogen bromide (HBr) results in the formation of which compound?**
(a) Ethane (b) Ethanol (c) Glycol (d) Bromoethane

12. **Which colour of bromine is discharged when it reacts with an alkene?**
(a) Reddish brown (b) Purple (c) Blue (d) Green

13. **When alkenes react with water in the presence of sulphuric acid, it is called:**
(a) Cracking (b) Catalytic reduction
(c) Hydration reaction (d) Dehydrohalogenation

14. **A molecule of hydrogen halide (HX) is removed from a molecule of alkyl halide in:**
(a) Dehydration (b) Dehydrohalogenation
(c) Hydrohalogenation (d) Hydration

15. **Kerosene oil and diesel oil are often cracked to give:**
(a) Petrol (b) Alkenes (c) Hydrogen gas (d) All of these

16. **Dehydration means:**
(a) Removal of water molecule (b) Removal of hydrogen halide
(c) Addition of hydrogen (d) Addition of halogen

17. **Hydration means:**
(a) Addition of halogen (b) Addition of hydrogen halide
(c) Addition of water (d) Addition of alcohol

18. **Which of the following is not an example of alkynes?**
(a) Propyne (b) Ethyne (c) Butyne (d) Ethene

19. **In the acetylene torch, acetylene gas burns in oxygen to produce:**
(a) CO_2 and CO (b) CO_2 and H_2O
(c) H_2O and CO (d) CO_2, H_2O and CO

20. **Calcium carbide is known to cause:**
(a) Dizziness (b) Vomiting (c) Skin ulcer (d) All of these

22.4 Sources of Organic compounds

22.5 Refining of Petroleum

22.6 Physical Properties of different Petroleum Fractions

21. **The major sources of organic compounds are:**
(a) Coal (b) Petroleum (c) Natural gas (d) All of these

22. **The chief sources of aliphatic hydrocarbony are:**
(a) Coal and petroleum (b) Natural gas and coal
(c) Natural gas and petroleum (d) coke and coal

23. **What is the major source of aromatic hydrocarbons?**
(a) Natural gas (b) Coal (c) Petroleum (d) None of these

24. **The largest component of natural gas is:**
(a) CH_4 (b) CO_2 (c) CO (d) O_2

25. **How many compounds can be obtained when petroleum is boiled upto 400°C?**
(a) 200 (b) 300 (c) 400 (d) 500

26. **Where are petroleum and natural gas primarily found?**
(a) Between layers of porous rocks (b) Between layers of non-porous rocky
(c) On the ground (d) All of these

27. **When a well is first drilled, what is usually the first substance released?**
(a) Crude oil (b) Natural gas (c) Water (d) Solid bitumen

28. **Chemically, liquid petroleum is a complex mixture consisting mainly of:**
(a) Aromatic hydrocarbons (b) Inorganic salts
(c) Aliphatic hydrocarbons (d) Gaseous oxides

29. **Which of the hydrocarbons are starting material to prepare plastics?**
(a) alkanes (b) Alkynes (c) Cycloalkanes (d) Alkenes

30. **Benzene may be used to produce aromatic compounds like perfumes and:**
(a) Drugs (b) Dyes
(c) Photographic developers (d) All of these

31. **Benzene a petroleum product may be produced from:**
(a) n-hexane (b) Methane (c) Propane (d) Ethylene

32. **Petroleum in its crude state is a mixture of many:**
(a) Elements (b) Hydrocarbons (c) Oxides (d) Metals

33. **The process used to separate crude oil into useful fractions is known as:**
(a) Evaporation (b) Filtration
(c) Fractional distillation (d) Neutralization

34. **Which fraction contains 14–19 carbon atoms per molecule?**
(a) Kerosene oil (b) Diesel oil (c) Fuel oil (d) Lubricating oil

35. **Which fraction has a boiling range below 0°C?**
(a) Kerosene oil (b) Diesel oil (c) Refinery gases (d) Gasoline

36. **Gasoline has range of carbon atoms:**
(a) 1–4 (b) 5–10 (c) 6–10 (d) 10–14

37. **It is used as source of many useful hydrocarbons.**
(a) Lubricating oil (b) Naphtha (c) Bitumen (d) Diesel oil

38. **Diesel oil is used to run:**
(a) Cars (b) Buses (c) Trucks (d) All of these

39. **It is the fracting having boiling point 340–500°C.**
(a) Fuel oil (b) Diesel oil (c) Bitumen (d) Lubricating oil

40. **Which of the following has range of carbon atom above 35?**
(a) Naphtha (b) Petrol (c) Fuel oil (d) Bitumen

41. **Lubricating oil has a range of carbon atoms:**
(a) 6–10 (b) 14–19 (c) 19–35 (d) Above 35

42. **170–250°C is a boiling range of:**
(a) Diesel oil (b) Kerosene oil (c) Gasoline (d) Fuel oil

43. **Diesel oil has a range of carbon atoms:**
(a) 14–19 (b) 5–6 (c) 10–14 (d) Above 20

44. Which of the following fraction has boiling range 65–170 °C?

(a) Gasoline (b) Naphtha (c) Fuel oil (d) Lubricating oil

45. As the number of carbon atoms in a hydrocarbon chain increases, the boiling point:

(a) Increases (b) Decreases

(c) Remains the same (d) Becomes zero

Answers

1.	(c)	2.	(a)	3.	(d)	4.	(b)	5.	(a)	6.	(b)	7.	(b)
8.	(c)	9.	(d)	10.	(b)	11.	(d)	12.	(a)	13.	(c)	14.	(b)
15.	(d)	16.	(a)	17.	(c)	18.	(d)	19.	(b)	20.	(d)	21.	(d)
22.	(c)	23.	(b)	24.	(a)	25.	(d)	26.	(b)	27.	(b)	28.	(c)
29.	(d)	30.	(d)	31.	(a)	32.	(b)	33.	(c)	34.	(b)	35.	(c)
36.	(b)	37.	(b)	38.	(d)	39.	(d)	40.	(d)	41.	(c)	42.	(b)
43.	(a)	44.	(b)	45.	(a)								

Additional Short Question

Short-Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

22.1 Alkenes **22.2 Important Reactions of Alkenes** **22.3 Alkynes**

1. What are alkenes?

Ans. Alkenes: Alkenes are unsaturated hydrocarbons containing one or more carbon-carbon double bond.

2. What is another name of alkenes?

Ans. Alkenes are also called olefins.

3. State the general formula for alkenes.

Ans. The general formula for alkenes is C_nH_{2n}.

4. Name three methods used to prepare alkenes.

Ans. Alkenes can be prepared by:

- Dehydration of alcohols
- Dehydrohalogenation of alkyl halides
- Cracking of alkenes.

5. For what purposes are alkenes used?

Ans. Alkenes are widely used in the synthesis of various products, like plastics and fuels.

6. What does dehydration mean?

Ans. Dehydration means removal of water molecule.

7. What is meant by the dehydration of alcohols?

Ans. Dehydration of alcohols means the removal of a water molecule from an alcohol. It is carried out with a dehydrating agent like concentrated sulphuric acid.

8. Write the chemical equation for the preparation of ethane from ethanol.

Ans. $\underset{\text{Ethanol}}{CH_3-CH_2-OH} \xrightarrow[H_2SO_4]{180^\circ C} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$

9. Define dehydrohalogenation of alkyl halides.

Ans. It is the removal of a molecule of hydrogen halide (HX) from a molecule of alkyl halide. It is done with potassium hydroxide dissolved in ethanol.

10. Write the chemical equation for the preparation of ethane from chloroethene.

Ans. $\underset{\text{Chloroethane}}{CH_3-CH_2Cl} + KOH \xrightarrow[\text{Alcohol}]{180^\circ C} \underset{\text{Ethene}}{CH_2=CH_2} + KCl + H_2O$

11. What is an elimination reaction?

Ans. It is a reaction that occurs when a molecule is removed from a saturated compound to produce an unsaturated compound.

12. What is cracking?

Ans. Cracking: Cracking is a process which is carried out to convert high molecular mass alkanes to lower alkanes and alkenes.

13. How is cracking carried out?

Ans. Cracking is carried out by heating alkenes at high temperature in the absence of oxygen and in the presence of zeolites as catalysts.

14. Why is cracking commercially important?

Ans. Cracking is important commercially because it produces smaller alkenes.

Smaller alkene which are useful as fuel.

Alkenes (ethene and propere) which are useful starting materials to produce many commercially important chemicals.

For Example: Kerosene oil and diesel oil which contain higher molecular mass alkanes are often cracked to give petrol, alkenes and hydrogen gas.

15. Why are alkenes considered to be very reactive compounds?

Ans. Alkenes are very reactive compounds. Their chemical reactivity is due to the presence of a carbon-carbon double bond.

16. What is catalytic hydrogenation?

Ans. Catalytic Hydrogenation: It is the addition of hydrogen to alkenes in the presence of nickel metal as a catalyst to give alkanes as the products.

17. What is another name of catalytic hydrogenation reaction?

Ans. Another name of catalytic hydrogenation reaction is catalytic reduction reaction.

18. How do alkenes react with halogens?

Ans. Halogens are readily added to alkenes in the presence of a non-polar solvent to give alkyl halides.

19. Name the product formed when ethane reacts with bromine.

Ans. When ethane reacts with bromine, 1, 2–Dibromoethane is formed.

20. Name the products obtained after cracking of kerosene oil and diesel oil.

Ans. Kerosene oil and diesel oil which contain higher molecular mass alkanes are often cracked to give petrol, alkenes and hydrogen gas.

21. What do kerosene oil and diesel oil contain?

Ans. Kerosene oil and diesel oil contain higher molecular mass alkanes.

22. Why do alkenes undergo addition reactions?

Ans. Alkenes undergo addition reactions because of the presence of a carbon-carbon double bond. In these reactions reactants combine to form a single new product.

23. What conditions are required for the hydrogenation of ethane?

Ans. Nickel (Ni) catalyst, a temperature of 150 °C and 2 atm pressure are required for the hydrogenation of ethane.

24. What is hydrohalogenation of alkenes?

Ans. It is a reaction in which hydrogen halides can be added to a double bond of an alkene.

25. Name the product formed when ethane reacts with hydrogen bromide.

Ans. Bromoethane is the product formed when ethane reacts with hydrogen bromide.

26. What is a hydration reaction?

Ans. Hydration Reaction: It is a reaction in which alkenes react with water in the presence of sulphuric acid. This reaction takes place at around 300°C.

27. What are alkynes?

Ans. Alkynes are unsaturated hydrocarbons which contain at least one $-C \equiv C-$ bond.

28. How are alkynes represented?

Ans. Alkynes are represented by the general formula $C_n H_{2n-2}$

29. How are alkynes named?

Ans. Alkynes are named by counting the number of carbon atoms present in the longest continuous chain that contains the triple bond.

Examples:

$CH \equiv CH$	$CH_3 - C \equiv CH$
Ethyne	Propyne
$Ch \equiv C-CH_2 - CH_3$	$CH_3 - C \equiv C-CH_3$
But – 1–yne	But – 2–yne

30. What is ethyne?

Ans. The simplest unsaturated hydrocarbon containing a triple bond is called ethyne or acetylene gas.

31. What alkeyne is used for welding and cutting purposes?

Ans. Ethyne or acetylene gas is used for welding and cutting purposes.

32. Write the balanced chemical equation for the combustion of ethyne.

Ans. $2CH \equiv CH + 5O_2 \longrightarrow 4CO_2 + 2H_2O + \text{Heat}$

33. How is acetylene gas used in the food industry?

Ans. Acetylene gas is used for the artificial ripening of green fruits, where it accelerates the ripening process and induces colour change.

34. Why is the use of calcium carbide prohibited in our country?

Ans. The use of calcium carbide is prohibited in our country because it is known to cause serious health problems like dizziners, vomiting and skin ulcer.

22.4	Sources of Organic Compounds
22.5	Refining of Petroleum

35. What are the three main sources of organic compounds?

Ans. The three main sources of organic compounds are coal, petroleum and natural gas.

36. What are the chief sources of aliphatic hydrocarbons?

Ans. Natural gas and petroleum are chief sources of aliphatic hydrocarbons.

37. What is liquid petroleum?

Ans. Liquid petroleum is a complex mixture of mainly aliphatic hydrocarbons.

38. Name the principal products of petroleum refining.

Ans. Although the principal products of petroleum refining are various types of fuels, yet a large number of other important chemicals can also be produced from these fuels, for example alkenes and benzene.

39. Which are the starting material to prepare plastics?

Ans. Alkenes are the starting material to prepare plastics.

40. What is benzene?

Ans. Benzene is an aromatic hydrocarbon, may be produced from n-hexane.

41. State the uses of benzene.

Ans. Benzene may be used to produce thousands of useful aromatic compounds like:

- Perfumes
- Drugs
- Dyes
- Photographic developers.

42. What is petroleum?

Ans. Petroleum: Petroleum in a crude state is a mixture of many hydrocarbons which do not burn easily. To make it useful, petroleum must be separated into different fractions by a process called refining of petroleum.

43. Which scientific method is used for refining of petroleum?

Ans. Fractional distillation is used for refining of petroleum at about 400°C.

44. At what temperature is fractional distillation done?

Ans. Fractional distillation is done at about 400°C.

45. What is the first step in the refining process after obtaining crude oil?

Ans. The first step in the refining process is neutralization of the crude oil by washing it with acidic or basic solution.

46. Where do the heaviest fractions collect in the fractionating column?

Ans. At the bottom of the fractionating column the heaviest fractions are collected.

47. Where do the hydrocarbon fractions having lower boiling points condense into liquid state in the fractionating column?

Ans. The hydrocarbon fractions having lower boiling points condense into liquid state near the top of the fractionating column.

48. What is the boiling range of refinery gases?

Ans. The boiling range of refinery gases is below 0°C.

49. What do you know about boiling range, carbon atoms range and uses of naphtha?

Ans. Boiling range: Boiling range of naphtha is 65–170°C.
Range of carbon atoms: Range of carbon atoms in naphtha is 6–10.
Uses: Naphtha is used as source of many useful hydrocarbons.

50. Tell boiling range, range of carbon atoms and uses of kerosene oil.

Ans. Boiling point: Boiling point of kerosene oil is 170–250°C.
Range of carbon atoms: Range of carbon atoms in kerosene oil is 10–14.
Uses: Kerosene oil is used in jet engines.

51. Can you tell the boiling range of diesel oil?

Ans. Boiling range of diesel oil is 250°C–340°C.

52. What is range of carbon atoms in diesel oil?

Ans. In diesel oil the range of carbon atoms is 14–19.

53. Tell uses of diesel oil.

Ans. Diesel oil is used to run cars, buses and trucks.

54. What is boiling range of fuel oil?

Ans. The boiling range of fuel oil is 340°C–500°C.

55. Tell range of carbon atoms in fuel oil.

Ans. Range of carbon atoms in fuel oil is above 20.

56. Discuss uses of fuel oil.

Ans. Fuel oil is used in ships and to run power plants.

57. What is boiling range, carbon atom range and use of bitumen?

Ans. Boiling range: Boiling range of bitumen is above 500°C.
Range of carbon atoms: Range of carbon atoms of bitumen is above 35.
Uses: Bitumen is used to construct roads and to water proof roofs and pipes.

58. What happens to the temperature as you move from the bottom to the top of the fractionating column?

Ans. The temperature decreases as we move from the bottom to the top of the fractionating column.

59. Which fraction is used to drive automobiles?

Ans. Gasoline (petrol) is used to drive automobiles.

60. Name the fraction that is used in jet engines.

Ans. Kerosene oil is used in jet engines.

61. Which fractions is used to run cars, buses and trucks.

Ans. Diesel oil is used to run cars, buses and trucks.

62. Name the fraction that is used in ships and to run power plants.

Ans. Fuel oil is used in ships and to run power plants.

63. List four factors that determine the physical properties of a petroleum fractions.

Ans. Four following factors determine the physical properties of a petroleum fractions.

(i) Number of carbon and hydrogen atoms present in the molecule of a fraction.
(ii) Volatility. (iii) Boiling point range. (iv) Viscosity.

64. How does the number of carbon atoms affect the boiling point of a fraction?

Ans. As the number of carbon atoms increases, the molecular mass and intermolecular forces increase, leading to a higher boiling point.

65. Why are fractions at the top of the column more inflammable?

Ans. Fractions at the top of the column are more inflammable because they have high volatility and low boiling points, meaning they turn into vapour and ignite more easily them heaver fractions.

66. Which fractions have high viscosity?

Ans. Fractions with more carbon atoms (like bitumen) have high viscosity.

67. What is volatility?

Ans. Volatility: It is the tendency of a substance to evaporate (turn into gas).

68. Which fractions have high volatility?

Ans. Fractions at the top of the fractionating column have high volatility.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Which of the following compounds is expected to give addition reaction?
(a) $CH_3 - CH_3$ (b) $CH_2 = CH_2$ (c) CH_4 (d) $CH_3–CH_2–CH_3$

2. Which of the followings is not used as a fuel?
(a) LPG (b) CNG (c) Diesel (d) Asphalt

3. Indicate the type of the following reaction.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

(a) Substitution (b) Oxidation (c) Reduction (d) Addition

4. Which species acts as a reducing agent in the reaction between ethene and $KMnO_4$?
(a) H_2O (b) $CH_2 = CH_2$ (c) $KMnO_4$ (d) NaOH

5. The product which will be formed when propene reacts with bromine molecule.
(a) 1,2–Dibromopropane (b) 1,1–Dibromopropane
(c) 2,3–Dibromopropane (d) 1,3–Dibromopropane

6. Select the name of the petroleum fraction which generates electricity in power plants.
(a) Bitumen (b) Lubricating oil (c) Kerosene oil (d) Fuel oil

7. The molecule eliminated in the following reaction is:

$$CH_3 - CH_2 - Br + KOH \xrightarrow{\text{Ethanol}} CH_2 = CH_2 + KBr + H_2O$$

(a) Br_2 (b) H_2 (c) HBr (d) H_2O

8. **Fractional distillation of petroleum is based on:**
   (a) Viscosity (b) Boiling point range
   (c) Flammability (d) Melting point range

Answers

1 (b) 2 (d) 3 (b) 4 (b) 5 (a) 6 (d) 7 (c) 8 (b)

B. Short Answer Questions

22.1 Give two examples of addition reactions.

Ans. Addition Reactions: Addition reactions are those reactions in which reactants combine to form a single new product.

Example of Addition Reactions:

Addition of Hydrogen: Hydrogen is added to alkenes in the presence of nickel metal as a catalyst to give alkanes as the products.

$$CH_2 = CH_2 + H_2 \xrightarrow[150\ ^\circ C,\ 2\ atm.\ pressure]{Ni} \underset{Ethane}{CH_3 - CH_3}$$

22.2 Give the names of the compounds obtained from coal tar and petroleum.

Ans. Compounds obtained from coal tar: Following compounds are obtained from coal tar:

- Benzene
- Toluene
- Phenol
- Naphthalene

Compounds obtained from petroleum: Following compounds are obtained for petroleum:

- Refinery gases
- Gasoline (petrol)
- Naphtha
- Kerosene oil
- Diesel oil
- Lubricating oil
- Fuel oil
- Bitumen

22.3 How ethene is oxidized by cold aqueous solution of potassium permanganate.

Ans. Oxidation with $KMnO_4$: Alkenes can react with cold and dilute alkaline potassium permanganate to give an important compound called ethane-1,2–diol.

$$CH_2 = CH_2 + H_2O + [O] \xrightarrow{KMnO_4} \underset{\substack{OH\quad OH\\ Ethan\text{-}1,\ 2\text{-}diol\ (Glycol)}}{CH_2 - CH_2}$$

22.4 Differentiate between elimination and addition reactions.

Ans. Elimination Reaction: It is a reaction that occurs when a molecule is removed from a saturated compound to produce an unsaturated compound.

Example:

$$\underset{Chloroethane}{CH_3 - CH_2Cl} + KOH \xrightarrow[Alcohol]{180^\circ C} \underset{Ethene}{CH_2 = CH_2} + KCl + H_2O$$

Addition Reaction:

Addition reaction is the reaction in which reactants combine to form a single new product.

Example:

$$CH_2 = CH_2 + H_2 \xrightarrow[150\ ^\circ C,\ 2\ atm.\ pressure]{Ni} CH_3 - CH_3$$

22.5 Name the starting materials used to generate oxyacetylene flame:

Ans. Oxygen and acetylene gas (C_2H_2) are the starting materials used to generate oxyacetylene flame.

22.6 How can an alkene be identified?

Ans. Alkenes can be identified by following reactions:

- Halogenation reaction
- Oxidation reaction
- Iodine Test

Halogenation Reaction:

When bromine is added to an alkene, the reddish brown colour of bromine is rapidly discharged.

$$CH_2 = CH_2 + Br_2 \xrightarrow{CCl_4} \underset{\substack{|\quad\quad |\\ Br\quad Br}}{CH_2 - CH_2}$$

Oxidation Reaction:

When an alkene reacts with cold and dilute alkaline potassium permanganate, the purple colour of potassium permanganate is rapidly discharged.

$$CH_2 = CH_2 + H_2O + [O] \xrightarrow{KMnO_4} \underset{\substack{OH\quad OH\\ Ethan\text{-}1,\ 2\text{-}diol\ (Glycol)}}{CH_2 - CH_2}$$

Iodine Test:

Similarly alkenes also discharge the voilet colour of iodine.

C. Constructed Response Questions

22.1 What is the difference between the terms dehydration and dehydrohalogenation?

Ans. Dehydration means removal of water molecule from an alcohol using a dehydrating agent like concentrated sulphuric acid.

$$CH_3-CH_2-OH \xrightarrow[H_2SO_4]{180^\circ C} CH_2=CH_2 + H_2O$$

Dehydrohalogenation:

Dehydrohalogenation means removal of a molecule of hydrogen halide (HX) from a molecule of alkyl halide using alcoholic KOH.

$$CH_3-CH_2Cl + KOH \xrightarrow[Alcohol]{180^\circ C} CH_2=CH_2 + KCl + H_2O$$

22.2 You have got two test tubes A and B containing a saturated and unsaturated compound (Alkene). How will you identify the two?

Ans. Identification of saturated and unsaturated compounds:

Add bromine water to both the test tubes. The test tube where the reddish brown colour disappears contains the alkene (unsaturated compound).

The test tube where the colour remains same contains the saturated compound.

22.3 Why is oxyacetylene flame so hot?

Ans. Ethyne (acetylene) has a high carbon-to-carbon hydrogen ratio. When burned in oxygen, it undergoes complete combustion, releasing a massive amount of energy (3000°C) because the triple bond energy is released rapidly. This is why oxyacetylene flame is so hot.

22.4 Do you expect ethyne to decolourize a cold solution of KMnO4?

Ans. Yes, Ethyne is unsaturated (contains a triple bond). Like alkenes, when ethyne is allowed to react with cold basic $KMnO_4$ solution then the triple bond present in the ethyne is oxidized by $KMnO_4$. It means, the two groups of (–OH) add on each carbon. Each carbon loses one water molecule to give a Ethan–1,2–diol as a product.

The compound (Ethan–1,2–diol) compound is an unstable compound. So, it undergoes further oxidation to form oxalic acid.

$$CH \equiv CH + 2[O] + 2H_2O \xrightarrow{Alkaline\ KMnO_4} CHO-CHO + 2[O] \text{ Ethan–1,2–diol}$$

$$\longrightarrow COOH-COOH$$

Oxalic acid

22.5 How do chlorine and hydrogen chloride add to ethene?

Ans. Reaction of Chlorine with Ethene:

Chlorine reacts with ethane to form 1,2–dichloroethene.

$$CH_2=CH_2 + Cl_2 \longrightarrow Cl-CH_2-CH_2-Cl$$

1,2–dichaloroethane

Reaction of Hydrogen Chloride with Ethene:

Hydrogen Chloride reacts with ethene to form chloroethane.

$$CH_2=CH_2 + HCl \longrightarrow CH_3-CH_2-Cl$$

Chloroethane

D. Descriptive Questions

22.1 Describe two methods of preparation for ethene.

Ans. For answer see Q1

22.2 Describe the fractional distillation of petroleum.

Ans. For answer see Q7

22.3 Which properties of petroleum fractions change with their boiling points?

Ans. For answer see Q9

22.4 Explain with examples the cracking of alkanes.

Ans. For answer see Q2

22.5 Give uses of acetylene.

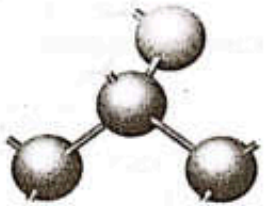
Ans. For answer see Q5 (uses of Acetylene)

CHAPTER 23 Monohydroxy Alkanes or Alcohols

Student Learning Outcomes

After studying this chapter, students will be able to::

- Describe the manufacture of ethanol (This can be done by discussing fermentation of aqueous glucose at 25-35 °C in the presence of yeast and in the absence of oxygen catalytic addition of steam to ethene at 300°C and 6000kPa /6 atm in the presence of an acid catalyst including a comparison of the advantages and disadvantages of the two methods)
- Describe the combustion of alcohols
- Discuss the applications of alcohols as fuels, including their advantages and disadvantages over fossil fuels.
- Explain the role of alcohols in various industries such as pharmaceuticals, cosmetics, and fuel production.
- Discuss the impact of alcohols on daily life, including their use as solvents and disinfectants.



Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: Describe the preparation of ethanol by fermentation process.

Ans. Ethanol:

Ethyl alcohol or ethanol is a very important member of homologous series of Monohydroxy alkanes or alcohols. It is manufactured on large scale by the fermentation

of glucose by yeast.

Fermentation of Glucose by Yeast:

Fermentation is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.

Examples:

Preparation of yogurt, bread and ethyl alcohol are some examples of the fermentation reactions.

The Chemical Process:

Glucose can be converted to ethyl alcohol in the presence of yeast at around 35°C and in a neutral or acidic solution.

This fermentation reaction must be carried out in the absence of air (anaerobic conditions) to obtain ethanol.

Catalyst:

Yeast contains an enzyme which acts as a catalyst in this reaction.

Balanced Chemical Equation:

The balanced chemical equation for the fermentation of glucose is as follows:

$$C_6H_{12}O_6 \underset{\text{Yeast}}{\overset{35^\circ C}{\rightleftharpoons}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

Products of the Reaction:

Carbon dioxide gas comes out of the reaction mixture leaving behind a mixture of ethanol and water.

Conditions for Reaction:

Temperature Sensitivity:

The temperature of the process must be kept around 35°C to get the maximum yield of the product.

- A lower temperature decreases the rate of the reaction.
- The higher temperature makes the enzyme inactive in anaerobic conditions.

Exclusion of Oxygen:

Oxygen is excluded from the reaction because it converts the resulting ethanol into ethanoic acid.

Alcohol concentration:

Since ethanol is toxic to yeast in high concentration, yeast is made inactive when the concentration of ethanol in the reaction mixture exceeds 15%.

Q.2: Discuss the preparation of ethanol by hydration of ethene or Ethylene.

Ans. Preparation of Ethanol:

It is prepared in the industries on large scale by the hydration of Ethene or Ethylene which is discussed below.

Hydration of Ethene or Ethylene:

Hydration of ethene is an addition reaction. In this reaction water is added across

the double bond of the ethene.

The reaction is carried out by passing a mixture of ethene and steam over hot phosphoric acid (H_3PO_4), which acts a catalyst.

Mechanism:

Hydrogen atom of H_2O attaches itself to one carbon atom of ethene and the hydroxyl group to other atom. During this addition, the double bond breaks down to give a saturated compound, ethanol.

Chemical Equation:

$$\underset{\text{Ethene}}{CH_2 = CH_2} + H_2O \xrightarrow[300^\circ C,\ 60\ \text{atm. pressure}]{H_3PO_4} \underset{\text{Ethanol}}{CH_3 - CH_2OH}$$

Gaseous ethanol obtained is then condensed into its liquid form.

Industrial Importance and Applications:

Hydration of ethene is an important industrial process because ethanol is a versatile compound. It has a wide range of applications from alcoholic drinks to fuels and as a solvent.

Q.3: Give a comparison of fermentation reaction and catalytic hydration of ethene for the preparation of ethanol.

Ans. Comparison of Methods of Production of ethanol:

Hydration of Ethene	Fermentation
Reaction is performed at high temperature and at high pressure.	It takes place at around 35°C and at atomspheric pressure.
Starting material for the process is obtained from crude oil, which is a non-renewable source.	Starting material for this method is a renewable source, such as cane-sugar.
Rate of reaction is high.	Rate of reaction is low. It may take days to complete.
The reaction produces relatively pure alcohol.	The reaction produces 15% alcohol which needs further distillation to increase the concentration. Distillation requires energy.
Ethanol produced in this method is expensive.	Ethanol produced in this process is cheap.

Q.4: Explain combustion of Alcohols.

(OR) Explain why the amount of heat evolved (ΔH) increases as you move from methanol to butanol in the homologous series.

Ans. Combustion of Alcohols:

Alcohols are flammable, therefore, burn in air to produce CO_2 and H_2O evolving a large amount of heat.

Example:

Methanol, ethanol and 1-propanal, all burn completely in excess of air because they contain a hydrocarbon chain.

Balanced Chemical Equations:

$$\underset{\text{Methanol}}{2CH_3OH} + 3O_2 \longrightarrow 2CO_2 + 4H_2O\ \Delta H = -726\text{kJ/mol}$$

$$\underset{\text{Ethanol}}{C_2H_5OH} + 3O_2 \longrightarrow 2CO_2 + 3H_2O\ \Delta H = -1367\ \text{kJ/mol}$$

$$\underset{\text{Propanol}}{2C_3H_7OH} + 9O_2 \longrightarrow 6CO_2 + 8H_2O\ \Delta H = -2017\ \text{kJ/mol}$$

$$\underset{\text{Butanol}}{2C_4H_9OH} + 12O_2 \longrightarrow 8CO_2 + 10H_2O\ \Delta H = -2676\text{kJ/mol}$$

Mechanism of Heat Evolution:

During combustion of alcohols:

- The weaker C–H bonds in C–H_2 groups break the stronger C=O and O–H bonds are formed in CO_2 and H_2O respectively.

This explains the reason due to which the amount of heat evolved increases with the addition of a $-CH_2$ group in the alcohol homologous series.

23.3	Applications of Alcohols as Fuels
23.4	Role of Ethanol in Industries
23.5	Impact of Alcohols on Daily Life

Q.5: Describe applications of Alcohols as fuels.

(OR) Describe advantages and disadvantages of alcohols as fuels.

Ans. Applications of Alcohols as Fuels:

Alcohols are also used as fuels instead of petrol and diesel to run an automobile.

The first four aliphatic alcohols namely methanol, ethanol, propanol and butanol have such properties which make them suitable to be used in internal combustion engines.

Advantages of Alcohols as Fuels:

(i) Alcohols are obtained from renewable sources.
(ii) Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.
(iii) Alcohols have higher fuel efficiency as compared to petrol or diesel fuels.

Disadvantages of Alcohols as Fuels:

(i) Alcohols have less energy per volume than gasoline. It means more fuel is needed to travel the same distance.
(ii) Alcohols can increase wear and tear on engine components.
(iii) Land is utilized to grow crops which then yield alcohols. This fact affects the

cultivation of food crops.

Q.6: Discuss the applications of ethanol in Pharmaceutical industry.

Ans. Role of Ethanol in Pharmaceutical Industry:

Ethyl alcohol serves as a very common ingredient in a variety of manufacturing processes in pharmaceutical industry.

(i) It possesses bactericidal activity and it is often used as a disinfectant in hand sanitizer and ethylated spirit.

(ii) It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.

(iii) Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.

Q.7: Describe the applications of ethanol in cosmetic industry.

Ans. Role of Ethanol in Cosmetic Industry:

Ethyl alcohol plays an important role in cosmetic industry because of its following properties:

(i) Being highly volatile it evaporates in a very short time.

(ii) Deodorizing and anti-inflammatory properties.

(iii) Refreshing and antimicrobial properties.

Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.

Q.8: Explain impact of alcohols on daily life.

Ans. Impact of Alcohols on Daily Life:

(i) Ethyl alcohol is an essential part of first aid kit in every home in the form of methylated spirit.

Ethylated spirit is used as an antiseptic, for dressing of wounds. As an antidote for snake bites.

(ii) In many parts of the world, ethanol is used as high efficiency fuel to drive vehicles.

(iii) Ethanol is widely used as a solvent in perfumes.

(iv) It is relatively safe and can be used to dissolve many organic compounds which are insoluble in water.

23.1 Quick Check!

1. What is the role of yeast in fermentation reaction?

Ans. Yeast acts as a biological catalyst. It contains enzymes (specifically Zymase) that provide the necessary chemical pathway to break down glucose into ethyl alcohol and carbon dioxide.

2. At which temperature enzymes present in yeast get inactive?

Ans. The enzymes present in yeast become inactive at temperatures higher than 35 °C.

23.2 Quick Check!

1. Why oxygen is excluded when the fermentation reaction is carried out?

Ans. Oxygen is excluded when the fermentation reaction is carried out because it converts the resulting ethanol into ethanoic acid.

2. Which method for the preparation of ethene involves renewable source?

Ans. Fermentation is the method for the preparation of ethane that involves renewable source, such as cane-sugar.

23.3 Quick Check!

1. Why does butanol evolve a higher amount of heat than propanol when burnt in oxygen?

Ans. Butanol evolve more heat then propanol when burnt because butanol has a longer hydrocarbon chain more bonds to react, leading to the formation of more CO_2 and H_2O molecules, which releases more energy (heat).

23.4 Quick Check!

1. Why does the amount of heat evolved during burning of alcohols go on increasing from lower to higher alcohols?

Ans. The amount of heat evolved during burning of alcohols go on increasing from lower to higher alcohols due to the following reasons.

- Higher alcohols have more carbon and hydrogen atoms in their molecules. For example, Methanol has ore carbon (CH_3OH), while Ethanol has two (C_2H_5OH).
- During combustion of alcohols the weaker C-H bonds in-CH groups break and the stronger C=O and O-H bonds are formed in CO_2 and H_2O respectively. As the molecules size increases, there are more C-H and C-C bonds available to react.
- Each additional–CH_2– group in the homologous series adds a consistent amount of energy to the total heat evolved. Therefore, the more fuel (Carbon and hydrogen) present per molecule, the more energy is released upon burning.

2. Why burning of alcohols does not produce oxides of sulphur unlike fossil fuels?

Ans. Alcohols are obtained from renewable souces consisting of carbon (C), hydrogen (H) and Oxygen (O). They do not contain sulphur. When these burn, they only produce CO_2 and H_2O. No oxides of sulphur are formed during their combustion.

On the other hand, fossil fuels are formed from ancient organic matter that often contains sulphur impurities. When there fossil fuels are burned, the sulphur reacts with oxygen to form sulphur dioxide (SO_2) or sulphur trioxide (SO_3) which causes pollution.

INTERESTING INFORMATION

- Alcohols are produced from plant materials which, in turn, are the result of the photosynthesis process using CO_2 of the atmosphere. The same CO_2 is generated when these bioalcohols are burnt in internal combustion engine. The overall process is considered to be carbon neutral because it does not increase the concentration of carbon dioxide gas in the atmosphere.
- Ethanol as a fuel reduces greenhouse gas emissions by 44 to 52% as compared to petrol. Besides this, ethanol also cuts down on other harmful pollutants like CO_x NO_x and particulate matter.

DO YOU KNOW?

- Ethyl alcohol as a drink can cause hangover, alcohol poisoning, accidents and risky behaviour. Long-term use of alcohol is known to cause more than 200 different diseases.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

23.1 Manufacture of Ethyl Alcohol ($CH_3 - CH_2 - OH$)

23.2 Combustion of Alcohols

1. **What is the biological process of breaking down complex substances into simpler ones using yeast enzymes called?**
   (a) Fermentation (b) Oxidation (c) Distillation (d) Reduction
2. **Which of the following specific substance is converted into ethyl alcohol in the presence of yeast?**
   (a) Ethanoic acid (b) Glucose (c) Yogurt (d) Carbon dioxide
3. **What is the ideal temperature for the fermentation process to achieve the maximum yield?**
   (a) 15 °C (b) 25 °C (c) 35 °C (d) 45 °C
4. **Fermentation must be carried out in the absence of air, a condition known as:**
   (a) Aerobic (b) Acidic (c) Anaerobic (d) Basic
5. **According to the balanced chemical equation, what is the by product of fermentation along with ethanol?**
   (a) Water (b) Carbon dioxide (c) Oxygen (d) Nitrogen
6. **If oxygen is not excluded from the reaction, ethanol will be converted into:**
   (a) Ethanoic acid (b) Yeast (c) Glucose (d) methanol
7. **Why does the fermentation process stop when the alcohol concentration exceeds 15%.**
   (a) The glucose runs out (b) The temperature drops
   (c) Ethanol becomes toxic to the yeast (d) Oxygen enters the mixture
8. **What happens to the yeast enzymes if the temperature of the process becomes too high?**
   (a) They work faster (b) They produce more gas
   (c) They become inactive (d) They turn into glucose
9. **In what type of solution should the fermentation reaction be carried out?**
   (a) Strongly basic (b) Neutral or acidic (c) Highly alkaline (d) None of these
10. **What role does yeast play in the Chemical reaction?**
    (a) Reactant (b) Solvent (c) Catalyst (d) Product
11. **Which of the following is a specific example of a fermentation reaction?**
    (a) Preparation of bread (b) Melting ice

(c) Burning wood (d) Boiling water

12. **What is the effect of a lower temperature on the fermentation process?**
    (a) It makes the yeast toxic (b) It decreases the rate of the reaction
    (c) It turns ethanol into glucose (d) It increases the yield of product
13. **What is the state of the carbon dioxide as it leaves the mixture during fermentation?**
    (a) Solid (b) Liquid (c) Gas (d) Plasma
14. **What remains behind in the mixture after carbon dioxide gas comes out during fermentation?**
    (a) Glucose (b) Yeast
    (c) Ethanoic acid (d) Ethanol and water
15. **What temperature is necessary for the yeast enzymes to remain active?**
    (a) Above 50 °C (b) Around 35 °C (c) Below 45 °C (d) At 75 °C
16. **On burning in air, alcohols produce:**
    (a) Carbon dioxide (b) Water (c) Large amount of heat (d) All of these
17. **How much heat is produced in the following reaction?**
    $2CH_2OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O\ \Delta H =$
    (a) 1367 kJ/mol (b) 2017 kJ/mol (c) 726 kJ/mol (d) 2676 kJ/mol
18. **How much heat is produced when ethanol burns in excess of air?**
    (a) 1367 kJ/mol (b) 26 kJ/mol (c) 2017 kJ/mol (d) 726 kJ/mol
19. **When propanol burns in excess of air; _____ energy is produced.**
    (a) 726 kJ/mol (b) 2017 kJ/mol (c) 1367 kJ/mol (d) 2676 kJ/mol
20. **It is the energy produced when butanol burns in air.**
    (a) 726 kJ/mol (b) 1367 kJ/mol (c) 2017 kJ/mol (d) 2676 kJ/mol
21. **It is a formula of ethanol.**
    (a) CH_2OH (b) C_2H_5OH (c) C_3H_7OH (d) C_4H_4OH
22. **What type of chemical reaction occurs during the hydration of ethene to produce ethanol?**
    (a) Addition reaction (b) Substitution reaction
    (c) Elimination reaction (d) Redox reaction
23. **Which catalyst is essential for the industrial hydration of ethene?**
    (a) Nickel (Ni) (b) Phosphoric acid (H_3PO_4)
    (c) Iron (Fe) (d) Manganese dioxide (MnO_2)
24. **What are the standard industrial conditions for the hydration of ethene?**
    (a) 35 °C and 1 atm pressure (b) 300 °C and 60 atm pressure
    (c) 100 °C and 200 atm pressure (d) 500 °C and 10 atm pressure
25. **Comparing the cost and purity, which method produces expensive bat pure ethanol?**
    (a) Combustion (b) Hydration of ethene
    (c) Fermentation (d) Hydration of ethene

23.3 Applications of Alcohols as Fuels

23.4 Role of Ethanol in Industries

23.5 Impact of Alcohols on Daily Life

26. What is the chemical name for H_3PO_4?
(a) Sulphuric acid (b) Phosphoric acid (c) Hydrochloric acid (d) Nitric acid

27. Hydration of ethane turns an unsaturated bond into a _____ compound.
(a) Saturated (b) Acidic (c) Basic (d) Gaseous

28. In the hydration reaction, ethane reacts with:
(a) Liquid water (b) Steam (gas) (c) Ice (Solid) (d) All of these

29. Which process is "Green" or uses renewable sources?
(a) Hydration (b) Fermentation (c) Combustion (d) Distillation

30. Ethanol made from crude oil is usually:
(a) Cheap (b) Free (c) Expensive (d) Unavailable

31. Which alcohol has the shortest carbon chain?
(a) Ethanol (b) Butanol (c) Methanol (d) Propanol

32. Which of the following alcohol has the longest carbon chain?
(a) Methanol (b) Ethanol (c) Propanol (d) Butanol

33. Select the alcohols which are commonly used in internal combustion engines.
(a) Methanol, ethanol (b) Propanol, butanol
(c) Pentanol, hexanol (d) a and b both

34. Which harmful pollutant, common in fossil fuels, is NOT produced when burning alcohols?
(a) Water vapour (b) Carbon dioxide
(c) Oxides of sulphur (d) Nitrogen oxides

35. How does the heat evolved during combustion change as you move from lower to higher alcohols?
(a) It decreases (b) It increases
(c) It disappears (d) It remain constant

36. Which of the following is used in hand sanitizers?
(a) Ethanol (b) Butanol (c) Propanol (d) Methanol

37. Ethanol is used in hand sanitizers primarily because of its:
(a) Colour (b) Smell
(c) Slow evaporation (d) Bactericidal activity

38. In the pharmaceutical industry, methylated spirit is often used as a/an.
(a) Antiseptic (b) Antibiotic (c) Vaccine (d) Painkiller

39. By what percentage ethanol can reduce greenhouse gas emissions compared to petrol?
(a) 10% to 20% (b) 90% to 100% (c) 44% to 52% (d) 30% to 49%

40. Which of these is a known long-term health risk of alcohol consumption?
(a) Improve memory (b) Enhanced driving skills
(c) Stronger immune system
(d) Cause of more than 200 different diseases

41. Which of the following is also used as an antidote for snake bites?
(a) Propanol (b) Butanol (c) Methanol (d) Ethanol

42. Ethanol evaporate very quickly when put on the skin because it is:
(a) Very heavy (b) A solid (c) Highly volatile (d) Freezing cold

43. Which of the following is used in a first aid kit to clean wounds?
(a) Cooking oil (b) Diesel
(c) Petrol (d) Methylated spirit

44. Which gas is NOT made when you burn pure alcohol?
(a) Water vapour (b) Oxides of sulphur
(c) Carbon dioxide (d) Oxygen

45. In the pharmaceutical industry, ethanol is used as a preservaties in :
(a) Bandages (b) Gauze (c) Vaccines (d) Pyodine

46. Ethanol and _____ help solubilize many drugs.
(a) Isopropanol (b) Butanol (c) Propanol (d) Methanol

47. Alcohols have higher fuel efficiency as compared to:
(a) Petrol (b) Diesel (c) Kerosene oil (d) a and b both

Answers

1.	(a)	2.	(b)	3.	(c)	4.	(c)	5.	(b)	6.	(a)	7.	(c)
8.	(c)	9.	(b)	10.	(c)	11.	(a)	12.	(b)	13.	(c)	14.	(d)
15.	(b)	16.	(d)	17.	(c)	18.	(a)	19.	(b)	20.	(d)	21.	(b)
22.	(a)	23.	(b)	24.	(b)	25.	(d)	26.	(b)	27.	(a)	28.	(b)
29.	(b)	30.	(c)	31.	(c)	32.	(d)	33.	(d)	34.	(c)	35.	(b)
36.	(a)	37.	(d)	38.	(a)	39.	(c)	40.	(d)	41.	(d)	42.	(c)
43.	(d)	44.	(b)	45.	(c)	46.	(a)	47.	(d)				

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

23.1 Manufacture of Ethyl Alcohol ($CH_3 - CH_2 - OH$)

23.2 Combustion of Alcohols

1. What are Monohydroxy alkanes or alcohols?
Ans. Monohydroxy alkanes or alcohols are an important class of organic compounds.

2. How can Monohydroxy alkanes or alcohols be obtained?
Ans. Some of these alcohols can be obtained by the reactions in which living organisms

are used as catalysts. They can also be synthesized in the laboratory.

3. What is ethyl alcohol or ethanol?

Ans. Ethyl alcohol or ethanol is a very important member of homologous series of monohydroxy alkanes or alcohols.

4. How is ethyl alcohol or ethanol manufactured on large scale?

Ans. Ethyl alcohol or ethanol is manufactured on large scale by the following processes:

- Fermentation of Glucose by Yeast
- Hydration of Ethene or Ethylene

5. What is Fermentation?

Ans. Fermentation:

Fermentation is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.

6. Write the balanced chemical equation for the fermentation of glucose.

Ans. $C_6H_{12}O_6 \xrightarrow[\text{Yeast}]{\text{35°C}} 2C_2H_5OH + 2CO_2$

7. At which temperature enzymes present in yeast get inactive in fermentation reaction?

Ans. The enzymes present in yeast in fermentation reaction become inactive at temperatures higher than 35°C in anaerobic conditions.

8. Name three common products produced through fermentation.

Ans. Three common products produced through fermentation are:

- Yogurt
- Bread
- Ethyl alcohol

9. What are the necessary conditions for the fermentation of glucose?

Ans. The reaction requires:

- A temperature of approximately 35°C.
- A neutral or acidic solution
- Anaerobic conditions (the absence of air)

10. What is the role of yeast in fermentation reaction?

Ans. Yeast contains an enzyme which acts as a catalyst. In fermentation reaction, yeast speeds up the breakdown of glucose into ethanol and carbon dioxide.

11. Why is oxygen excluded from the fermentation mixture?

Ans. Oxygen is excluded from the fermentation mixture because it converts the resulting ethanol into ethanoic acid.

12. What happens when the concentration of ethanol in the reaction mixture exceeds 15%?

Ans. Ethanol is toxic to yeast in high concentration, yeast is made inactive when the concentration of ethanol in the reaction mixture exceeds 15%.

13. Which gas is released as a by-product during the fermentation of glucose?

Ans. Carbon dioxide (CO_2) is released as a by-product during the fermentation of glucose.

14. What remains in the mixture after the gas has escaped during the fermentation of glucose?

Ans. A mixture of ethanol and water remains in the mixture after the gas has escaped during the fermentation of glucose.

15. What is the main raw material used to make ethyl alcohol?

Ans. The main raw material used to make ethyl alcohol is glucose.

16. Which microorganism is used in the fermentation process?

Ans. Yeast is the microorganism in the fermentation process.

17. What is the ideal temperature for making ethanol?

Ans. The ideal temperature for making ethanol is 35°C.

18. Does fermentation require air?

Ans. No, it must be done in anaerobic conditions (without air).

19. What happens to the rate of fermentation reaction at low temperature?

Ans. A lower temperature decreases the rate of the reaction.

20. Write the chemical formula for Ethyl alcohol?

Ans. The Chemical formula for Ethyl Alcohol is $CH_3–CH_2–OH$.

21. Is the solution for fermentation basic or acidic?

Ans. The solution for fermentation should be neutral or acidic.

22. Define hydration of ethene.

Ans. Hydration of Ethene: Hydration of ethene is an addition reaction. In this reaction water is added across the double bond of the ethene to produce ethanol.

23. What are the specific conditions required for the hydration of ethene?

Ans. The hydration of ethene requires:

- A temperature of 300 °C.
- A pressure of 60 atm.
- Phosphoric acid (H_3PO_4) as a catalyst.

24. Write the chemical equation for the hydration of ethene.

Ans.

$$\underset{\text{Ethene}}{CH_2 = CH_2(g)} + H_2O(g) \xrightarrow[\text{300 C, 60 atm pressure}]{H_3PO_4} \underset{\text{Ethanol}}{CH_3 - CH_2 \\ H \quad OH}$$

25. Name three industrial application of ethanol.

Ans. Ethanol has a wide range of application from alcoholic drinks to fuels as a solvent.

26. Why is hydration of ethene an important industrial process?

Ans. Hydration of ethene is an important industrial process because ethanol is a versatile compound.

27. Contrast the starting material used in hydration and fermentation.

Ans. Starting material for the process of hydration of ethene is obtained from crude oil, which is a non-renewable source.

Starting material for the process of fermentation is a renewable source, such as cane-sugar.

28. Which method of ethanol production is faster?

Ans. The rate of reaction of hydration of ethene is high, where as the rate of fermentation reaction is low and it may take days to complete.

29. How does the purity of ethanol differ between the hydration of ethene and fermentation processes?

Ans. Hydration of ethene produces relatively pure alcohol. On the other hand, fermentation produces 15% alcohol which needs further distillation to increase the concentration.

30. Which method is more cost-effective for producing cheap ethanol?

Ans. Ethanol produced in hydration of ethene is expensive, whereas ethanol produced in fermentation is cheap.

31. Why are alcohols considered flammable?

Ans. Alcohols are flammable because they contain a hydrocarbon chain that burn in air to produce CO_2 and H_2O evolving a large amount of heat.

32. What is the general balanced equation for the combustion of methanol?

Ans. $2C_3H_7OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$ $\Delta H = -726$ kJ/mol

33. Write a balanced equation for the combustion of ethanol?

Ans. $2C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$ $\Delta H = -136$ kJ/mol

34. What is the general balanced equation for the combustion of propanol?

Ans. $2C_3H_7OH + 9O_2 \longrightarrow 6CO_2 + 8H_2O$ $\Delta H = -2017$ kJ/mol

35. Write a balanced equation for the combustion of butanol.

Ans. $2C_4H_9OH + 12O_2 \longrightarrow 8CO_2 + 10\,H_2O$ $\Delta H = -2676$ kJ/mol

36. Explain why the heat evolved increases as you go down the alcohol homologous series.

Ans. During combustion of alcohols the weaker C–H bonds in $-CH_2$ groups break and the stronger C=O and O–H bonds are formed in CO_2 and H_2O respectively.

37. Why does butanol evolve more heat than propanol when burnt?

Ans. Butanol has a longer hydrocarbon chain with more bonds to react, leading to the formation of more CO_2 and H_2O molecules, which releases more energy.

38. What is added to ethene to make ethanol?

Ans. Water in the form of steam is added to ethene to make ethanol.

39. Which catalyst is used in the hydration of ethene?

Ans. Phosphoric acid (H_3PO_4) is used as a catalyst in the hydration of ethene.

40. What are the two main conditions for hydration of ethene or ethylene?

Ans. The two main conditions for hydration of ethene or ethylene are:

- High temperature (300 °C).
- High ressure (60 atm).

23.3 Applications of Alcohols as Fuels
23.4 Role of Ethanol in Industries
23.5 Impact of Alcohols on Daily Life

41. Which alcohols are commonly used as fuels in internal combustion engines?

Ans. The first four aliphatic alcohols namely methanol, ethanol, propanol and butanol are commonly used as fuels in internal combustion engines.

42. From which sources are alcohols obtained?

Ans. Alcohols are obtained from renewable sources.

43. How are alcohols produced?

Ans. Alcohols are produced from plant materials which, in turn, are the result of the photosynthesis process using CO_2 of the atmosphere.

44. Why is bioalcohols considered "carbon netural"?

Ans. Bioalcohols is considered "carbon netural" because it does not increase the concentration of carbon dioxide gas in the atmosphere.

45. What is a socio-economic disadvantage of producing alcohol fuels?

Ans. Land is utilized to grow crops which then yield alcohols. This fact affects the cultivation of food crops.

46. Why does the heat evolved during combustion increase from lower to higher alcohols?

Ans. Higher alcohols have more carbon and hydrogen atoms per molecule, meaning more chemical bonds are broken and reformed releasing more energy.

47. What does make the alcohols environmental friendly as compared to fossil fuels?

Ans. Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.

48. By what percentage can ethanol reduce greenhouse gas emissions compared to petrol?

Ans. Ethanol as a fuel reduces greenhouse gas emissions by 44 to 52% as compared to petrol.

49. What harmful pollutants ethanol cuts down?

Ans. Ethanol cuts down harmful pollutants like CO_x, NO_x and particulate matter.

50. How is ethanol used in the pharmaceutical industry?

Ans. Ethanol is used as a disinfectant in hand sanitizer and methylated spirit. It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.

51. What property makes ethanol useful in hand sanitizers?

Ans. Ethanol possesses bactericidal activity, meaning it can kill bacteria. This property makes ethanol useful in hand sanitizer.

52. What do help many drugs solubilize?

Ans. Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.

53. Name some cosmetic products that contain ethanol.

Ans. Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.

54. What is methylated spirit and how is it used in first aid?

Ans. Methylated spirit is a form of ethyl alcohol. It is used as an antiseptic, for dressing of wounds and as an antidote for snake bites.

55. Why is ethanol widely used in the perfume industry?

Ans. Ethanol is an effective solvent that can dissolve many organic compounds that are insoluble in water. This is why it is used in the perfume industry.

56. What are the immediate health risks of consuming alcohol?

Ans. Ethyl alcohol as a drink can cause hangover, alcohol poisoning, accidents and risky behaviour.

57. What is the long-term impact of alcohol consumption?

Ans. Long-term use of alcohol is known to cause more than 200 different diseases.

58. What can be used in cars instead of petrol or diesel to run in automobile?

Ans. Alcohols can be used instead of petrol and diesel to run as automobile.

59. What is the common name for alcohol used in a first aid kit?

Ans. Methylated spirit is the common name for alcohol used in a first aid kit.

60. What is one use of methylated spirit besides cleaning wounds?

Ans. Methylated spirit is used as an antidote for snake bites.

61. What part of the car can be damaged by using alcohols?

Ans. Alcohols can increase wear and tear on engine components.

62. Why does ethanol evaporate quickly on the skin?

Ans. Enthanol evaporates quickly on the skin because it is highly volatile.

63. Why is ethanol added to afters have or foundation creams?

Ans. Ethanol is added to aftershave or foundation creams for its refreshing, antimicrobial, and deodorizing properties.

64. How does ethanol help in making medicine?

Ans. Ethanol is used as a solvent and preservative in many pharmaceutical preparations including vaccines.

65. Can ethanol dissolve things that water cannot?

Ans. Yes, ethanol dissolves many organic compounds that are insoluble in water.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Which conditions are considered best for the fermentation of glucose?

(a) 35 °C, fresh yeast, absence of oxygen (b) 45 °C, yeast

(c) 45 °C; absence of oxygen (d) 35 °C, fresh yeast

2. Which catalyst other than H_3PO_4 can also be used for hydration of alkenes?

(a) NaOH (b) H_2SO_4 (c) CH_3COOH (d) Ni

3. Alcohol which has the maximum heat of combustion is:

(a) $CH_3CH_2CH_2OH$ (b) CH_3CH_2OH

(c) CH_3OH (d) $CH_3CH_2CH_2CH_2OH$

4. The most environment friendly fuel is:

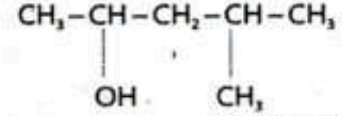
(a) coal (b) kerosene oil (c) ethanol (d) wood

5. Which property or properties of ethanol make it suitable to be used in cosmetic industry?

(a) Easily Flammable (b) Highly volatile and deodorizing

(c) Antipyretic (d) Sedative

6. Which is the correct name of the following alcohol:



(a) 2-Methylpentan-4-ol (b) 4-Methylpentan-2-ol

(c) Hexan-2-ol (d) Hexan-4-ol

7. Which property of ethanol makes it suitable for cleaning wounds?

(a) Good solvent (b) Volatility (c) Antiseptic (d) Deodorizing

8. Which alcohol is used to accomplish all the following tasks:
It is added in petrol to improve combustion. It serves as a feed stock to prepare vinegar and many other organic compounds.

(a) Propanol (b) Propan-2-ol (c) Ethanol (d) Methanol

Answers

1. (a) **2.** (b) **3.** (d) **4.** (c) **5.** (b) **6.** (b) **7.** (c) **8.** (c)

B. Short Answer Questions

23.1 Give two advantages of burning of alcohols over the burning of fossil fuel?

Ans. Advantages of Alcohols as Fuels:

(i) Alcohols are obtained from renewable sources.

(ii) Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.

(iii) Alcohols have higher fuel efficiency as compared to petrol or diesel fuels.

23.2 Which properties of ethyl alcohol make it useful for cosmetic industry?

Ans. Role of Ethanol in Cosmetic Industry: Ethyl alcohol plays an important role in cosmetic industry because of its following properties:

(i) Being highly volatile it evaporates in a very short time.

(ii) Deodorizing and anti-inflammatory properties.

(iii) Refreshing and antimicrobial properties.
Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.

23.3 How is ethyl alcohol important for pharmaceutical industry?

Ans. Role of Ethanol in Pharmaceutical Industry: Ethyl alcohol serves as a very common ingredient in a variety of manufacturing processes in pharmaceutical industry.

(i) It possesses bactericidal activity and it is often used as a disinfectant in hand sanitizer and ethylated spirit.

(ii) It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.

(iii) Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.

23.4 Give any two disadvantages of fermentation reactions.

Ans. Disadvantages of Fermentation: Two disadvantages of fermentation are:

(i) Fermentation produces 15% alcohol which needs further distillation to increase the concentration.

(ii) Rate of fermentation is low. It may take days to complete.

23.5 Write the conditions involved in the hydration of ethene.

Ans. To convert ethene into ethanol, the following conditions are required:

- **Catalyst:** Phosphoric acid (H_3PO_4).
- **Temperature:** Approximately 300 °C.
- **Pressure:** High pressure (60 atmospheres).

C. Constructed Response Questions

23.1 How ethanol is obtained as a by-product in sugar industry?

Ans. Obtaining Ethanol as by-Product in Sugar Industry: Ethanol is produced from molasses, which is the thick, dark brown liquid left over after sugar crystals have been extracted from sugarcane juice. Molasses contains about 15% to 50% fermented sugar.
it is done by the process of fermentation.
Fermentation: It is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.
Following steps are involved in the process of fermentation.
(i) Dilution: Molasses is diluted with water to reduce the sugar concertration to about 10% to 12%
(ii) Yeast (Saccharomyces cerevisiae) is added to the mixture.
(iii) Enzymes in the yeast (invertase and zymase) break down the sucrose into glucose and fructose, and then into ethanol and carbon dioxide.

Chemical Equation:

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose Glucose Fructose

$$C_6H_{12}O_6 + H_2O \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

Ethanol

23.2 Why do we get relatively impure alcohol in the fermentation process?

Ans. The alcohol obtained directly from fermentation is relatively impure (usually 10 % -- 15% concentration) for two main reasons.

- Yeast is a living organism. When the concentration of ethanol reaches about 14% — 15%, It becomes toxic to the yeast, deactivating the enzymes and stopping the fermentation process.
- Along with ethanol, the process produces water, left over sugars, and small amounts of other organic compounds (like glycerol or higher alcohols), which remain mixed in the solution.
- Along with ethanol, the process produces water, left over sugars, and small amounts of other organic compounds (like glycerol or higher alcohols), which remain mixed in the solution.
- To obtain pure alcohol, the mixture must undergo fractional distillation.

23.3 How do properties of ethyl alcohol help us to utilize it as fuel?

Ans. Ethyl alcohol (ethanol) has several chemical and physical properties that make it an effective fuel or fuel additive. These properties are discussed below:

- It burns with a clear, blue, smokeless flame, producing a significant amount of heat energy.

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{Heat}$$

- Ethanol has a high octane number, which helps prevent "engine knocking" and allows engines to run more efficiency at higher compression ratios.
- Since ethanol contains Oxygen in its molecular structure, it promotes more complete combustion of the fuel blend, reducing toxic emissions.
- Unlike fossil fuels, it is a renewable energy source because it is derived from crops like sugarcane and corn.

D. Descriptive Questions

23.1 Give a comparison of fermentation reaction and catalytic hydration of ethene for the preparation of ethanol.

Ans. For answer see Q3.

23.2 Describe the preparation of ethanol by fermentation process.

Ans. For answer see Q1.

23.3 Describe the applications of ethanol in pharmaceutical and cosmetic industries?

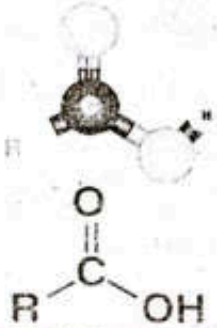
Ans. For answer see Q6 + Q7.

CHAPTER 24 Carboxylic Acids

Student Learning Outcomes

After studying this chapter, students will be able to:

- Describe the reactions of carboxylic acids with metals, bases and carbonates including names and formulae of the salts produced.
- Describe the formation of ethanoic acid by the oxidation of ethanol: with acidified aqueous potassium manganate (VII) & by bacterial oxidation during vinegar production
- Describe the reaction of a carboxylic acid with an alcohol using an acid catalyst to form an ester
- Describe the industrial applications of carboxylic acids and esters, including their use as solvents, flavours, fragrances, and plastics.
- Explain the role of carboxylic acids and esters in daily life, including their use in food preservation, cosmetics, and pharmaceuticals.



Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: What are carboxylic acid?

Ans. Organic acids or carboxylic acids are the class of organic compounds containing a

carboxyl group (-COOH) attached to an alkyl group or hydrogen. They are generally weak acids as compared to the mineral acids because they do not give proton easily. They occur naturally in living organisms and they can also be synthesized.

Q.2: Describe oxidation of ethanol to form ethanoic acid.

Ans. Oxidation of Ethanol: Ethanol is oxidized by the acidified potassium manganate (VII) to first ethanal which then further undergoes oxidation under the reaction conditions to give ethanoic acid.

Hot acidified potassium manganate (VII) acts as a very efficient oxidizing agent and oxidizes ethanol to ethanoic acid and during this reaction the purple colour of the reagent changes to colourless.

$$\underset{\text{Ethanol}}{CH_3-CH_2-OH} + [O] \xrightarrow{KMnO_4/H^+} \underset{\text{Ethanal}}{CH_3-\overset{O}{\overset{\|}{C}}-H} + H_2O$$

$$\underset{\text{Ethanal}}{CH_3-\overset{O}{\overset{\|}{C}}-H} + [O] \xrightarrow{KMnO_4/H^+} \underset{\text{Ethanoic acid}}{CH_3-\overset{O}{\overset{\|}{C}}-OH} + H_2O$$

Q.3: Explain fermentation reaction which is used to prepare acetic acid on commercial scale?

Ans. Preparation of Ethanoic acid by Oxidative Fermentation:

Alcoholic foodstuffs like grain, malt, rice or potato mesh are converted to vinegar when they undergo fermentation reaction in the presence of bacteria. These bacteria can produce vinegar from alcoholic foodstuffs if sufficient oxygen is provided. The overall chemical reaction in this fermentation process is:

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + O \longrightarrow \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$$

In this process, alcohol is fermented to vinegar in a tank provided with a continuous supply of oxygen. The liquid present in the tank is stirred continuously when the oxygen is bubbled through it. In this method, vinegar containing 15% ethanoic acid can be prepared in only 24 hours.

Q.4: Discuss reactions of carboxylic acids as acids.

Ans. Reactions of carboxylic Acids as Acids

Reaction with Metals: Generally carboxylic acids are much weaker acids than the mineral acids. However, some carboxylic acids react with more reactive metals rather slowly to give a salt evolving hydrogen gas. For example, dilute ethanoic acid reacts with magnesium metal to give magnesium ethanoate and hydrogen gas.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + Mg \longrightarrow \underset{\substack{\text{Magnesium}\\ \text{Ethanoate}}}{(CH_3COO)_2Mg} + H_2$$

Reaction with bases: Reactions of carboxylic acids with bases like metal hydroxides are simple neutralization reactions. Ethanoic acid reacts with sodium hydroxide to give sodium ethanoate and water.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

Ethanoic acid — Sodium hydroxide — Sodium ethanoate

Reaction of Carboxylic Acids with Carbonates: When solid sodium carbonate is mixed with an aqueous solution of ethanoic acid, effervescence takes place due to evolution of CO_2 gas and sodium ethanoate is formed in the solution.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$$

Ethanoic acid — Sodium Carbonate — Sodium ethanoate

Reaction proceeds slowly with marble chips ($CaCO_3$).

$$2CH_3COOH + CaCO_3 \longrightarrow (CH_3COO)_2Ca + CO_2 + H_2O$$

Ethanoic acid — Calcium carbonate — Calcium ethanoate

Q.5: Describe reaction of carboxylic acids with alcohols.

(OR) What is esterification reaction? Explain.

Ans. Reaction of Carboxylic Acids with Alcohols (Esterification)

Carboxylic acids form esters when they are heated with excess of alcohols in the presence of concentrated H_2SO_4, as a catalyst. Reaction is called esterification reaction.

$$2CH_3COOH + CaCO_3 \longrightarrow (CH_3COO)_2Ca + CO_2 + H_2O$$

Ethanoic acid — Calcium carbonate — Calcium ethanoate

24.4 Industrial Applications of Carboxylic Acids and Esters

24.5 Carboxylic Acids and Esters in Daily Life

Q.6: Describe the industrial applications of carboxylic acids and esters.

Ans. Carboxylic acids and Esters as Solvents: Acetic acid dissolves many compounds such as oils, sulphur, iodine and water. In industry, acetic acid is used as a solvent for resins, paints and lacquers.

Esters are also commonly used as solvents. Ethyl acetate is used to extract caffeine from coffee. It is also used as nail polish and paint remover. Some volatile esters are used as solvents for coatings, paints, varnishes, plastics, resins and lacquers.

Carboxylic acids and Esters as Flavouring agents: Flavouring agents are substances added to give an additional taste or flavour to a substance. They also help in masking unpleasant tastes of drugs especially used by children. Organic acids like tartaric acid, citric acid and malic acid are very commonly used as flavour enhancers in food industry.

The sour taste of foods is largely due to these acids. They are also responsible to improve the taste of some food and beverage products especially soft drinks.

Esters have pleasant odours and flavours. They are added to food products to improve their smell or taste.

Carboxylic Acid and Esters as Synthetic Fibers: Esters have also an important role to play in the production of synthetic polymers. A very important polymer, polyester is made by reacting diols and dicarboxylic acids. Esters are also important in the manufacture of soaps and detergents.

Carboxylic acids and their derivatives are very commonly used to give different types of plastics. For example, acetic acid is used in the production of cellulose acetate plastic. Palmitic and stearic acids are extensively used in the production of soaps, cosmetics, pharmaceuticals, candles and protective coatings. Oleic acid is used in the manufacture of soaps and detergents. Acrylic acid is a starting reagent to prepare many long-chain polymers called acrylates.

Uses of carboxylic acids in daily life

Q.7: Describe applications of carboxylic acids in daily life.

Ans. Applications of carboxylic Acids in Daily Life:

Food preservatives : Food preservatives are chemical compounds which are added in food stuff to prevent or retard the growth of microorganisms.

Examples: Benzoic acid, acetic acid, propionic acid and methyl and ethyl esters of 4-hydroxy benzoic acid. The presence of these preservatives helps to maintain the quality of food and extend shelf-life. The foods which are preserved include jams, juices, fruit juices, milk and many other drinks. Acetic acid is very widely used as preservative in pickles.

Jam, Juices and pickles

Carboxylic acids and their compounds used in Medicines:

Carboxylic acids and the compounds obtained from them are very commonly used as medicines such as aspirin and ibuprofen.

Addition of some carboxylic acids during preparation of medicines help to improve

drug delivery, absorption, and overall performance.

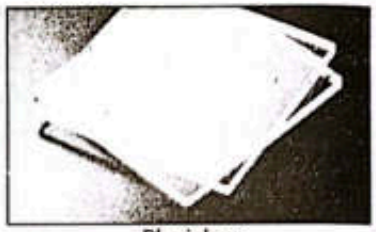
Plasticizers:

Citric acid esters are primarily plasticizers which are used in many industries.

Plexiglass:

Polymethyl methacrylate is used as a substitute of glass and it is named as Plexiglass.

Polyester



Plexiglass

Household Fragrant Items: Carboxylic acids occur in many common household fragrant items. A list of such items is given in the Table.

Carboxylic Acids in House hold items

Item	Carboxylic Acid
Vitamin C	Ascorbic acid
Lemons	Citric acid
Vinegar	Acetic acid
Apple, grapes, carrots	Malic acid

Q.8: Describe applications of esters in daily life:

Ans. Applications of Esters in Daily Life: Esters are an important component of many fruits and are responsible to enhance their flavours. They generally have a pleasant smell and they are commonly used as fragrances in many food products used in daily life.

Esters and their Flavours

Esters	Flavour
Methyl butyrate	Apple
Ethyl butyrate	Pine apple
n-Amyl acetate	Pears, Bananas
n-Octyl acetate	Orange
Methyl salicylate	Apricot

24.1 Quick Check!

1. Can you oxidize methanol with $KMnO_4$ Just like ethanol?

Ans. Yes. It would oxidize and convert into methanoic acid (HCOOH).

2. Explain the difference between a fermentation reaction and a chemical reaction.

Ans. Fermentation Reaction:

It is a biochemical process carried out by living organism (like bacteria or yeast) to convert substances.

Chemical Reaction:

A standard Chemical reaction (like oxidation in a lab) uses chemical reagents and catalysts without living cells.

24.2 Quick Check!

1. Is Ethanoic acid is a weak acid?

Ans. Yes. Ethanoic acid is a weak acid because it does not give protons easily as compared to mineral acids.

2. How will calcium carbonate react with ethanoic acid?

Ans. Calcium carbonate will react slowly with ethanoic acid to produce calcium ethanoate salt, water, and carbon dioxide gas, which causes fizzing.

24.3 Quick Check!

1. Explain the function of a preservative.

Ans. Food Preservatives are chemical compound which are added in food stuff to prevent or retard the growth of microorganisms. The presence of preservatives help to maintain the quality of food and extend shelf-life. For example, acetic acid is very widely used as preservative in pickles.

2. Give examples of some citrus fruits.

Ans. Citrus fruits are known for their high vitamin C content and acidic (citric acid) nature. Common examples include:

- Lemons
- Oranges
- Grapefruits
- Tangerines (Kinnow)
- Pomelos

INTERESTING INFORMATION

Pure acetic acid is also called glacial acetic acid. It is a corrosive and colourless solid, completely miscible with water.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

1. Carboxylic acids are defined by the presence of which functional group?

(a) –OH (Hydroxyl) (b) CHO (Aldehyde)

(c) –COOH (Carboxyl) (d) CO (carbonyl)

2. **compared to mineral acids, organic acids are generally:**
(a) stronger (b) Weaker (c) Highly volatile (d) Non-reactive

3. **In the oxidation of ethanol, what is the first product formed before it becomes ethanoic acid?**
(a) Methane (b) Ethene (c) Ethanal (d) Methanol

4. **What colour change occurs in potassium maganate (VII) during the oxidation of ethanol?**
(a) Purple to colourless (b) Colourless to purple
(c) Orange to green (d) red to blue

5. **Which process is used to convert alcoholic foodstuffs like rice or malt into vinegar?**
(a) Dehydration (b) Oxidative fermentation
(c) Hydrolysis (d) Reduction

6. **The concentration of ethanoic acid prepared in 24 hours via the fermentation method is:**
(a) 5 % (b) 10 % (c) 15 % (d) 25 %

7. **When ethanoic acid reacts with magnesium metal, which gas is evolved?**
(a) Carbon dioxide (b) Hydrogen (c) oxygen (d) Ethane

8. **The reaction between ethanoic acid and sodium hydroxide is classified as a:**
(a) Redox reaction (b) Fermentation
(c) Neutralization reaction (d) Addition reaction

9. **What observation indicates the reaction of ethanoic acid with carbonates?**
(a) Colour change to blue (b) Formation of a solid precipitate
(c) Effervescence (bubbling) (d) Evolution of heat only

10. **Which salt is formed when ethanoic acid reacts with marble chips ($CaCO_3$)?**
(a) Sodium ethanoate (b) Calcium carbonate
(c) Calcium ethanoate (d) Magnesium ethanoate

11. **What are the products when ethanoic acid reacts with sodium carbonate?**
(a) Sodium ethanoate and hydrogen
(b) Sodium ethanoate, water and carbon dioxide
(c) Ethanal and water (d) Carbon dioxide and hydrogen

12. **The reaction between a carboxylic acid and an alcohol is called:**
(a) Oxidation (b) Fermentation (c) Esterification (d) Sponification

13. **Which catalyst is essential for the formation of esters?**
(a) Acidified $KMnO_4$ (b) Dilute HCl
(c) Concentrated H_2SO_4 (d) Magnesium ribbon

14. **What is the product of the reaction between ethanoic acid and methanol?**
(a) Ethyl ethanoate (b) Methyl ethanoate
(c) Methane (d) Ethyl methanoate

15. **In the reaction $CH_3COOH + CH_3CH_2OH$, what is the second product formed alongside the ester?**
(a) Hydrogen gas (b) Oxygen (c) Carbon dioxide (d) Water

16. **What is the role of bacteria in the production of vinegar?**
(a) They facilitate the fermentation reaction
(b) They act as a metal catalyst
(c) They stop the oxidation process (d) They change the colour of the liquid

24.4 Industrial Applications of Carboxylic Acids and Esters

24.5 Carboxylic Acids and Esters in Daily Life

17. **Which term is used to describe pure acetic acid that exists as a corrosive, colourless solid?**
(a) Glacial acetic acid (b) Aqueous acetate
(c) Crystalline ester (d) Liquid vinegar

18. **Which ester is commonly used to extract caffeine from coffee and as a nail polish remover?**
(a) Methyl salicylate (b) n-octyl acetate
(c) Polyester (d) Ethyl acetate

19. **Organic acids like tartaric and citric acid are used in the food industry primarily as:**
(a) Solvents for oils (b) Flavour enhancers
(c) Synthetic fibers (d) Colouring agents

20. **Which pair of compounds reacts to form the synthetic polymer known as polyester?**
(a) Esters and water (b) Diols and dicarboxylic acids
(c) Methanol and acetic acid (d) Water and diols

21. **Which carboxylic acid is commonly used as a preservative in pickles?**
(a) Acetic acid (b) Malic acid (c) Ascorbic acid (d) Oleic acid

22. **Which acid is extensively used in the production of soaps and detergents?**
(a) Citric acid (b) Benzonic acid
(c) Hydrochloric acid (d) Oleic acid

23. **Which ester provides the flavour of "pineapple"?**
(a) Ethyl butyrate (b) Methyl salicylate
(c) Methyl butyrate (d) n-Amyl acetate

24. What material is produced using polymethyl methacrylate and serves as a substitute for glass?

(a) Nail polish (b) Polyester (c) Bakelite (d) Plexiglass

25. Which of the following acid is naturally found in apples, grapes and carrots?

(a) Malic acid (b) Ascorbic acid (c) Tartaric acid (d) Acetic acid

26. It is an ester found in pears and bananas.

(a) Methyl salicylate (b) Methyl butyrate

(c) n-octyl acetate (d) n-Amyl acetate

Answers

1.	(c)	2.	(b)	3.	(c)	4.	(a)	5.	(b)	6.	(c)	7.	(b)
8.	(c)	9.	(c)	10.	(c)	11.	(b)	12.	(c)	13.	(c)	14.	(b)
15.	(d)	16.	(a)	17.	(a)	18.	(d)	19.	(b)	20.	(b)	21.	(a)
22.	(d)	23.	(a)	24.	(d)	25.	(a)	26.	(d)				

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

24.2 Reactions of carboxylic Acids as Acids

24.3 Reaction of Carboxylic Acids with Alcohols (Esterification)

1. What are carboxylic acids?

Ans. Carboxylic Acids:

Organic acids or carboxylic acids are the class of organic compounds containing a carboxylic group (-COOH) attached to an alkyl group or hydrogen.

2. Compare carboxylic acid to the mineral acids:

Ans. Carboxylic acids are weak acids as compared to the mineral acids because they do not give proton easily.

3. Define esterification.

Ans. Esterification:

Carboxylic acids form esters when they are heated with excess of alcohols in the presence of concentrated HS_2O_4, as a catalyst. This reaction is called esterification reaction.

4. What is oxidative fermentation?

Ans. Oxidative Fermentation:

It is a process where alcoholic foodstuffs like grain, malt, rice or potato mesh are converted to vinegar when they undergo fermentation reaction in the presence of

bacteria.

5. In how many hours vinegar containing 15% ethanoic acid can be prepared by oxidative fermentation?

Ans. By oxidative fermentation, vinegar containing 15% ethanoic acid can be prepared in only 24 hours.

6. What is the functional group of carboxylic acids?

Ans. The functional group of carboxylic acids is the carboxyl group (–COOH), which consists of a carbonyl group (C=O) and a hydroxyl group (–OH) attached to the same carbon atom.

7. Why are organic acids classified as "weak acids"?

Ans. Organic acids are considered weak acids because they do not give up protons (H^+ ions) easily compared to mineral acids like HCl or HS_2O_4.

8. What is the observation when ethanol is oxidized by acidified $KMnO_4$?

Ans. The purple colour of the potassium manganate (VII) reagent changes to colourless as the reaction proceeds.

9. Name the intermediate product formed during the oxidation of ethanol to ethanoic acid.

Ans. The intermediate product formed during the oxidation of ethanol to ethanoic acid is ethanol (an aldehyde).

10. What are the requirements for the oxidative fermentation of alcohol into vinegar?

Ans. It requires alcoholic foodstuffs (like grain or rice), the presence of specific bacteria, and a continuous supply of oxygen.

11. Compare the reaction of carboxylic acid with mineral acids when reacting with metals.

Ans. Carboxylic acids react much more slowly with reactive metals than mineral acids do.

12. Write the word equation for the reaction between ethanoic acid and magnesium.

Ans. Ethanoic acid + Magnesium ⟶ Magnesium Ethanoate + Hydrogen

13. How can you chemically test for the presence of a carboxylic acid using carbonates?

Ans. Add a carbonate (like sodium carbonate) to the solution. If a carboxylic acid is present, effervescence (bubbling) will occur due to the release of carbon dioxide gas.

14. What salt is formed when ethanoic acid reacts with marble Chips?

Ans. When ethanoic acid reacts with marble chips calcium ethanoate $(CHC_3COO)_2$ Ca is

formed.

15. What is the role of concentrated H_2SO_4 in esterification?

Ans. Concentrated H_2SO_4 acts as a catalyst to speed up the reaction between the acid and the alcohol.

24.4 Industrial Applications of Carboxylic Acids and Esters

24.5 Carboxylic Acids and Esters in Daily-Life

16. What is glacial acetic acid?

Ans. Glacial Acetic Acid:

Pure acetic acid is also called glacial acetic acid. It is a corrosive and colourless solid, completely miscible with water.

17. Enlist some uses of ethyl acetate.

Ans. Uses of Ethyl acetate:

- Ethyl acetate is used to extract caffeine from coffee.
- It is also used as nail polish and paint remover.

18. Mention uses of some volatile esters.

Ans. Some volatile esters are used as solvents for coatings, paints, varnishes, plastics, resins and lacquers.

19. What are flavouring agents?

Ans. Flavouring Agents:

Flavouring agents are substances added to give an additional taste or flavour to a substance.

They also help in making unpleasant tastes of drugs especially used by children.

20. What is importance of esters in food products?

Ans. Esters have pleasant odours and flaw ours. They are added to food products to improve their smell or taste.

21. Why is acetic acid used as a solvent in industry?

Ans. Acetic acid is an effective solvent because it can dissolve many compounds such as oils, sulphur, iodine and water. In industry, acetic acid is used as a solvent for resins, points and lacquers.

22. Which organic acids are used as flavour enhancers?

Ans. Organic acids like tartaric acid, citric acid and malic acid are very commonly used as flavour enhancers. The sour taste of foods is largely due to these acids. They are also responsible to improve the taste of some food and beverage products especially soft drinks.

23. How is polyester made?

Ans. Polyester is a very important polymer. It is made by reacting diols and dicarboxylic acids.

24. In which fields palmitic and Stearic acids are used?

Ans. Palmitic and stearic acid are extensively used in the production of soaps, cosmetics, pharmaceuticals, candles and protective coatings.

25. Which acid is used in the manufacture of soaps and detergents?

Ans. Oleic acid is used in the manufacture of soaps and detergents.

26. What are food preservatives?

Ans. Food preservatives are chemical compounds which are added in food stuff to prevent or retard the growth of microorganisms.

Examples:

Benzoic acid, acetic acid, propionic acid and methyl and ethyl esters of 4-Hydroxy benzoic acid.

27. What is the importance of food preservatives?

Ans. The presence of food preservatives helps to maintain the quality of food and extend shelf-life.

28. Give examples of foods which are preserved?

Ans. The foods which are preserved include jams, juices, fruit juices, milk and many other drinks.

29. Name the acid which is used as preservative in pickles.

Ans. Acetic acid is very widely used as preservative in pickles.

30. Give examples of carboxylic acids used in medicines.

Ans. Aspirin and Ibuprofen are common medicines carboxylic acids are also added during drug preparation to improve drug delivery, absorption, and overall performance.

31. What is Plexiglass?

Ans. Plexiglass:

Polymethyl methacrylate is used as a substitute of glass and it is named as plexiglass.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Identify the ester functional group:

(a) –COOR (b) –COOH (c) $\geq C = O$ (d) $-CH_2-OH$

2. During the oxidation of ethanol by acidified $KMnO_4$, which element is reduced?

(a) K (b) O (c) Mn (d) H

3. Fermentation of foodstuff in the presence of acetic acid bacteria needs a sufficient supply of oxygen. What is the role of oxygen in this process?

(a) It enhances the reactivity of bacteria
(b) It oxidizes ethanol which is formed during the reaction
(c) It inhibits the destruction of bacteria (d) It inhibits the oxidation of acetic acid

4. Which organic acid is used as a component of food?

(a) Formic acid (b) Oxalic acid (c) Propanoic acid (d) Acetic acid

5. Which of the following acids is present in apples?

(a) Citric acid (b) Tartaric acid (c) Acetic acid (d) Malic acid

6. Which substances will react to produce $CH_3-CH_2-CH_2-COOC_2H_5$?

(a) $CH_3CH_2CH_2COOH$ and CH_3OH (b) CH_3CH_2COOH and CH_3CH_2OH
(c) $CH_3CH_2CH_2COOH$ and CH_3CH_2OH (d) $CH_3CH_2CH_2COOH$ and CH_3OH

7. What is the formula of ester formed by the reaction of methanol with propanoic acid?

(a) $CH_3COOCH_2CH_3$ (b) $CH_3CH_2COCH_2$
(c) $CH_3CH_2COOCH_3$ (d) $CH_3CH_2OCOCH_3$

8. Which polymer is made by reacting a diol and a dicarboxylic acid?

(a) Polyethene (b) Polyester (c) Polystyrene (d) Polyamide

9. Which compound is used as a synthetic fiber?

(a) Methyl acetate (b) Polyester (c) Resin (d) n-Amyl

Answers

1. (a) **2.** (c) **3.** (b) **4.** (d) **5.** (d) **6.** (c) **7.** (c)
8. (b) **9.** (b)

B. Short Answer Questions

24.1 What is an esterification reaction?

Ans. Reaction of Carboxylic Acids with Alcohols (Esterification) : Carboxylic acids form esters when they are heated with excess of alcohols in the presence of concentrated H_2SO_4, as a catalyst. Reaction is called esterification reaction.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \rightleftharpoons[H_2SO_4] \underset{\substack{\text{Ethyl ethanoate}\\(\text{an ester})}}{CH_3COOC_2H_5} + H_2O$$

Reaction proceeds slowly with marble chips ($CaCO_3$).

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Methanol}}{CH_3OH} \rightleftharpoons[H_2SO_4] \underset{\text{Methyl ethanoate}}{CH_3COOCH_3} + H_2O$$

24.2 Name an oxidizing agent used to oxidize alcohols.

Ans. Acidified potassium manganate (VII) ($KMnO_4/H^+$) is an oxidizing agent used to oxidize alcohols.

24.3 Why sufficient oxygen is provided during fermentation to prepare acetic acid from ethanol?

Ans. Sufficient oxygen is provided during fermentation to prepare acetic acid from ethanol. It is because the process is oxidative fermentation, that takes place in the presence of bacteria. These bacteria require oxygen to chemically oxidize the ethanol into acetic acid.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + O_2 \longrightarrow \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$$

24.4 What is the role of carboxylic acids in the preparation of beverages?

Ans. Carboxylic acids act as flavour enhancers and improve the taste of beverage products, especially soft drinks. Acids like citric acid provide a characteristic sour taste.

24.5 Give a practical example in which an acid or an ester is used as a flavouring agent.

Ans. Acid: Citric acid is used in soft drinks for a sour flavour.
Ester: Ethyl butyrate is used to provide a pineapple flavour in food products.

24.6 Which carboxylic acids are very oftenly used as flavour enhancers?

Ans. Carboxylic acids like tartaric acid, citric acid and malic acid are very commonly used as flowour enhancers in food industry.

24.7 Which property of acetic acid does make it suitable to act as preservative in pickle?

Ans. The ability of acetic acid to inhibit microbial growth which is responsible for food spoilage by lowering the pH is the basic property which make it sutiable to act as preservative in pickle.

C. Constructed Response Questions

24.1 How does ethanol react with propanoic acid?

Ans. Ethanol reacts with propanoic acid to form ethyl propanoate and water.

$$CH_3CH_2COOH + CH_3CH_2OH \xrightarrow{H_2SO_4} CH_3CH_2COOCH_2CH_3 + H_2O$$

24.2 How does acetic acid react with Mg and $MgCO_3$?

Ans. Acetic acid react with magnesium to form magnesium ethanoate

$$\underset{\substack{\text{Acetic}\\\text{Acid}}}{2CH_3COOH} + \underset{\text{Magnesium}}{MgCO_3} \longrightarrow \underset{\substack{\text{Magnesium}\\\text{ethanoate}}}{(CH_3COO)_2Mg} + \underset{\substack{\text{Magnesium}\\\text{gas}}}{H_2}$$

Reaction of Acetic Acid with Magnesium Carbonate

$$\underset{\substack{\text{Acetic}\\\text{Acid}}}{2CH_3COOH} + \underset{\text{Magnesium}}{Mg} \longrightarrow \underset{\substack{\text{Magnesium}\\\text{ethanoate}}}{(CH_3COO)_2Mg} + \underset{\substack{\text{Hydrogen}\\\text{gas}}}{H_2O + CO_2}$$

24.3 How carboxylic acids are used as solvents?

Ans. Acetic acid is used as a solvent for dissolving oils, sulphur, iodine and water. In industry, acetic acid is used as a solvent for resins, paints and lacquers.

24.4 How carboxylic acid are used in daily life?

Ans. For Answer See Question No.7

D. Descriptive Questions

24.1 Explain fermentation reaction which is used to prepare acetic acid on commercial scale.

Ans. For answer see Q3

24.2 Describe the industrial applications of carboxylic acids and esters.

Ans. For answer see Q6

24.3 What are flavouring agents? Which carboxylic acids are used as flavouring agents?

Ans. Flavouring Agents: Flavouring agents are substances added to give an additional taste or flavour to a substance.

They also help in masking unpleasant tastes of drugs especially used by children.

Flavour Enhancers: Organic acids like tartaric acid, citric acid and malic acid are very commonly used as slowour enhancers in food industry.

- The sourtaste of foods in largely due to these acids.
- They are also responsible to improve the taste of some food and beverage products especially soft drinks.

Carboxylic Acids as Flavouring Agents: Carboxylic acids occur in many common household fragrant items. A list of such items is given in the table below:

Item	Carboxylic Acid
Vitamin C	Ascorbic acid
Lemons	Citric acid
Vinegar	Acetic acid
Apple, grapes, carrots	Malic acid

24.4 Explain the reactions of carboxylic acids with metals and carbonates.

Ans. For answer see Q4

24.5 Describe applications of esters in daily life.

Ans. For answer see Q8

CHAPTER 25 Biochemistry

Student Learning Outcomes

After studying this chapter, students will be able to::

- Explain the importance and basics of nutrition and healthy eating.
- Recognize the main biomolecules; carbohydrates, proteins, lipids and nucleic acids. their sources along with the required daily intake for young adults.
- Identify carbohydrates as a source of energy.
- Describe proteins as natural polyamides and that they are formed from amino acid monomers with the general structure.
- Draw the general structure of proteins.
- Explain the sources, use and structure of proteins, lipids and carbohydrates.
- Describe the importance of nucleic acids
- Explain vitamins, their sources and their importance to health
- Identify applications of biochemistry in testing (blood test, pregnancy test, cancer screening, parental genetic testing), genetic engineering, gene therapy and cloning

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

Q.1: What is biochemistry? Describe three main classes of food.

Ans. Biochemistry: Biochemistry is the study of chemical substances which play a vital role in the processes taking place in living organisms.

Main classes of food:

Carbohydrates, lipids or fats and proteins are the three classes of foods which not only provide energy to human beings but are also responsible for their body structures. Lipids provide, on the average, twice as much energy as provided by carbohydrates or proteins.

Proteins are present in all living organisms. They form skin, hair, muscle, blood and almost all the organs of animals. They also play a very important role in all life processes.

Fats and oils come from a variety of natural sources like animals, plants and marine organisms. Animal fats are particularly located in tissues cells. Butter and ghee are a

special type of animal fats which are made from milk.

Q.2: Write a note on the importance of nutrition?

Ans. Nutrition:

Nutrition is the study of the nutrients present in food and how they maintain a healthy body.

Nutrients:

Nutrients are the components of food that are needed on regular basis to maintain health and prevent diseases.

A healthy human body needs the following nutrients.

Carbohydrates:

They are the main source of energy for the human body. They also help body to use protein and fat efficiently.

A healthy adult needs 225 to 325 grams of carbohydrates par day for a standard 2000 calorie diet. However, individuals with higher activity levels may need more carbohydrates to meet their daily needs.

Lipids:

They are also essential nutrients because they act as major energy reserves for our body. They also provide insulation and protection for vital organs of our body. A daily intake of fats for an adult is roughly between 44 to 78 grams.

Protiens:

They also supply energy to our body. They are needed to build new cells and repair the injured ones. An adult should consume 60 grams of proteins per day.

Vitamins and minerals:

They help in growth, reproduction, the operation and maintenance of the body. A balanced diet rich in fruits, vegetables and grains can provide most of the vitamins and minerals needed daily.

Q.3: What are the basics of healthy eating? Also discuss healthy eating?

Ans. Basics of healthy eating:

The following are basics of healthy eating:

(i) Consume a wide range of foods including fruits, vegetables, whole grains, lean proteins, and healthy fats.
(ii) They are full of nutrients which are required by our body.
(iii) Eat less and stay hydrated.
(iv) Reduce intake of saturated fats, sugar, and sodium.
(v) Avoid eating processed and poor quality foods.

Healthy Eating:

A healthy and balanced diet performs the following functions:

(i) It prevents diseases like heart disease, diabetes, some cancers and osteoporosis.
(ii) Adequate nutrition provides fuel for healthy growth and development, leading to

maintain a healthy weight.

(iii) A balanced diet can positively impact brain function and supports a strong immune system.

Q.4: What are carbohydrates? Discuss some important carbohydrates in detail.

Ans. Carbohydrates:

Carbohydrates are the most abundant naturally occurring compounds on earth.

They contain the elements carbon, hydrogen and oxygen.

Because of the sweet taste of some carbohydrates, they are commonly called "sugars".

Apart from a number of hydroxyl groups, they also contain aldehyde or ketonic functional groups.

Classification of carbohydrates:

Carbohydrates can be classified into three groups on the difference in their properties:

- Monosaccharide
- Oligosaccharides
- Polysaccharides

Important Carbohydrates:

(i) Glucose:

Glucose, the most abundant carbohydrate, is also called grape sugar or dextrose.

It is present in fruits such as grapes, in honey and also in the sap of plants.

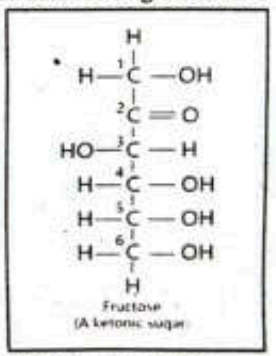
It is the main source of energy for all animals and is thus present in their blood and urine.

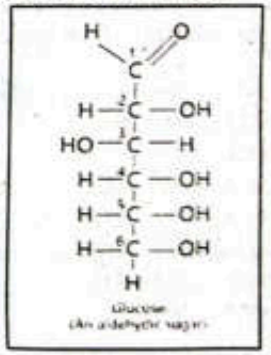
(ii) Fructose:

Fructose is another carbohydrate which is present in sweet fruit juices and honey.

Both glucose and fructose have the same molecular formula, $C_6H_{12}O_6$.

Open chain structures of glucose and fructose are shown here.





(iii) Sucrose, Lactose and maltose

Sucrose, lactose and maltose are other important carbohydrates. All these

carbohydrates have the same molecular formula $C_{12}H_{22}O_{11}$

Sucrose is present in sugar cane and sugar beets.

Maltose is found in breads and other cereals.

Lactose is present in milk.

(iv) Polymeric carbohydrates:

Starch and cellulose are the two examples of important polymeric carbohydrates. They have a common formula $(C_6H_{10}O_5)_n$.

Starch is found in foods like potatoes, rice and grains.

Cellulose sources include plant materials like wood, cotton etc.

Q.5: What are proteins? How are they formed? Identify different functions of proteins in the human body.

Ans. Proteins:

Proteins are very large molecules containing C, H, O, N and sulphur atoms.

Types of proteins:

The human body contains thousands of different type of proteins where they perform a large number of functions.

There are fibrous proteins that are found in muscles, hair, nails, skin and connective tissues.

Besides fibrous proteins harmones and enzymes are also proteins in nature.

Functions of proteins in human body:

- The hormone insulin controls the level of sugar in the blood stream.
- Enzymes are the catalysts which speed up the biochemical reactions taking place in our body.
- Hemoglobin which carries oxygen in the blood stream and delivers to different parts of the body is also a protein.

Formation of proteins:

All proteins are formed by linking together molecules called amino acids.

Amino acids:

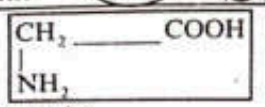
An amino acid has two functional groups,

- a carboxyl group ___ COOH
- an amino group ___ NH_3.

Glycine:

The simplest amino acid is called glycine.

The structural formula of glycine is:



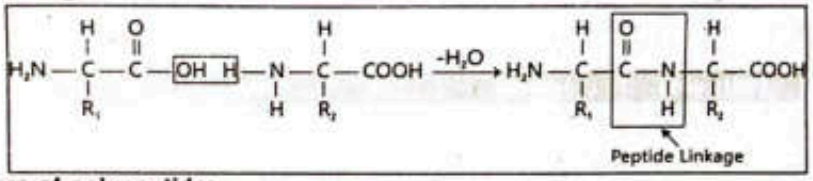
Number of proteins in the human body:

Although the number of proteins present in the human body runs into thousands, they are all formed by linking togehter only twenty amino acids.

Q.6: Construct peptide linkage and explain the structure of a polypeptide.

Ans. Peptide linkage:

The basic reaction which leads to the formation of long chains of proteins involves the elimination of water from two molecules of same or different amino acids. The molecule which is formed as a result of this reaction is called a peptide and it contains a peptide linkage as shown below.

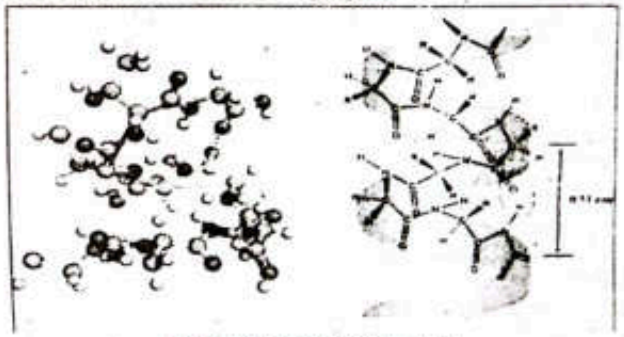


Structure of polypeptide:

This peptide molecule has a carboxyl group and an amino group at its two ends. It is capable of reacting further with two molecules of amino acids to give ultimately a long chain composed of many acid molecules called a polypeptide.

Three Dimensional Structure:

This polypeptide chain then undergoes twists and turns and assumes a three dimensional structure shown in the following figure:



Ball and stick model of polypeptide.

Q.7: Explain denaturation of proteins with examples.

Ans. Denaturation of Proteins:

Complex changes in proteins occur when they are subjected to heat, a change in pH

or an attack by oxidizing and reducing agents. The phenomenon is called denaturation of proteins.

Example:

A familiar example is the frying or boiling of an egg which involves the denaturation of egg albumin (protein), the principal component of egg white.

Q.8: Describe lipids in detail.

Ans. Lipids:

Lipids are the nutrients. Most lipids are composed of simpler substances called fatty acids which serve as their building blocks.

Fatty acids:

Fatty acids are long chain carboxylic acids containing from 12 to 28 carbon atoms.

Examples:

Examples of simple fatty acids along with their sources are as given below.

Some simple fatty acids.

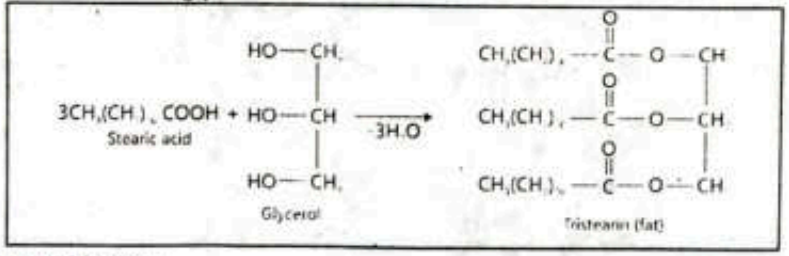
Fatty acid	Source	Structure
Lauric acid	Coconut oil	$CH_3(CH_2)_{10}COOH$
Stearic acid	Animal fats	$CH_3(CH_2)_{16}COOH$
Palmitic acid	Palm oil	$CH_3(CH_2)_{14}COOH$
Oleic acid	Olive oil	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$

Fats:

Fatty acids react with an alcohol called glycerol to give triester which are called fats.

For example:

Stearic acid reacts with glycerol to form tristearin which is a fat. A triester of glycerol is also called triglyceride.



Importance of Lipids:

Animal fats are located particularly in adipose tissue cells. Vegetable oils are present in seeds and roots of plants. Lipids mainly serve as energy rich source in animals.

Q.9: What are vitamins? Explain the importance of vitamins.

Ans. Vitamins:

These are organic substances which do not directly serve the purpose of providing

energy and building cells of our body like carbohydrates, lipids and proteins.

Biological Function:

Vitamins are necessary to maintain normal health and growth of our body. These compounds are known to function as catalysts for the biological processes going on in our body.

Origin of the name:

Since the first such compound discovered was an amine, so they were named vital amines or vitamins. Over the years, scientists have prepared 13 vitamins needed by the human body.

Importance of vitamins:

Vitamin A is present in milk, egg, fish and liver.

Essential for skin health and vision. Its deficiency causes night blindness and dry skin.

Vitamin D:

Vitamin D may be obtained from butter and fish liver oils. Our skin can also prepare vitamin D directly in the presence of sunlight. This vitamin is related to normal teeth and bone development. Its deficiency causes a disease called rickets.

Vitamin C:

Vitamin C, also called ascorbic acid. Vitamin C is found in citrus fruits, green pepper and tomatoes. Its deficiency in our body causes scurvy.

Vitamins B_1 and B_2:

Vitamins B_1, and B_2 are distributed widely in nature. They are present in red meat, nuts and leafy vegetables. Deficiency of vitamin B_1 leads to fatigue and depression. Deficiency of vitamin B_2 causes inflammation of the lips and dryness and burning of eyes.

Q.10:What are DNA and RNA? Describe the role played by them in our body.

Ans. DNA and RNA:

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) both are nucleic acids. These compounds are responsible for the existence, development and reproduction of all forms of life. Both DNA and RNA are chemically similar compounds which play different roles within the cell.

Molecules of DNA are very large as compared to those of RNA.

A DNA molecule may have molecular mass of up to 660 Da.

A DNA molecule lengths of up to 12 cm when stretched out.

They are mostly found in the nucleus of the cells.

Molecules of RNA are much smaller as compared to those of DNA.

A RNA molecule may have molecular mass 340 Da.

RNA molecules are mostly found outside the cell nucleus.

Function of DNA:

The function of DNA is to store information and pass it on to RNA, at the proper time.

Function of RNA:

The function of RNA, in turn, is to read, decode and use the information to make proteins.

Q.11: Discuss applications of biochemistry in different fields.

Ans. Applications of biochemistry:

Blood Test:

Doctors use the blood tests to identify various health conditions including infections, diabetes, anemia, organ failure and much more. Basic blood chemistry tests check the amount of electrolytes, fats, proteins, glucose and enzymes. These tests give important information about how well a person's kidneys, liver, and other organs are working.

Pregnancy Test:

A pregnancy test checks the urine on blood to see if a woman is pregnant or not. HCG is a hormone produced in the body when a woman gets pregnant. Doctors usually perform two tests to check pregnancy. Quantitative blood tests can measure the exact amount of HCG present in the blood. It can also give information about how far long the pregnancy has progressed.

Blood test for cancer screening:

A specific type of blood test called the Galleri test is performed to detect cancer in early stages. It uses DNA sequencing to find the characteristic patterns which may tell whether a person is suffering from cancer or not.

Parental genetic testing:

Genetic tests are often performed by taking a sample of blood or saliva. Persons get genetic testing to know if they have genetic changes themselves or if they can pass on genetic changes to their children.

Genetic engineering:

Genetic engineering is a method for changing an organism's genome. This can involve changing one single DNA base or can involve deleting or inserting a whole region of DNA. It is done to modify the genes to enhance the capabilities of the organism beyond what is normal. Plants can be made to fight diseases or pollution by changing them through genetic engineering.

Gene Therapy:

In gene therapy doctor fixes a faulty gene or replaces it with a healthy gene in order to cure a disease or enable the body to fight the disease in a better way. This technique

may be helpful in future to fight with a wide range of diseases like diabetes, AIDs, cancer and haemophilia.

Cloning:

Cloning describes the methods used to create an exact genetic replica of a cell, a tissue or the whole organism. The copied material is called a clone and it will have the same genetic characteristics as the original one.

25.1 Quick Check!

1. **Which two functions are performed by proteins?**

Ans. **Functions of Protiens:**

- They form skin, hair, muscle, blood and almost all the organs of animals.
- They also play a very important role in all life processes.

2. **Is milk a fat, a protein or both?**

Ans. Milk is both a fat and a protein.

25.2 Quick Check!

1. **What is a balanced diet?**

Ans. **Balanced Diet:** A balanced diet is one rich in fruits, vegetables and grains that provides most of the vitamins and minerals needed by the body daily for growth, reproduction and body maintenance.

2. **Name any three nutrients.**

Ans. • Carbohydrates • Lipids • Proteins

25.3 Quick Check!

1. **Name any two sources of starch.**

Ans. **Two sources of starch:** • Potatoes • Rice

2. **Are all carbohydrates equally beneficial for our health?**

Ans. No, while they are a main energy source, different types serve different roles.
For example:
Complex carbohydrates like starch provide sustained energy, while excess intake of simple sugars (like sucrose) can lead to health issues.

25.4 Quick Check!

1. **What are hormones made of?**

Ans. Most hormones are made of proteins (specifically chains of amino acids) or steroids (lipids derived from cholesterol).
Examples:

- Insulin is a protein hormone.
- Testosterone is a steroid hormone.

2. **What is denaturation?**

Ans. **Denaturation of Protein:** Complex changes in proteins occur when they are subjected to heat, a change in pH or an attack by oxidizing and reducing agents. The phenomenon is called denaturation of proteins.
Example:
A familiar example is the frying or boiling of an egg.

25.5 Quick Check!

1. What is the role of lipids in our body?

Ans. Role of Lipids in Our Body:

- They provide, on the average, twice as much energy as provided by carbohydrates or protiens.
- They are key parts of cell membranes.
- They help maintain body temperature and cushion internal organs.
- Some lipids act as hormones.

2. Which is an unsaturated fatty acid?

Ans. Unsaturated Fatty Acid:

An unsaturated fatty acid is a fatty acid that contains one or more double bonds between carbon atoms in its chain. Because of these double bonds, they are typically liquid at room temperature (e.g, vegetable oils like olive oil or sunflower oil).

25.6 Quick Check!

1. Which vitamin is presnet in lemon?

Ans. Vitamin C (ascorbic acid) is present in lemon.

2. Compare the roles played by vitamins and carbohydrates in our body?

Ans. Roles of vitamins in our body:

They are necessary to maintain normal health and growth of our body.

These compounds are known to function as catalysts for the biological processes going on in body.

Roles of carbohydrates in our body:

- Carbohydrates are the main sources of energy for the human body. Their main role is to provide immediate energy for cellular activities.
- They also help body to use protein and fat efficienctly.

25.7 Quick Check!

1. What is the function of RNA?

Ans. The function of RNA is to read, decode and use the information received from DNA to make proteins.

2. What are the basic differences between DNA and RNA?

Ans.

Feature	DNA	RNA
Sugar	Deoxyribose	Ribose
Structure	Double stranded (Helix)	Single-stranded
Bases	Adenine, Guanine, Cytosine, Thymine	Adenine, Guanine, Cytosine, Uracil
Function	To store information and pass it on to RNA, at the proper time.	To read, decode and use the information to make proteins.

INTERESTING INFORMATION

- Acesulfame potassium is the most recently approved sweetener. It is used in soft drinks.

- Glycogen is a carbohydrate that serves the same energy storage function in animals that starch serves in plants.

- Molecular mass of polymers are often expressed in millions or billions of Daltons (Da).
- Lactose is widely used in baking and in commercial milk used for infants unlike sucrose, it is a reducing sugar.
- Everyone, from infants to adult, needs protein. Children need large amounts of proteins for proper growth, and adults need protein to replace what is lost each day by the body's normal biochemical reactions.

INTERESTING INFORMATION

- Soap has been known since at least 600BC when it was prepared by boiling goat fat with extracts of wood ash. The cleansing properties of soap did not become widespread until the 18th century. Chemically, soap is a mixture of sodium salts of the long chain fatty acids produced by hydrolysis of animal fat with alkali.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

25.1 The Importance of Nutrition

25.2 Carbohydrates

1. Which class of food provides, on average, twice as much energy as carbohydrates and protiens?
(a) Protiens (b) Lipids (c) Minerals (d) Vitamins

2. What are the primary elements that compose carbohydrates?
(a) Hydrogen, Helium and Carbon (b) Carbon, Nitrogen and Oxygen
(c) Carbon, Hydrogen and Oxygen (d) Phosphorus, Carbon and Hydrogen

3. Based on the functional groups, how is fructose classified?
(a) Ketonic sugar (b) Oligosaccharide (c) Polymeric sugar (d) Aldehydic sugar

4. Which of the following is a common source of the carbohydrates known as Lactose?
(a) Cereals (b) Milk (c) Potatoes (d) Sugar cane

5. The recommended daily intake of proteins for a healthy adult is:
(a) 60 grams (b) 225 to 325 grams (c) 44 to 78 grams (d) 100 grams

6. It is the carbohydrate that serves as the energy storage function in animals, similar as the starch works in plants.
(a) Glycogen (b) Cellulose (c) Glucose (d) Maltose

7. According to the "Basics of Healthy Eating" which of the following should be reduced in the diet?
(a) Lean proteins (b) Water intake

(c) Sodium and sugar (d) Whole grains

8. **What is the shared molecular formula for Glucose and Fructose?**
(a) $(C_6H_{10}O_5)_n$ (b) $C_6H_{12}O_6$ (c) $C_{12}H_{22}O_{11}$ (d) CH_4

9. **It is a source of cellulose.**
(a) Potato (b) Grain (c) Cotton (d) Honey

10. **Which of the following is present in sugar cane and sugar beets?**
(a) Glucose (b) Fructose (c) Maltose (d) Sucrose

11. **Which of the following is also known as grape sugar or dextrose?**
(a) Sucrose (b) Maltose (c) Glucose (d) Fructose

25.3 Proteins
25.4 Lipids
25.5 Vitamins

12. **Which of the following element is NOT typically a component of the proteins?**
(a) Sulphur (b) Phosphorus (c) Nitrogen (d) Carbon

13. **It is a protein that is responsible for controlling the level of sugar in the blodstream.**
(a) Albumin (b) Insulin (c) Hemoglobin (d) Glycine

14. **These are the two functional groups present in an amino acid.**
(a) Hydroxyl and carboxyl (b) Ester and Amine
(c) Carboxyl and Amino (d) Aldehyde and Amine

15. **The formation of a peptide linkage involves the elimination of which molecules?**
(a) Water (b) Hydrogen gas (c) Carbon dioxide (d) Ammonia

16. **Which of these factors can cause the denaturation of proteins?**
(a) Heat and change in pH (b) Exposure to light
(c) Freezing only (d) Distilled water

17. **It is the source of Lauric acid.**
(a) Coconut oil (b) Palm oil (c) Olive oil (d) Animal fats

18. **What is the chemical name for the 'fat' molecule formed from three stearic acid molecules and glycerol?**
(a) Cholesterol (b) Tristearin (c) Glyceryl palmitate (d) Oleic acid

19. **Chemically, soap is defined as:**
(a) Sodium salts of long chain fatty acids
(b) Pure glycerol
(c) A type of fibrous protein (d) A mixture of vitamins

20. **Deficiency of which vitamin leads to the disease 'Scurvy'?**
(a) Vitamin D (b) Vitamin B_1 (c) Vitamin C (d) Vitamin A

21. **Which vitamin can the body prepare directly in the presence of sunlight?**
(a) Vitamin A (b) Vitamin B_2 (c) Vitamin C (d) Vitamin D

22. **The source of stearic acid is:**
(a) Coconut oil (b) Animal fats (c) Palm oil (d) Olive oil

23. **From olive oil, we get fatty acid:**
(a) Lauric acid (b) Palmitic acid (c) Oleic acid (d) Stearic acid

24. **Which of the following is the source of palmitic acid?**
(a) Palm oil (b) Olive oil (c) Coconut oil (d) Animal fats

25. **Deficiency of which vitamin causes night blindness and dry skin?**
(a) Vitamin A (b) Vitamin C (c) Vitamin B_1 (d) Vitamin B_2

26. **Fatigue and depression are due to the deficiency of vitamin:**
(a) A (b) B_1 (c) D (d) B_2

25.6 Nucleic Acids
25.7 Applications of Biochemistry

27. **Which of the following molecules are primarily responsible for the storage of genetic information?**
(a) Carbohydrates (b) Proteins (c) DNA (d) Lipids

28. **The approximate molecular mass of an RNA molecule is:**
(a) 12 cm (b) 340 Da (c) 660 Da (d) 10 cm

29. **Where is RNA mostly found within a cell?**
(a) Outside the cell nucleus (b) Inside the nucleus
(c) In the mitochondria only (d) Attached to cell wall

30. **Which hormone is deteched in the body to confirm pregnancy through a urine or blood test?**
(a) Adrenalin (b) Insulin (c) Estrogen (d) HCG

31. **The Galleri test is a specific type of blood test used for:**
(a) Anemia detection (b) Cancer screening
(c) Pregnancy (d) Organ failure diagnosis

32. **Which medical technique involves replacing a 'faulty gene' with a healthy one?**
(a) Parental Genetic testing (b) Gene Therapy
(c) DNA sequencing (d) Blood chemistry test

33. **Carbohydrates, proteins and fats together with water constitute about _____ of the most living organisms.**
(a) 69 % (b) 79 % (c) 89 % (d) 99 %

34. **What is the specific role of RNA in protein synthesis?**
(a) To store information forever (b) To identifiy infections in blood
(c) To acts as genetic replica of the cell (d) To read, decode and use information

35. **The molecules mass of DNA molecule is up to:**
(a) 460 Da (b) 560 Da (c) 660 Da (d) 760 Da

36. **Molecules of DNA are mostly found in the _____ of the cells.**
(a) Nucleus (b) cytoplasm (c) Lysosome (d) Cell membrane

Answers

1.	(b)	2.	(c)	3.	(a)	4.	(b)	5.	(a)	6.	(a)	7.	(c)
8.	(b)	9.	(c)	10.	(d)	11.	(c)	12.	(b)	13.	(b)	14.	(c)
15.	(a)	16.	(a)	17.	(a)	18.	(b)	19.	(a)	20.	(c)	21.	(d)
22.	(b)	23.	(c)	24.	(a)	25.	(a)	26.	(b)	27.	(c)	28.	(b)
29.	(a)	30.	(d)	31.	(b)	32.	(b)	33.	(d)	34.	(d)	35.	(c)
36.	(a)												

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

25.1 The Importance of Nutrition

25.2 Carbohydrates

1. Define Biochemistry.

Ans. Biochemistry:

Biochemistry is the study of chemical substances which play a vital role in the processes taking place in living organisms.

2. What are three classes of foods? Discuss their importance.

Ans. Classes of foods:

Carbohydrates, lipids, fats and proteins are the three classes of foods.

Importance:

- They provide energy to human beings.
- They are also responsible for their body structures.

3. Which nutrient provides the most energy?

Ans. Lipids porivide, on the average, twice as much energy as provided by carbohydrates or proteins.

4. From where fats and oils come?

Ans. Fats and oils come from a variety of natural sources like animals, plants and marine organisms.

5. Where are animal fats located?

Ans. Animal fats are particularly located in tisues cell.

6. Name the type of animal fats which are made from milk.

Ans. Butter and ghee are a special type of animal fats which are made from milk.

7. What is the general chemical composition of carbohydrates.

Ans. They contain the elements carbon, hydrogen and oxygen. Most contain aldyhyde or ketonic functional groups.

8. Define nutrition.

Ans. Nutrition:

Nutrition is the study of the nutrients present in food and how they maintain a healthy body.

9. What are nutrients?

Ans. Nutrients:

Nutrients are the components of food that are needed on regular basis to maintain health and prevent diseases.

10. What nutrients does a healthy human body need?

Ans. A healthy human body needs the following nutrients:

- Carbohydrates • Lipids • Proteins • Vitamins and minerals

11. How are carbohydrates classified?

Ans. Carbohydrates are classified into three groups:

- Monosaccharides • Oligosaccharides • Polysaccharides

12. How much carbohydrates does a healthy adult need?

Ans. A healthy adult needs 225 to 325 grams of carbohydrates per day for a standard 2000 calorie diet.

13. What is a daily intake of fats for an adult?

Ans. A daily intake of fats for an adult is roughly between 44 to 78 grams.

14. How much proteins does an adult consume?

Ans. An adult should consume 60 grams of proteins per day.

15. Define balanced diet.

Ans. Balanced diet:

A balanced diet is one rich in fruits, vegetables and grains that provides most of the vitamins and minerals needed by the body daily for growth, reproduction and body maintenance.

16. What is the molecular formula of sucrose, lactose and maltose?

Ans. The molecular formula of sucrose, lactose and maltose is $C_{12}H_{22}O_{11}$.

17. Name the carbohydrates present in sugar cane, sugar beets, breads, cereals and milk.

Ans.

- Sucrose is present in sugar cane and sugar beets.
- Maltose is found in breads and other cereals.
- Lactose is present in milk.

18. What is the molecular formula of starch and cellulose?

Ans. The molecular formula of starch and cellulose is $(C_6H_{10}O_5)_n$.

19. Name the sources of starch.

Ans. Sources of starch:

Starch is found in foods like potatoes, rice and grains.

20. What is Glycogen?

Ans. Glycogen:

Glycogen is a carbohydrate that serves the same energy storage fucntion in animals that starch serves in plants.

25.3	Proteins
25.4	Lipids
25.5	Vitamins

21. What elements are proteins composed of?

Ans. Proteins are very large molecules containing carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N) and Sulphur (S).

22. What is the function of the hormone insulin?

Ans. Insuline is a protien that controls the level of sugar in the blood stream.

23. Define enzymes

Ans. Enzymes:

Enzymes are the catalysts which speed up in the biochemical reactions taking place in our body.

23. What are buliding blocks of proteins?

Ans. All proteins are formed by linking together molecules called amino acids.

24. What are the two functional group of an amino acid?

Ans. An amino acid has two functional groups:

- A carboxyl group $-COOH$
- An amino group $-NH_2$

25. Name the simplest amino acid with its structural formula.

Ans. The simplest amino acid is called glycine. Its structural formula is:

$$\begin{array}{l} CH_2\text{---}COOH \\ | \\ NH_2 \end{array}$$

26. What are the building blocks of lipids?

Ans. Most lipids are composed of simpler substances called fatty acids which serve as their building blocks.

27. Define fatty acids. Give examples.

Ans. Fatty Acids:

Fatty acids are long chain carboxylic acids containing from 12 to 28 carbon atoms.

Examples:

Lauric acid, stearic acid, palmitic acid, oleic acid etc.

28. Define fats.

Ans. Fats:

Fatty acids react with an alcohol called glycerol to give tristearin which are called fats.

Example:

Stearic acid reacts with glycerol to form tristearin which is a fat.

29. What is triglyceride?

Ans. A triester of glycerol is also called triglyceride.

30. Tell the role of lipids in our body.

Ans. Lipids serve as an energy rich source and are started in adipose tissue cells.

31. Where are animal fats located in the body?

Ans. Animal fats are located particularly in adipose tissue cells.

32. Where are vegetable oil present in plants?

Ans. Vegetable oils are present in seeds and roots of plants.

33. What is the chemical composition of soap?

Ans. Chemically, soap is a mixture of sodium salts of the long chain fatty acids produced by hydrolysis of animal fat with alkali.

34. What are vitamins?

Ans. Vitamins:

These are organic substances which do not directly serve the purpose of providing energy and building cells of our body like carbohydrates, lipids and proteins.

35. Meention biological function of vitamins.

Ans. Biological function of vitamins:

Vitamins are necessary to maintain normal health and growth of our body. These compounds are known to function as catalysts for the biological processes going on in our body .

36. Which vitamin is called ascorbic acid?

Ans. Vitamin C is also called ascorbic acid.

37. Which vitamin can our skin prepare?

Ans. Our skin can prepare vitamin D directly in the presence of sunlight.

38. What are two types of nucleic acids?

Ans. Two types of nucleic acids are:

- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)

39. What are nucleic acids responsible for?

Ans. These compounds are responsible for the existence, development and reproduction of all forms of life.

40. Compare molecular mass of DNA and RNA molecules.

Ans. A DNA molecule may have molecular mass of up to 660 Da.

A RNA molecule may have molecular mass 340 Da.

41. What is function of DNA?

Ans. Function of DNA:

The function of DNA is to store information and pass it on to RNA, at the proper time.

42. Explain the function of RNA?

Ans. Function of RNA:

The function of RNA is to read, decode and use the information received from DNA to make protiens.

43. For what purposes do doctors use the blood tests?

Ans. Doctors use the blood tests to identify various health conditions indluding

infections, diabetes, anemia, organ failure and much more.

44. What do the basic blood chemistry tests check?

Ans. The basic blood chemistry tests check the amount of electrolytes, fats, protiens, glucose and enzymes.

45. What does a pregnancy test check for?

Ans. It checks for HCG (Human chorionic Gonadotropin), a hormone produced in the body when a woman becomes pragnant.

46. What is the Galleri test?

Ans. Galleri Test:

It is a specific type of blood test which is performed to detect cancer in early stages.

47. What is genetic engineering?

Ans. Genetic Engineering:

It is a method for changing an organisms genome. It can involve changing one single DNA base or can involve deleting or inserting a whole region of DNA.

48. How may gene therapy be helpful in future?

Ans. Gene therapy may be helpful in future to fight with a wide range of diseases like diabetes, AIDs, Cancer and hemophilia.

49. Define Cloning.

Ans. Cloning:

Cloning describes the methods used to create an exact genetic replica of a cell, a tissue or the whole organism.

50. What is clone?

Ans. Clone:

Clone is an exact genetic replica of a cell, a tissue or the whole organism. It has the same genetic characteristics as the original one.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ **Choose and tick the correct answer from the given choices.**

1. Functional groups present in fructose are:

(a) Hydroxyl and aldehyde (b) Hydroxyl and Ketone
(c) Hydroxyl and ester (d) Hydroxyl and amide

2. Which functional group is present in a fat?

(a) Carboxyl group (b) Ester group (c) Carbonyl group (d) Hydroxyl group

3. Which function is not performed by proteins in our body?

(a) They serve as chemical messengers.
(b) They serve as storage of energy-rich fuel.
(c) They store genetic information.
(d) They serve as catalysts for biochemical reactions.

4. Which functional groups react to produce a peptide linkage in proteins?

(a) Carboxyl group and hydroxyl group (b) Carboxyl group and amino group

(c) Hydroxyl group and amino group (d) Ester group and amino group

5. The test performed to detect cancer in early stages is:

(a) Genetic test (b) Urine test (c) Galleri test (d) Electrolyte test

6. Fatigue and depression are caused by deficiency of:

(a) Vitamin A (b) Vitamin C (c) Vitamin D (d) Vitamin B_1

Answers

1. (b) 2. (b) 3. (c) 4. (b) 5. (c) 6. (c)

B. Short Answer Questions

25.1 What is the difference between glucose and fructose?

Ans. Glucose and fructose both are carbohydrates. They both have the same molecular formula, $C_6H_{12}O_6$, but Glucose is an aldehydic sugar (containing an aldehyde group), while fructose is a ketonic sugar (containing a ketone group).

25.2 Give two examples of denaturation of proteins.

Ans. Examples of denaturation of proteins:

(i) **Boiling an egg:**
The liquid albumin becomes a solid white mass.

(ii) **Curdling of milk:**
Adding acid (like lemon juice) causes milk protiens to clump together.

25.3 What are the sources of vitamin D?

Ans. Sources of Vitamin D:

Vitamin D may be obtained from butter and fish liver oils. Our skin can also prepare vitamin D directly in the presence of sunlight.

25.4 What is the role of enzymes in our body?

Ans. Role of Enzymes in our body:

Enzymes are protein in nature. They are the catalysts which speed up the biochemical reactions taking place in our body such as digestion and metabolism, without being consumed in the process.

25.5 Which commercial products are obtained from oils and fats?

Ans. Soap (via saponification), margarine, paints, and cosmetics are the commercial products which are obtained from oils and fats.

25.6 Which vitamin helps in blood clotting?

Ans. Vitamin K helps in blood clotting.

C. Constructed Response Questions

25.1 What is the function of DNA?

Ans. Functions of DNA:

Deoxyribonucleic Acid is a nucleic acid carrying the genetic instructions. It is responsible for the existence, development and reproduction of all forms of life.
Function of DNA:
The function of DNA is to store information and pass it on to RNA, at the proper time.

25.2 Write down three important functions played by proteins in our body.

Ans. Functions of protiens in our body:

1. **Structural support:**
   Protein builds and repairs muscles, skin, bones, tendons and ligaments after injuries, collagen provides elasticity and strength to skin and connective tissue.
2. **Metabolic Catalysis:**
   Enzymes are specialized proteins that speed up essential chemical reactions, such as digestion (e.g., amylase in saliva breaking down carbohydrates) or energy production.
3. **Transport:**
   Hemoglobin is a protein which carries oxygen in blood stream and delivers to different parts of the body.

25.3 Fatty acids serve as building blocks of lipids just like amino acids are for proteins. Comment on this statement.

Ans. This statement is correct. Just as proteins are polymers made of amino acid monomers linked by peptide bonds, many lipids (specifically triglycerides) are formed by the combination of glycerol and fatty acids. Proteins and lipids are the fundamental building blocks of their respective biomolecules.

25.4 Write down about the sources of vitamin C. Which diseases are caused by its deficiency?

Ans. Sources of Vitamin C:

Vitamin C, also called ascorbic acid is found in citrus fruits, green pepper and tomatoes.

Deficiency Disease:

Deficiency of vitamin C in our body causes scurvy (bleeding gums).

25.5 Write down the names of two polymeric carbohydrates.

Ans. Two examples of polymeric carbohydrates are:

- Starch
- Cellulose

D. Descriptive Questions

25.1 What are the sources of fructose, maltose and lactose?

Ans. Sources of Fructose:

Fructose is a carbohydrate which is present in sweet fruit juices and honey.

Sources of Maltose:

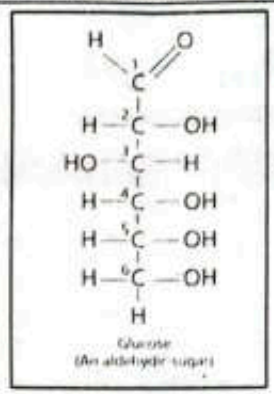
Maltose is a carbohydrate which is found in breads and cereals.

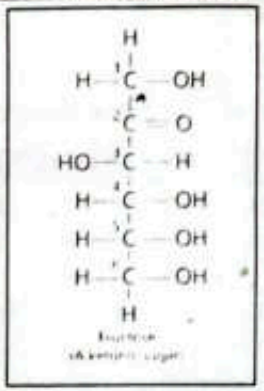
Sources of Lactose:

Lactose is a carbohydrate which is present in milk.

25.2 Draw open chain structures of glucose and fructose.

Ans. Open stuctures of glucose and fcuctose:





25.3 Construct peptide linkage and explain the structure of a polypeptide.

Ans. For Answer See Q 6

25.4 What are DNA and RNA? Describe the role played by them in our body.

Ans. For Answer See Q 10

25.5 Compare the roles played by carbohydrates, proteins and lipids in our body.

Ans. Comparison of roles played by carbohydrates, proteins and lipids in our body:

	Carbohydrates	Proteins	Lipids
Unit Basis	Monosaccharides (e.g: Glucose)	Amino Acids	Fatty acids and Glycerol
Energy yield	4 k cal / g	4 k cal / g	6 k cal / g
Storage form	Glycogen	Not stored	Adipose Tissue
Primary Role	Provides immediate energy for the body and brain.	Building blocks for tissues, muscles and enzymes.	Long-term energy reserve and insulation
Specific functions	Spare protein from being broken down for energy, support digestive health via fiber and assist in structurual and functional roles like cell membrane formation.	catalyzes chemical reactions; carries oxygen (homoglobin); provides immunity (antibodies).	Protect vital organs; help in the absorption of fat soluble vitamins (A, D, E, K); forms cell membrane.

CHAPTER 26 Polymers

Student Learning Outcomes

After studying this chapter, students will be able to::

- Define polymers as large molecules built up from many smaller molecules called monomers.
- Identify the repeating units and / or linkages in addition polymers and in condensation polymers.
- Deduce the structure or repeating unit of a condensation polymer from given monomers and vice versa, limited to:
  a. polyamides from a dicarboxylic acid and a diamine
  b. polyesters from a dicarboxylic acid and a diol.
- Describe the differences between addition and condensation polymerization.
- State that plastics are made from polymers.
- Describe how the properties of plastics have implications for their disposal.
- Describe the environmental challenges caused by plastics, limited to:
  - disposal in landfill sites
  - accumulation in oceans
  - formation of toxic gases from burning
- Describe the structure of:
  - nylon, a polyamide
  - PET, a polyester The full name for PET, polyethylene terephthalate, is not required.
- State that PET can be converted back into monomers and repolymerised
- Outline the importance of polymers in the textile industry. (Examples for polymers being used may be given along with their specific properties).

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

26.1	Types of Polymers
26.2	Structures of Monomer from Polymer

Q.1: Describe the following:

• **Monomers** • **Polymerization** • **Types of polymers** • **Importance of polymers**

Ans. Monomers: Polymers or macromolecules are extremely large molecules which

are formed by linking together a very large number of simple molecular units called monomers.

Polymerization: The process of formation of a polymer from a monomer is called polymerization.

Types of polymers: Carbohydrates, proteins and nucleic acids are the everyday examples of polymers which exist naturally. Whereas plastics, synthetic fibers, and natural rubber are the examples of man-made polymers. One of the most significant changes which has occurred throughout the world, has been the gradual replacement of metals, wood and cotton with man-made synthetic polymers.

Importance of polymers: Polymers are important in our daily life due to their high strength, flexibility and resistance to heat and chemicals. These properties make them useful for a wide range of applications.

Q.2: Write a note on addition polymers.

Ans. Addition Polymers:

Addition Polymers are one of the main types of polymers. Addition polymers are formed when monomer molecules containing a double bond combine together through a covalent bond to give a very large molecule.

Example:

A large number of ethene molecules add together to give one very big molecule which is called polythene or polythene.

Explanation:

During this reaction C = C double bond in ethene breaks down to allow ethene molecules to join together. Polymerization reactions usually take place at high pressure and in the presence of a catalyst.

In addition polymerization, no molecule is eliminated and no by-product is formed.

$$\underset{\text{Monomer}}{2CH_2=CH_2} \longrightarrow +\underset{\text{Repeat unit}}{CH_2+CH_2-CH_2}+CH_2+$$

$$nCH_2=CH_2 \longrightarrow +\underset{\text{Polyethene}}{CH_2-CH_2}+_n$$

Q.3: What are condensation polymers. How are they formed?

OR How is PET formed? Can you recycle this polymer?

Ans. Condensation Polymers:

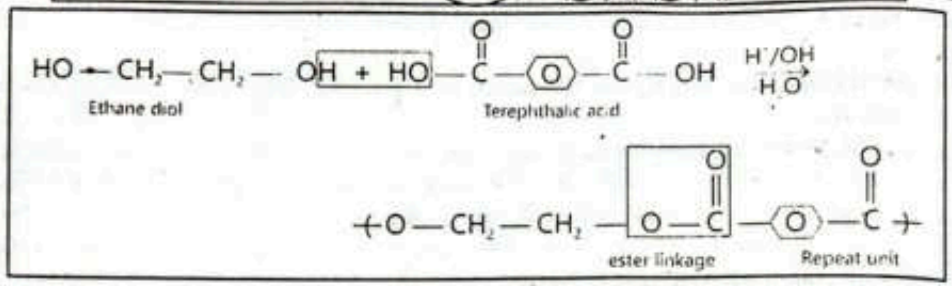
Condensation polymers are one of the main types of polymers.

Formation of Condensation Polymers:

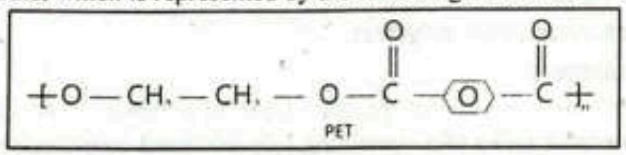
A condensation polymer is formed when two different molecules containing two different functional groups react together with the elimination of a small molecule like H_2O, HCl and NH_3 etc. The reaction takes place in the presence of an acid or a base.

Formation of Polyethene Terephthelate (PET):

Ethane diol reacts with a dicarboxylic acid (terephthalic acid) to give a polymer called Polyethylene Terephthalate group of the diol to give an ester linkage.



This product is called a repeat unit. Since the functional groups are present at both ends of the resulting molecule, the polymerization process continues at both ends to give a very big molecule, which is represented by the following structure.



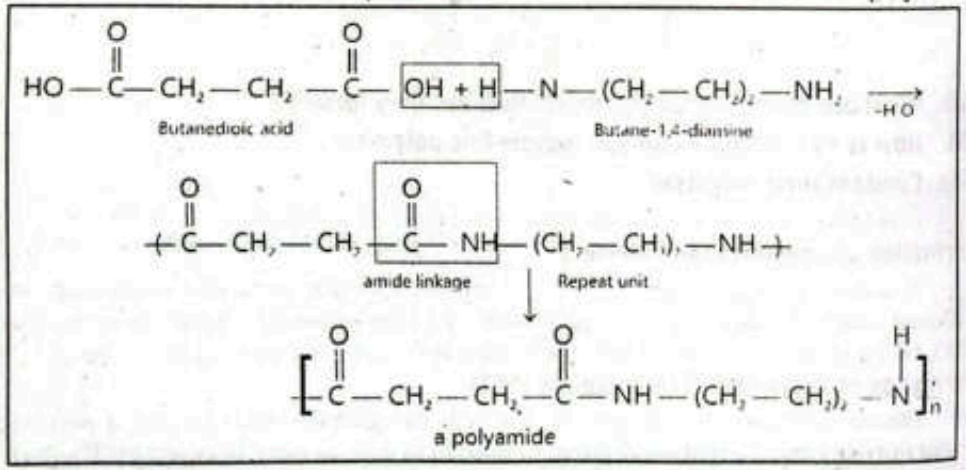
Recycling of PET:

PET can be recycled by chemically breaking down to the monomer units. Chemically recycling can be done through heating the polymer in the absence of oxygen.

Q.4: Write formation of polyamide.

Ans. Formation of a Polyamide:

Another condensation polymer, a polyamide, is formed when butanedioic acid reacts with a diamine. Each –COOH group of the dicarboxylic acid reacts with each $-NH_2$ group present in diamine to form an amide linkage. A water molecule is lost during the condensation reaction. The repeat unit thus formed is then converted into a polymer.



Q.5: Differentiate between addition and condensation polymerizations.

Ans.

Addition Polymerization	Condensation Polymerization
A single monomer is used which should have a double or a triple bond.	This polymerization takes place between two monomers. The monomer molecules have two functional groups present one on each end of the molecule.
It involves an addition reaction and only a single product is formed.	It involves the condensation between two monomers with the elimination of a small molecule like H_2O, HCl or NH_3.
The molecular mass of the product polymer can be found by adding the molecular masses of all the monomers used.	The molecular mass of the polymer cannot be found by adding the molecular masses of all the monomers.
The polymer formed contains only the single bonds along the polymer backbone chain.	The polymer formed contains a specific linkage, e.g. ester linkage or amide linkage.
Examples of addition polymers are polyethene, polystyrene, polyvinylchloride (PVC), etc.	Example of condensation polymers are polyester, nylon, bakelite, etc.

Q.6: (a) Write down reactions along with the conditions to prepare polyamide and polyester.

Ans. Preparation of Polyester:

(i) Write down the structure of a condensation polymer, polyester.

$\{CO-CH_2-CH_2-\mathbf{CO-O}-CH_2-CH-O\}$

(ii) Identify the repeating unit in the polymer. Remove the brackets, the extended bonds at bone the ends and the subscript n. Break the bond between CO and O of the ester linkage. Add OH to the each end of the dicarboxylic acid monomer. Add H to each end of the diol monomer.

$$\{CO\text{-}CH_2\text{-}CH_2\text{-}CO\text{-}O\text{-}CH\text{-}CH\text{-}O\}$$

$$n\{CO\text{-}CH\text{-}CH\text{-}CO\text{-}O\text{-}CH\text{-}CH\text{-}O\} \rightarrow$$

$$nHO\text{-}CO\text{-}CH_2\text{-}CH\text{-}CO\text{-}OH + nH\text{-}O\text{-}CH\text{-}CH\text{-}O\text{-}H$$

Preparation of Polyamide:

(i) Write down the structure of a condensation polymer, a polyamide.

$\{CO-CH-CH_2-\mathbf{CO-NH}-(CH-CH_2)-NH\}$

(ii) Identify the repeating unit in the polymer. Remove the brackets, remove the extended linkage at both the ends and subscript n. Break the bond between the CO and NH of the amide linkage. Add OH to the each end of dicarboxylic acid monomer. Add H to each end of the diamine monomer.

$$n\{CO - CH_2 - CH_2 - CO - NH - (CH_2 - CH_2) - NH\}$$

$$\longrightarrow nHO-CO-CH_2-CH_2-CO-OH$$

$$+ nH - NH - (CH_2 - CH_2) - NH - H$$

(b) Write down reaction alongwith the conditions to prepare addition polymer.

Ans. Addition Polymer:

(i) Write down the structure of addition polymer.

$\{CH_2-CH_2\}$

(ii) Identify the repeating unit in the polymer. Remove the brackets, the extended bonds from each side and the subscript n. Change the single bond to a double bond.

$\{CH_2-CH_2\} \longrightarrow n\ \{CH_2-CH_2\} \longrightarrow CH_2=CH_2$

26.3	Plastics
26.4	Importance of Polymers in the Textile Industry
26.5	Adverse Effects of Plastics

Q.7: Describe polymers of plastic and their uses.

Ans. Plastic Polymers: Polymerizatoin of monomers like ethylene, propylene and styrene gives polyethylene (PE), polypropylene (PP) and polystyrene (PS) respectively. All these polymers are a few examples of compounds called Plastics. These plastics are used to make all types of carry-home food containers, eg.,

Plastic products

Uses: Soft drink bottles, water bottles, juice bottles etc. They are also used to manufacture shopping bags, kitchen-wares, buckets, tables, chairs, food wrappers, cups and plates etc. Plastics are light weight, flexible and durable. They can be easily moulded into solid objects of almost any desired shape. All these properties have led to their widespread use in almost any sphere of our daily life. Starting form early 20th century millions of tons of plastics are made every year

Q.8: Describe the role of synthetic polymers in the textile industry.

Ans. Synthetic Polymers:

Polymers which are used in the textile industry are called synthetic fibers.

Examples: Nylon, polyester, rayon, acrylic etc.

Role of Synthetic Polymers in the Textile Industry:

The properties of synthetic fibers which enable them to be used in textile industry are as follows:

1. They are cheaper in cost than natural fibers like cotton and silk.
2. They are stronger and more durable than natural fiber.
3. They do not shrink.
4. They resist wrinkling.
5. They are light weight and quick drying.
6. They are moth and insect resistant.

Polymers in textile

Q.9: Describe the effects of synthetic polymers on the environment.

Ans. Adverse Effects of Plastics:

Unlike other materials, plastics do not undergo biodegradation. When articles made of plastics are discarded, they can take upto 1000 years to break down. This fact has led to build up of huge amounts of plastics in the environment. Accumulation of suc a huge amount of different articles made of plastics has caused widespread environmental problems.

- **Plastic Pollution:**

Plastic pollution is found almost everywhere on lands, in air and in all the water bodies: rivers, ponds, lakes, seas and oceans. This pollution has reached to an extremely alarming level and has led to cause serious health problems.

- **Burning of discarded Plastic Articles:**

Discarded plastic articles we put in the binds are disposed of through burning, dumping in the landfill, thrown in the drains from where they make their way to rivers and oceans. Burning of discarded plastic articles in town, creates a hazardous environmental condition because this releases dangerous gases in air.

Plastic pollution

26.1 Quick Check!

1. Give an example of a commercial product which is formed using polyethene.

Ans. Common commercial products include carry home food containers, soft drink bottles, water bottles and shopping bags.

2. Write three properties of synthetic polymers.

Ans. Properties of Synthetic Polymers:

(i) They do not shrink. **(ii)** They resist wrinking.

(iii) They are light weight and quick drying.

26.2 Quick Check!

1. How an ester linkage between two monomers is formed?

Ans. An ester linkage between two monomers is formed through a chemical reaction between a carboxyl group (COOH) and one monomer and a hydroxyl group (OH) of another monomer. During this process, a molecule of water (H_2O) is released, creating the bond known as an ester linkage.

R C(O) O R'

2. How does condensation polymerization occur?

Ans. A condensation polymer is formed when two different molecules containing two different functional groups react together with the elimination of a small molecule like H_2O, HCl and NH_3 etc.

Example:

The formation of polyester (like PET) or polyamide (like Nylon).

26.3 Quick Check!

1. What do you understand by the term repeating unit?

Ans. Repeating Unit:

A repeating unit is the smallest part of a polymer chain that, when linked together repeatedly, forms the entire macromolecule.

- It represents the chemical structure derived from the original monomer(s) after the polymerization process is complete.
- In a chemical formula, the repeating unit is usually enclosed in brackets with a subscript 'n' [e.g., $(M)_n$] indicating that the unit repeats hundreds or thousands of times.

2. Draw the structure of a polyamide linkage.

Ans. A polyamide linkage (also called an amide bond) is the chemical connection formed between an amino group and a carboxyl group. It is the defining feature of polymers like Nylon.

The structure of the polyamide linkage is:

C(O) NH

In a polymer chain, it looks like this:

[Rest of chain C(O) NH Rest of Chain]

INTERESTING INFORMATION

- Properties of polymers can be changed through careful control of their chemical structure and composition enabling their use in highly specific application like non-stick coating (Teflon).

- By varying the type and proportion of monomers, chemists can make such polymers which shows specific properties, such as flexibility, strength and thermal stability to meet specific application requirements.
- Polymers can be 3D printed using a variety of techniques. These techniques involve layer-by-layer deposition of the polymer material to create three-dimensional objects.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

26.1	Types of Polymers
26.2	Structure of Monomer from Polymer

1. What is another term used for polymers due to their extremely large size?

(a) Micromolecules (b) Macromolecules (c) Monomers (d) Isotopes

2. Which of the following is a naturally occurring polymer?

(a) Plastic (b) Nylon (c) Nucleic acids (d) PVC

3. Synthetic polymers have largely replaced which of the following materials?

(a) Wood (b) Cotton (c) Metals (d) All of these

4. Which property makes polymers useful for a wide range of applications?

(a) Resistance to chemicals (b) High strength
(c) Flexibility (d) All of these

5. Addition polymers are formed from monomers that specifically contain:

(a) Only single bonds (b) A double bond
(c) An ester linkage (d) An amide linkage

6. In addition polymerization, what is the by-product?

(a) Water (b) Ammonia
(c) Hydrogen chloride (d) No by product is formed

7. Which conditions are usually required for polymerization reactions?

(a) Low pressure and no catalyst (b) High pressure and a catalyst
(c) High pressure and oxygen (d) Vacuum and low temperature

8. Condensation polymerization occurs between monomers that have:

(a) Triple bonds (b) One functional group
(c) Two different functional groups (d) No functional groups

9. Which of these is a common small molecule eliminated during condensation?

(a) CH_4 (b) H_2O (c) O_2 (d) CO_2

10. Terylene (PET) is formed from which two monomers?

(a) Ethane diol and Terephthalic acid (b) Ethene and Propane
(c) Butane dioic acid and Diamine (d) Adipic acid and glycol

11. **A polyamide linkage (amide linkage) is represented as:**
(a) –COOH– (b) –CONH– (c) $-CH_2-CH_2$ (d) –O

12. **What does the subscript 'n' represent in a polymer structure?**
(a) Number of catalyst (b) Number of repeating units
(c) Number of double bonds (d) Temperature of reaction

13. **To identify the monomer of an addition polymer, you must change the single bond of the repeating unit into a:**
(a) Single bond (b) Double bond (c) Ester linkage (d) Amide linkage

14. **When identifying the monomers of a polyester, what is added to the dicarboxylic acid end?**
(a) –OH (b) –H (c) $-CH_3$ (d) $-NH_2$

15. **Which polymer is used for non-stick coating on pans (Teflon)?**
(a) PVC (b) Nylon
(c) Polytetrafluoroethylene (d) Bakelite

26.3 Plastics

26.4 Importance of Polymers in the Textile Industry

26.5 Adverse Effects of Plastics

16. **Which monomer is polymerized to produce polypropylene (PP)?**
(a) Propylene (b) Ethylene (c) Styrene (d) Vinyl Chloride

17. **Which monomer is polymerized to produce polyethylene (PE)?**
(a) Styrene (b) Ethylene (c) Vinyl chloride (d) Propylene

18. **Which of the following monomer is polymerized to produce polystyrene?**
(a) Ethylene (b) Vinyl chloride (c) Styrene (d) Propylene

19. **Polyethylene (PE), Polypropylene (PP) and Polystyrene (PS) are all common examples of:**
(a) Plastics (b) Proteins (c) Natural fibres (d) None of these

20. **Polymers used specifically in the textile industry are known as:**
(a) Natural fibers (b) Synthetic fibers (c) Catalysts (d) Plastics

21. **Which of the following is an example of a synthetic fiber?**
(a) Cotton (b) Silk (c) Wool (d) Nylon

22. **Approximately what percentage of global clothing industry materials do polyester and nylon account for?**
(a) 50% (b) 69% (c) 85% (d) 99%

23. **Which synthetic fiber is specifically noted for providing warmth and being soft?**
(a) Polyethylene (b) Nylon (c) Acrylic (d) Polystyrene

24. **How long can it take for some plastic articles to break down in the environment?**
(a) 10 years (b) 50 years
(c) 100 years (d) up to 1000 years

25. **Which property of plastic allows them to be formed into almost any desired shape?**
(a) Transparency (b) High density
(c) Mould easily (d) Heat conductivity

ANSWERS:

1.	(b)	2.	(c)	3.	(d)	4.	(d)	5.	(b)	6.	(d)	7.	(b)
8.	(c)	9.	(b)	10.	(a)	11.	(b)	12.	(b)	13.	(b)	14.	(a)
15.	(c)	16.	(a)	17.	(b)	18.	(c)	19.	(a)	20.	(b)	21.	(d)
22.	(b)	23.	(c)	24.	(d)	25.	(c)						

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques (Knowledge, Understanding, Application, Analytical & Conceptual)

26.1 Types of Polymers

26.2 Structure of Monomer From Polymer

1. **What are polymers?**

Ans. Polymers: Polymers or macromolecules are extremely large molecules which are formed by linking together a very large number of simple molecular units called monomers.

2. **Define polymerization.**

Ans. Polymerization: The process of formation of a polymer from a monomer is called polymerization.

3. **Distinguish between natural and man-made polymers.**

Ans. Natural Polymers: Natural polymers occur naturally in nature.

Examples: Carbohydrates, proteins and nucleic acids.

Man-made Polymers: These are the polymers created by humans.

Examples: Plastic, synthetic fibers and natural rubber (processed).

4. **What are two main types of polymers?**

Ans. Types of Polymers: Two main types of polymers are:

- Addition Polymers
- Condensation Polymers

5. Why have synthetic polymers replaced materials like metals, wood and cotton?

Ans. Synthetic polymers are preferred because of their high strength, flexibility and resistance to heat and chemicals making them more versatile for modern applications.

6. What are addition polymers?

Ans. Addition Polymers: Addition polymers are formed when monomer molecules containing a double bond combine together through a covalent bond to give a very large molecule.

Example: A large number of ethene molecules add together to give one very big molecule which is called polyethene or polythene.

7. What are the necessary conditions for addition polymerization?

Ans. These reactions usually take place under high pressure and in the presence of a catalyst.

8. Define condensation polymers.

Ans. Condensation Polymers: A condensation polymer is formed when two different molecules containing two different functional groups react together with the elimination of a smal molecule like H_2O, HCl and NH_3 etc.

9. What is PET (Polyethylene Terephthalate)?

Ans. PET (Polyethylene Terephthalate) is a common polyester formed by the condensation reaction between ethane diol and terephthalic acid. It is widely used in making plastic bottles.

10. How is a polyamide formed?

Ans. Polyamide is a condensation polymer, which is formed when butanedioic acid reacts with diamine. Each –COOH group of the dicarboxylic acid reacts with each $–NH_2$ group present in diamine to form an amide linkage. A water molecule is lost during the condensation reaction. The repeat unit thus formed is then converted into a polymer.

11. What is a repeating unit?

Ans. A repeating unit is the specific part of a polymer chain that is derived from the monomers and repeats many times to make up the complete macromolecule.

12. What happens to the C = C double bond during addition polymerization?

Ans. The double bond breaks down to allow ethene molecules to join together.

13. Why is no by product formed in addition polymerization?

Ans. No by product is formed in addition polymerization because it involves an addition reaction where no molecule is eliminated; all atoms of the monomers are retained in the polymers.

14. Give three examples of addition polymers.

Ans. Three exampels of addition polymers are:

- Polyethene (Polythene)
- Polystyrene
- Polyvinylchloride (PVC)

15. How is the molecular mass of an addition polymer calculated?

Ans. The molecular mass of an addition polymer is calculated by addition the molecular masses of all the monomers used.

16. Name three small molecules eliminated during condensation.

Ans. Three small molecules eliminated during condensation are water (H_2O), Hydrochloric acid (HCl) and Ammonia (NH_3).

17. How can PET be recycled?

Ans. PET can be recycled by chemically breaking down to the monomer units.

18. How can chemical recycling be done?

Ans. Chemical recycling can be done through heating the polymer in the absence of oxygen.

19. Give some examples of condensation polymers.

Ans. Some examples of condensation polymers are:

- Polyester
- Nylon
- Bakelite

20. What is the specific use of Teflon?

Ans. Teflon is used as non-stick coating for pans.

26.3	Plastics
26.4	Importance of Polymers in the Textile Industry
26.5	Adverse Effects of Plastics

21. Which monomers are used to create common plastics?

Ans. Monomers like ethylene, propylene and styrene are polymerized to produce polyethylene (PE), Polypropylene (PP) and Polystyrene (PS).

22. What are some common uses of plastics in the food industry?

Ans. Plastics are used to make carry home food containers, e.g: soft drink bottles, water bottles, juice bottles etc. They are also used to manufacture shopping bags, kitchen-wares, buckets, tables, chairs, food wrapers, cups and plates etc.

23. List four physical properties of plastics that make them useful.

Ans. Plastics are lightweight, flexible, durable and can be easily moulded into almost any desired shape.

24. Name common household items made of plastic.

Ans. Kitchen-wares, buckets, tables, chairs, shopping bags, cups and plates.

25. What are synthetic fibers?

Ans. Polymers which are used in the textile industry are called synthetic fibers. Examples. Nylon, Polyster, rayon, a cyelic etc.

26. What is the global significance of polyester and nylon in clothing?

Ans. The polyesters and nylon are the two common polymers which account for 69% of all the material used in clothing industry worldwide.

27. What are the specific uses of polyester and acrylic?

Ans. Use of polyester: Polyester is an important fiber for its strength and resistance to shrinking. It is commonly used in sports wear and hoisery.
Use of Acrylic: Acrylic is light weight, soft and provides warmth.

28. Why do plastics pose a major environmental threat?

Ans. Unlike other materials, plastics do not undergo biodegradation. They can take up to 1000 years to break down.

29. Where is plastic pollution most commonly found?

Ans. It is found almost everywhere on land, in the air, and in all water bodies including rivers, ponds, lakes, seas and oceans.

30. What are the common methods of disposing of plastic waste?

Ans. Discarded plastics articles we put in the bins are disposed of through burning, dumping in the landfill, thrown in the drains from where they make their way to rivers and oceans.

31. How does plastic waste reach the oceans?

Ans. Plastics thrown into drains eventually make their way into rivers and then into the oceans.

32. Why is the burning of plastic articles dangerous?

Ans. Burning of plastic articles is dangerous because it releases dangerous gases in air.

33. How can 3D printing use polymers?

Ans. Polymers can be 3D printed using a variety of techniques. There techniques involve layer by layer deposition of the polymer material to create three dimensional objects.

Exercise

Multiple Choice Questions

☆ Choose and tick the correct answer from the given choices.

1. Which of the following polymer is a synthetic polymer?
   (a) Starch (b) Rubber (c) Natural fat (d) Polyster

2. Which polymer has an amide linkage?
   (a) Polyester (b) Polyamide (c) Polyethene (d) Polystyrene

3. Identify an ester linkage:
   (a) $R-\overset{\overset{O}{\|}}{C}-O-R$ (b) $R-\overset{\overset{O}{\|}}{C}-R$

(c) $R-\overset{\overset{O}{\|}}{C}-O-NH-R$ (d) $R-\overset{\overset{O}{\|}}{C}-NH-R$

4. **The structure of the monomer of the following polymer is:**

$$[-CH_2-\underset{\underset{OCOCH_3}{|}}{CH}-]_n$$

(a) $CH_2=CH_2$ (b) $CH_2\ CH_2\ CH_3$
(c) $CH_2=CH-OCOCH_3$ (d) $CH_2\ CH\ CO\ O\ CH_3$

5. **Which of the following polymers can be recycled?**
(a) PET (b) Polystyrene (c) PVC (d) Epoxy

6. **Which of the following polymers is biodegradable?**
(a) Polyamide (b) Polyester (c) Starch (d) PET

7. **Which of the following polymers is obtained by condensation polymerization?**
(a) Polyvinyl chloride (b) Polystyrene
(c) Polyamide (d) Polyethene

ANSWERS:

1. (d) 2. (b) 3. (a) 4. (c) 5. (a) 6. (c) 7. (c)

B. Short Answer Questions

26.1 Give two examples each of addition polymers and condensation polymers.

Ans. Examples of Addition Polymers: Two examples of addition polymers are:
- Polyethene
- Polystyrene

Examples of Condensation Polymers: Two examples of condensation polymers are:
- Polyethylene Terephthalate (PET)
- Polyamide

26.2 How polymers are useful for us?

Ans. Polymers are important in our daily life due to their high strength, flexibility and resistance to heat and chemicals. They are used in food containers, clothing, kitchen ware and furniture.

26.3 How synthetic fibers are different from natural fibers?

Ans. Synthetic fibers are different from natural fibers in the following ways:
- They are chepaer in cost than natural fibers like cotton and silk.
- They are stronger and more durable than natural fiber.
- They do not shrink.
- They resist wrinkling.
- They are light weight and quick drying.
- They are moth and insect resistant.

26.4 Are natural polymers hazardous for the environment? Explain why?

Ans. No. Natural polymers (like starch and cellulose) are biodegradable, meaning they are broken down by microorganisms and do not accumulate as pollution.

26.5 Draw the structures of the following polymers.

(a) Polypropylene **(b) Polystyrene**

Ans. (a) Polypropylene: $\{CH_2 - CH(CH_3)\}_n$

(b) Polystyrene: $\{CH_2 - CH(C_6H_5)\}_n$

C. Constructed Response Questions

26.1 Why is it dangerous to burn discarded articles made of plastics?

Ans. Burning plastics is hazardous primarily due to the toxic emissions released into the atmosphere. Plastics are synthetic polymers often containing chlorine, fluorine, or various chemical additives.

- **Toxic Gases:** They release harmful gases such as hydrogen chloride (HCl), Dioxins and Furans. Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system and cause cancer.
- **Particulate Matter:** Burning produces thick black smoke containing the particulates that cause respiratory issues like asthma and bronchitis.
- **Carbon Monoxide:** In complete combustion produces CO, which is a poisonous gas that interferes with the blood's ability to carry oxygen.

26.2 Why is it not advisable to dump discarded synthetic articles in oceans?

Ans. Dumping synthetic materials (like plastics and nylon) in oceans creates a reverse environmental crisis known as marine pollution.

- **Non–Biodegradability:** Most synthetic articles do not decompose. They remain in the ocean for hundreds of years.
- **Threats to Marine Life:** Animals often mistakenly take plastic for food (e.g: sea turtles mistakenly consider plastic bags for jelly fish). This leads to starvation or internal injuries. Additionally, animals can become entangled in discarded plastic rings.
- **Microplastics:** Over time, sunlight break large plastics into tiny fragments called microplastics. These enter the food chain, absorbing toxins that eventually reach humans when we consume sea food.

26.3 What is the role of catalyst in addition polymerization?

Ans. In addition polymerization (like the formation of Polyethene), the catalyst serves three main purposes:

- **Initiation:** It breaks down to create an active species that attacks the double bond of the monomer.
- **Activation:** It lowers the activation energy required for the reaction to occur, allowing the polymerization to happen at lower temperatures and pressures.
- **Rate of Reaction:** It significantly increases the speed at which monomers link together to form long polymer chains.

26.4 Deduce the monomer from the following addition polymers.

(i) $\{CH_2-\underset{Cl}{\underset{|}{CH}}\}_n$ **(ii)** $\{CH-\underset{CN}{\underset{|}{CH}}\}_n$

To find the monomer from an addition polymer, we identify the repeating unit remove the extending bonds (the brackets and 'n'), and replace the single bond between the carbon atoms with a double bond (C = C).

(i) $\{CH_2-\underset{Cl}{\underset{|}{CH}}\}_n$

Polymer: $\{CH_2 - CH(Cl)\}_n$ (Polyvinyl chloride or PVC)

Monomer: Vinyl Chloride (Chloroethene)

Structure: $CH_2 = CH - Cl$

(ii) $\{CH_2-\underset{CN}{\underset{|}{CH}}\}_n$

Polymer: $\{CH_2 - CH(CN)\}_n$ (Polyacrylonitrile or PAN)

Monomer: Acrylonitrile (Cyanoethene)

Structure: $CH_2 = CH - CN$

D. Descriptive Questions

26.1 How is PET formed? Can you recycle this polymer?

Ans. For answers see Q.3

26.2 Differentiate between addition and condensation polymerizations.

Ans. For answers see Q.5

26.3 Write down reactions alongwith the conditions to prepare polyamide and polyester.

Ans. For answers see Q.6 (a)

26.4 Describe the role of synthetic polymers in the textile industry.

Ans. For answers see Q.8

26.5 Describe the effects of synthetic polymers on the environment.

Ans. For answers see Q.9

Pairing Scheme / Instructions for Preparation of Exam Paper of Chemistry for Class-10

ESSENTIAL INSTRUCTIONS FOR PAPER SETTERS

The paper of Chemistry (General) for class 10 will consist of 60 marks. Timing of the paper will be two hours. The paper will be made as per following details:

Objective: **Q-1:**
12 Multiple Choice Questions 1 × 12 12
The detail is as follows:

Chapter	14	15	16	17	18	19	20	21	22	23	24	26
No. of MCQs	1	1	1	1	1	1	1	1	1	1	1	1

Subjective: **Q-2:**
Part-I: 5 short answer questions have to be answered out of 8. 2 × 5 10
The detail is as follows:

Chapter	14	15	16	17	18
No. of Short Questions	2	1	1	2	2

Q-3:
Five (5) short answer questions have to be answered out of Eight (8). The detail is as follows: 2 × 5 10

Chapter	19	20	21	22
No. of Short Questions	2	2	2	2

Q-4:
Five (5) short answer questions have to be answered out of Eight (8). The detail is as follows: 2 × 5 10

Chapter	23	24	25	26
No. of Short Questions	2	2	2	2

Subjective: **Part-II:** This section will contain three detailed questions bifurcated in two-part **a & b** (carrying 5 & 4 marks each) and students have to attempt 2 questions The detail is as follows: 2 × 9 18

Q-5:

Chapter	14	15
Part	a	b

Q-6:

Chapter	20	22
Part	a	b

Q.7:

Chapter	23	25
Part	a	b

Model Paper of Chemistry For Class-10

Objective Type

Time Allowed: 15 Min Max. Marks: 12

Note: Four possible answers A, B, C and D to each question are given. The choice which you think is correct, fill that circle with marker or pen ink in the answer-book. Cutting or filling two or more circles will result in zero mark in that question.

1. Select the correct answer. (1×12=12)

(i) Which gas will diffuse at the fastest rate?
(a) HCl (b) SO_2 (c)✓ H_2 (d) CO_2

(ii) Volume occupied by 15 moles of ammonia gas at STP
(a) 224 dm^3 (b) 161 dm^3 (c)✓ 336 dm^3 (d) 265 dm^3

(iii) Which of the following metal is the highest in the electrochemical series?
(a) Tin (b) Iron (c)✓ Magnesium (d) Zinc

(iv) The shape of the crystal of NaCl is:
(a)✓ Cubic (b) Hexagonal (c) Rhombic (d) Trigonal

(v) The oxide that is neutral in character:
(a) Al_2O_3 (b) SO_2 (c) CO (d)✓ NO

(vi) The pH of distilled water is:
(a) 6.5 (b) 8.5 (c)✓ 7 (d) 7.5

(vii) Select the general formula of alkyne family.
(a) C_nH_{2n+1} (b) C_nH_{2n} (c) C_nH_{n-1} (d)✓ C_nH_{2n-2}

(viii) Which of the following is not used as a fuel?
(a) LPG (b) CNG (c) Diesel (d)✓ Asphalt

(ix) Which of the following acids is present in apple?
(a) Citric acid (b) Tartaric acid (c) Acetic acid (d)✓ Malic acid

(x) If the reactants posses an energy higher than the activation energy, than the reaction will be:
(a) Slow (b)✓ Fast (c) Not affected (d) Instantaneous

(xi) Which polymer can be recycled?
(a)✓ PET (b) Polystyrene (c) PVC (d) Epoxy

(xii) Which catalyst other than H_3PO_4 can also be used for hydration of alkenes.
(a) NaOH (b)✓ H_2SO_4 (c) CH_3COOH (d) Ni

Time Allowed: 1:45 Hrs **Max. Marks: 30**

Subjective Type (Part I)

Q.2: Write short answers to any five (05) questions: **(2 × 5 = 10)**

(i) Is condensation an endothermic process?
(ii) Why ice melts when the pressure is exerted on it?
(iii) Why is percentage yield important?
(iv) What are the main objectives of electroplating?
(v) Give any two features of the catalytic action of an enzyme.
(vi) From where do molecules get energy to attain higher energy state?
(vii) Name two insoluble carbonates.
(viii) What is crystal lattice?

Q.3: Write short answers to any five (05) questions: **(2 × 5 = 10)**

(i) How nitrogen is obtained from air?
(ii) How fossil fuels produce SO_2?
(iii) What is trachoma disease?
(iv) What is the difference between sedimentation and filteration?
(v) Define structural isomerism.
(vi) Write down the structural formula of Butan-2-ol.
(vii) How an alkene can be identified?
(viii) Why is oxyacetylene flame so hot?

Q.4: Write short answers to any five (05) questions: **(2 × 5 = 10)**

(i) Give any two disadvantages of fermentation reaction
(ii) How ethanol is prepared from ethene?
(iii) What is esterification reaction?
(iv) How does ethanol react with propanoic acid?
(v) What is the role of enzyme in our body? (vi) What is glycoside linkage?
(vii) What is the role of catalyst in addition polymerization?
(viii) How does condensation polymerization reaction occur?

Subjective Type (Part II)

Note: Attempt any two questions

Q5: (a) Differentiate between evaporation and boiling. **(5)**
(b) How would you identify the limiting reactant in a chemical reaction? **(4)**

Q6: (a) What is fertilizer? Mention the essential qualities of a good fertilizer. **(5)**
(b) Describe two methods of preparation for ethene. **(4)**

Q7: (a) Describe the applications of ethanol in pharmaceutical and cosmetic industries. **(5)**
(b) What are carbohydrates? Describe their classification with examples. **(4)**

HAMDARD CHEMISTRY

ہمدرد کتب خانہ

کی نئے نصاب کے مطابق مستند و معیاری امدادی کتب

ہمدرد امتحانی کتب برائے میٹرک کلاسز

ہمدرد امتحانی اُردو	ہمدرد امتحانی اسلامیات (لازمی)
ہمدرد امتحانی اسلامیات (اختیاری)	ہمدرد امتحانی ترجمۃ القرآن المجید
ہمدرد امتحانی ریاضی	ہمدرد امتحانی اخلاقیات
ہمدرد امتحانی مطالعہ پاکستان	ہمدرد امتحانی جنرل سائنس
ہمدرد امتحانی ہوم اکنامکس	ہمدرد امتحانی سوکس
ہمدرد امتحانی مبادیات تعلیم (ایجوکیشن)	
ہمدرد امتحانی فزکس	ہمدرد امتحانی کیمسٹری
ہمدرد امتحانی [illegible]	ہمدرد امتحانی بائیولوجی
ہمدرد امتحانی عربی	ہمدرد امتحانی کمپیوٹر سائنس [illegible]
HAMDARD IMTIHANI ENGLISH	HAMDARD IMTIHANI BIOLOGY
HAMDARD IMTIHANI CHEMISTRY	HAMDARD IMTIHANI PHYSICS
HAMDARD IMTIHANI MATHEMATICS	HAMDARD IMTIHANI GENERAL SCIENCE
HAMDARD IMTIHANI COMPUTER SCIENCE & ENTREPRENEURSHIP	

علاوہ ازیں میٹرک کلاسز کے تمام مضامین کے
ہمدرد سکالر اَپ ٹو ڈیٹ پیپرز بھی طلب فرمائیں۔

KNOWLEDGE
IS POWER

Price Rs. 390/-

Hamdard
KUTAB KHANA
Technical & Educational Publishers

14-Urdu Bazar, Lahore.
Tel: 042-37312368-37358947
Fax: 042-37210412
e-mail:hamdard.kutab@gmail.com
www.hamdardkutabkhana.com.pk

IE-1003