Q.9 Define filtration and crystallization.

Ans. **Filtration:** "The process in which insoluble particles (suspended particles or precipitates) are separated from liquids is called filtration."

Crystallization: "Crystallization is the removal of a solid from solution by increasing it concentration above the saturation point in such a manner that the excess solid separates out in the form of crystals."

Q.10 What is safe and reliable method for drying the crystals? Briefly explain.

Ans. **Vacuum Desiccator:**

A safe and reliable method of drying crystals is through a vacuum desiccator. **In this process, crystals are** spread over a watch glass and kept in vacuum desiccator for several hours. **Drying agents used in a desiccator** are $CaCl_2$, silica gel or phosphorous pentaoxide (P_2O_5)

◈◈◈◈◈

SELF-ASSESSMENT Chapter # 15

Total Mark: 30

Q.1 Encircle the correct option. **(1 × 6 = 6)**

(i) After the crystals are formed, they are typically separated from the mother liquor by:
a) Evaporation b) Decantation or filtration c) Sublimation d) Distillation

(ii) The method that can be used to separate two solid compounds with different solubilities in a solvent is:
a) Distillation b) Isolation c) Crystallization d) Filtration

(iii) It is suspected that a hand-written legal document has been changed by over writing some crucial figures. Which technique you will use to check the inks used at suspected places?
a) Distillation b) Chromatography c) Solvent Extraction d) Crystallization

(iv) The porous material used to separate the solid from the liquid during filtration is called the:
a) Filtrate b) Residue c) Filter medium d) Solvent

(v) The key difference between simple distillation and fractional distillation is the presence of a:
a) Condenser with a larger surface area. b) More powerful heat source.
c) Fractionating column. d) Vacuum pump.

(vi) In chromatography, a locating agent is used to:
a) Dissolve the sample for separation.
b) Carry the separated components along the stationary phase.
c) Make colorless separated components visible for identification.
d) Prevent the sample from interacting with the stationary phase.

Q.2 Write short answers of the following questions. **(2 × 8 = 16)**

(i) Differentiate gravity filtration and vacuum filtration.
(ii) Differentiate between adsorption and partition chromatography.
(iii) Why HF cannot be filtered through sintered glass crucible?
(iv) What is chromatography?
(v) Differentiate between stationary phase and mobile phase in chromatographic technique?
(vi) How does a Gooch crucible increases the rate of filtration?
(vii) Write down the uses/applications of chromatography.
(viii) What is the significance of distribution coefficient in chromatography?

Q.3 Extensive Questions. **(2 × 4 = 8)**

(a) Differentiate simple distillation and fractional distillation in construction and applications.
(b) Write down the procedure of ascending paper chromatography with diagram.

Chapter 16 LAB SAFETY AND PRACTICAL SKILLS

Student Learning Outcomes

After studying this chapter, students will be able to:

- Identify the chemical hazards in the lab in the context of the experiment being conducted. **(Knowledge)**
- Test that the equipment is working properly without any potential risk of injury before conducting an experiment. **(Knowledge)**
- Ensure that work space for conducting the experiment is not crowded with apparatus as to be hazardous. **(Knowledge)**
- Ensure that safe distance space is kept at all times from other investigators who may handling lab apparatus. **(Knowledge)**
- Identify what bodily harm could occur from physical, chemical, biological and safety hazards in context of the experiment being conducted. **(Knowledge)**
- Recognize that it is always better to ask for help from the lab instructor when unaware of how to use new apparatus. **(Knowledge)**
- Identify the proper waste disposal system for chemicals being used. **(Knowledge)**
- Set up apparatus following instructions given in written or diagrammatic form. **(Understanding)**
- Use apparatus to collect an appropriate quantity of data. **(Understanding)**
- Make observations including subtle differences in colour, solubility or quantity of materials. **(Understanding)**
- Make measurements using pipettes, burettes, measuring cylinders, thermometers, and other common laboratory apparatus. **(Understanding)**
- Decide how many tests or observations to perform. **(Understanding)**
- Identify where repeated readings or observations are appropriate. **(Understanding)**
- Replicate readings or observations as necessary, including where an anomaly is suspected. **(Understanding)**
- Identify where confirmatory tests are appropriate and the nature of such tests. **(Understanding)**
- Select reagents to distinguish between given ions. **(Knowledge)**
- Carry out procedures using simple apparatus in situations where the method may not be familiar to the candidate. **(Application)**
- Describe acid base titration to include the use of a burette, volumetric pipette and suitable indicator. **(Understanding)**
- Describe how identify the end point of a titration using an indicator. **(Understanding)**
- Describe tests to identify the anions: (a) CO_3^{2-}, (b) Cl^{1-}, Br^{1-} and I^{1-} (c) NO_3^{1-} (d) SO_4^{2-} (e) SO_3^{2-} **(Understanding)**
- Describe tests using aqueous NaOH and aqueous NH_3 to identify the aqueous cations: (a) Al^{3+} (b) NH_4^+ (c) Ca^{2+} (d) Cr^{3+} (e) Cu^{2+} (f) Fe^{2+} (g) Fe^{3+} and (h) Zn^{2+} **(Understanding)**

A chemistry laboratory is a chemist workshop. It is a place where a student is trained to observe the physical and chemical characteristics of substances by following definite procedures. Before starting the laboratory work, a student should get himself familiarized with the layout of the laboratory and various fittings provided on the laboratory table as well as the side shelves.

GENERAL INSTRUCTIONS TO THE STUDENTS

- Students are expected to conduct themselves in a responsible manner at all times in the lab.
- They are advised not to work alone in the lab. Experiments should be performed in the presence of lab instructor and other laboratory staff.
- Students should always wear lab coat and safety goggles while working in the lab. Girls must tie up their scarves and hair before start working in the lab.
- Determine the potential hazards related to any equipment or the experiment before beginning any work. Appropriate safety precautions must be observed at all cost.
- There must not be any crowding in the lab and students should stick to their work places at a safe distance from each other.
- Don't bring any food items in the lab. Never taste or smell any compound or a gas.
- Any accident or breakage of glassware must be reported to the Incharge of the laboratory immediately.
- If you cannot handle an instrument or an equipment properly then you must seek help from the instructor.
- Do not pour chemicals down the drains and do not utilize the sewer for chemical waste disposal.
- Follow the warning sign displayed in the lab.

> **Rack Your Mind!**
> 1. Before starting an experiment, what should you do to ensure safety?
> a) Wear casual clothes
> b) Test equipment for proper functioning
> c) Leave workspace crowded
> d) Work without supervision

COMMON TYPES OF HAZARDS IN A LABORATORY

(Exercise L.Q.1)

Q. Describe common types of the Chemistry lab hazards with two examples in each case.

Most hazards which we might face while working in the laboratory fall into three categories, physical, chemical and biological hazards.

Physical Hazards

The most common physical hazards are slips and falls when working on wet floor. A worker must take all types of precautions to avoid accidents related to physical hazards such as slipping, pulling, falling etc.

A worker should wear cut-resistant gloves while handling the broken glassware to prevent cuts, abrasions and skin damage. It should be mandatory for the laboratory staff to dispose off broken glassware in special container to prevent injury.

> **Rack Your Mind!**
> 2. What safety precautions should be taken regarding workspace and distance?

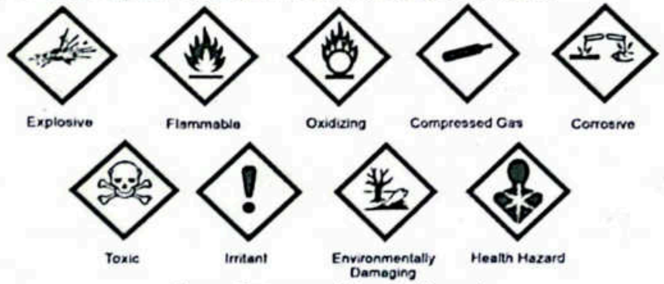


Figure: Pictogram of chemical hazards

Chemical Hazards

A laboratory worker must use the chemicals according to the standard procedures keeping in view the particular hazards and precautions required for the safe use.

Biological Hazards

The most common biological hazards are allergens, infectious diseases which are transferred from animals to humans and viral diseases.

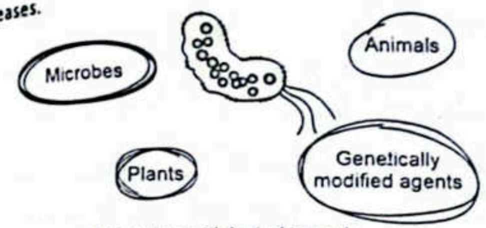


Figure: Some Biological Hazards

> **Rack Your Mind!**
> 3. How can you identify chemical hazards in the laboratory?

> **Rack Your Mind!**
> 4. What bodily harm can chemical hazards cause?
> a) Burns and poisoning
> b) Muscle strain
> c) Fractures
> d) Headache only

> **Rack Your Mind!**
> 5. Why should you test equipment before starting an experiment?

WASTE DISPOSAL SYSTEM FOR CHEMICALS

Disposal of Chemical Waste:

Chemical waste cannot be disposed off in bins or sewer system. Most chemical wastes must be disposed off keeping in view the following rules and regulation of Environmental Protection Agency (EPA).

1. Store chemical wastes in proper containers.
2. Label the chemical waste containers with the types of wastes, the date of waste and place of origin.
3. These containers are then transferred to the allocated site where these are appropriately treated to dispose them off.
4. Chemical treatment of wastes involves:
   (i) neutralization (ii) precipitation (iii) ion exchange (iv) oxidation/reduction.

FIRST AID IN LABORATORY

(Exercise L.Q.4)

Q. What are common accidents in the Chemistry lab? How they are managed in first aid treatment.

Every laboratory must have a first aid box. Common accidents and their first aid treatments are given in the Table below:

Table: Accidents and their First Aid Treatment

	Type of Accident	First Aid Treatment
1.	**Cuts** i. Minor cuts ii. Serious cuts	i. Remove the glass piece if any, apply a little methylated spirit or tincture iodine with a piece of cotton. Both act as disinfectant. ii. Apply pressure on the cut for about 10 minutes to stop bleeding. Consult a doctor.
2.	**Eye Injuries** i. Acid in the eye ii. Alkali in the eye iii. Foreign particle in the eye iv. Soreness in the eye	i. Wash thoroughly with water and then with 1% sodium bicarbonate solution. ii. Wash with water followed by 1% boric acid solution. iii. Do not rub the eyes. Remove the particle carefully with soft handkerchief then wash with water. iv. Put a drop of olive oil in the eyes and keep them closed for some time.
3.	**Burns**	i. Apply burnol or mustard oil.

	i. Burns with dry heat (flame, hot object) ii. Burns causing blisters iii. Acid burns iv. Alkali burns v. Bromine burns	ii. Wash freely with ice cold water. Then wash with a saturated solution of sodium bicarbonate and again with water. iii. Wash freely with water and then with 1% acetic acid solution and again with water, dry the skin and apply the burnol. iv. Wash fully with 2% ammonia solution and apply glycerin. Wipe off glycerin after sometime and apply burnol.
4.	**Poisons** i. Poisons swallowed ii. Acid swallowed iii. Caustic alkalies swallowed iv. Salt of heavy metals swallowed.	i. Spit immediately, wash mouth with water repeatedly. ii. Drink a lot of water or lime water or milk of magnesia. iii. Drink a lot of water; drink a glass of lemon or orange juice. iv. Take milk or white part of the egg.
5.	**Fire** i. Clothes catch fire ii. Beaker containing inflammable liquid catches fire. iii. Spirit or oil catches fire. iv. iv) Electric parts catch fire.	i. Do not run. Wrap with blanket or with dry cotton cloth. Lie down on the floor. ii. Cover the beaker with a duster or damp cloth. This will cut off the supply of oxygen. iii. Throw a mixture of sand and sodium bicarbonate. Do not throw water. It will simply spread the fire. iv. Switch off the electric supply immediately and throw sand. Do not throw water in such cases to extinguish fire.

QUICK CHECK 16.1

a) Mention common types of hazard.

Ans. Most hazards which we might face while working in the laboratory fall into three categories, physical, chemical and biological hazards.

(i) Physical Hazards
(ii) Chemical Hazards
(iii) Biological Hazards

b) How chemical waste is disposed off?

Ans. Chemical Waste:

1. Store chemical wastes in proper containers.
2. Label the chemical waste containers with the types of wastes, the date of waste and place of origin.
3. These containers are then transferred to the allocated site where these are appropriately treated to dispose them off.
4. Chemical treatment of wastes involves neutralization, precipitation, ion exchange, oxidation or reduction.

c) How H_2SO_4 burn is treated in the lab?

Ans. In the lab, an H_2SO_4 (sulfuric acid) burn is treated immediately by:

- Flush with water for at least 15–20 minutes to dilute and remove the acid.
- Remove contaminated clothing/jewelry carefully.
- Neutralize (optional) with a mild baking soda ($NaHCO_3$) solution after flushing.
- Cover with a sterile, non-adhesive dressing.
- Seek medical attention, especially for severe burns.

d) What are different types of burns?

Ans. Types of Burns:

- Burns with dry heat (flame, hot object)
- Burns causing blisters
- Acid burns
- Alkali burns
- Bromine burns

ACID-BASE TITRATION

Volumetric Analysis:

- Volumetric analysis is used to find the concentrations of solutions by means of a technique known as **titration**.
- In acid-base titration, a solution of unknown concentration is combined slowly and carefully with a known volume of a standard solution until a colour change shows the completion of the reaction.

> **Did You Know?**
> Phenolphthalein solution is prepared by adding one gram of the indicator in 500 cm³ of 50% ethanol. Use only one to two drops in 10 cm³ of the solution to be titrated. The color change is from pink to colorless as the pH decreases. The light pink color which marks the end point tends to fade gradually due to the interference of atmospheric carbon dioxide which slowly dissolves in the solution.

Indicator:

- The substance which indicates the completion of reaction by the change in its colour is called an indicator.

End Point:

- The moment at which the indicator changes colour is called the end point. Either solution can be taken in a burette with the other solution taken in a conical or a titration flask.

Materials Required

Burette, pipette, funnel, conical flask, HCl solution, NaOH solution, phenolphthalein.

> **Titrant:** A Solution of known Concentration.
> **Analyte:** Analyte (in titration) is the solution whose concentration is being determined. It is also called titrand.

Procedure of Titration

i. Rinse the pipette first with distilled water and then with the given NaOH solution.
ii. Rinse the conical flask with distilled water only.
iii. Pipette out 10 cm³ of NaOH solution into a conical flask.
iv. Add one to two drops of **phenolphthalein** indicator into it. The solution turns pink.

> **Rock Your Mind!**
> **6. In acid-base titration, which apparatus is used to deliver the acid or base dropwise?**
> a) Pipette b) Burette
> c) Measuring cylinder d) Beaker

v. Rinse the burette first with distilled water and then with the given HCl solution.
vi. Fix the burette on a clamp stand in an upright position.
vii. Fill it with the given HCl solution with the help of a funnel. Remove funnel from the burette.
viii. Using the tap at the base of the burette, allow the acid to flow into a beaker to remove any air bubble present in the nozzle.
ix. Note the burette reading as an initial reading using an anti-parallax card or a white paper.
x. During titration, place the conical flask on a white paper under the burette to see the colour change of the indicator clearly. Check that the burette does not leak.
xi. Carry out a rough titration by adding hydrochloric acid solution from the burette drop wise to the conical flask.
xii. The contents of the flask must be swirled adding of acid for thorough mixing.
xiii. Keep on adding acid till the colour of solution becomes light pink persistently. This will be the end point of the reaction.
Again, note down the burette reading, this will be the final reading. The difference of final and initial readings of burette will give the volume of the acid used.

Repeat the titration to get accurate and concordant readings. Take at least three concordant readings which agree with one another within 0.1 cm³.

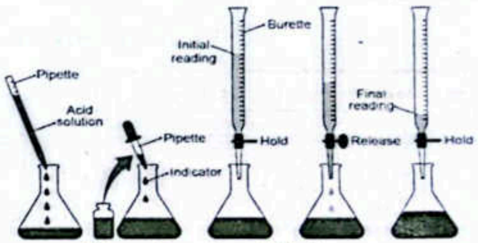


Figure: Procedure of Titration

Observations

Titration Number	Rough Reading	1	2	3
Final reading	x			
Initial reading	y			
Volume of acid used (cm^3)	(x – y)			

Volume of HCℓ solution used = ________ cm^3

Chemical Equation

$$NaOH_{(aq)} + HC\ell_{(aq)} \rightarrow NaC\ell_{(aq)} + H_2O_{(\ell)}$$

Calculation

Find out the molarity of NaOH solution by using the following molarity equation:

$$\begin{matrix} \text{Acid} & & \text{Base} \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \end{matrix}$$

M_1 = Molarity of acid solution

V_1 = Volume of the acid used

n_1 = No. of moles of the acid in the balanced chemical equation

M_2 = Molarity of base solution

V_2 = Volume of base solution used

n_2 = No. of moles of the base in the balanced chemical equation

$$M_2 = \frac{M_1V_1}{n_1} \times \frac{n_2}{V_2}$$

Molarity of the given base solution is ________ M.

Rack Your Mind!

7. How can you identify the end point in an acid-base titration?

QUICK CHECK 16.2

a) Define indicator and endpoint in a titration.

Ans. The substance which indicates the completion of reaction by the change in its colour is called an indicator. The moment at which the indicator changes colour is called the end point.

b) What is meant by concordant reading?

Ans. Concordant reading refers to multiple measurements (titres) that are in close agreement with each other usually with a minimal variability. In titration, one typically performs multiple trials to ensure accuracy. Concordant readings indicate that the process is consistent and reproducible, i.e., the results are likely reliable.

c) How the volume of the titrant used is calculated?

Ans. The volume of titrant used in titration is determined by reading the burette before and after the titration the difference between the initial and final burettte readings provides the volume of titrant added to reach the equivalence point.

TESTS FOR IDENTIFICATION OF ANIONS

a) Identification of Carbonate CO_3^{2-} Radical

Experiment	Observation	Inference
Take about 2 g of solid carbonate sample in a clean test tube and then add about 5 cm^3 of dilute HCℓ solution. Pass the gas evolved in the above step through a solution of lime water.	Effervescence takes place during which a gas evolves briskly, that turns lime water milky.	Carbonate (CO_3^{2-}) are indicated ions.

Reactions involved in the above steps

$$CO_{3(aq)}^{2-} + 2H^+_{(aq)} \rightarrow H_2O_{(\ell)} + CO_{2(g)}$$

$$\underset{\text{lime water}}{Ca(OH)_{2(aq)}} + CO_{2(g)} \longrightarrow \underset{\text{white ppt}}{CaCO_{3(s)}} + H_2O_{(\ell)}$$

Rack Your Mind!

8. Which reagent can be used to test for carbonate ions (CO_3^{2-})?
a) HCℓ b) NaOH
c) $AgNO_3$ d) NH_3

(b) Identification of Chloride ($C\ell^{1-}$), Bromide (Br^{1-}) and Iodide (I^{1-}) Radicals

Experiment	Observation	Inference
Take 2 g of solid sample in a test tube and add 5 cm^3 of distilled water to make the aqueous solution. Add a few drops of dil. HNO_3 solution to acidify the solution of the salt, finally add about 5 cm^3 of aqueous $AgNO_3$.	A thick white precipitate is formed which dissolves in aq. NH_3.	$C\ell^{-1}$ ions are indicated.
Take 2 g of solid sample in a test tube and add 5 cm^3 of distilled water to dissolve the salt. Add a few drops of dil. HNO_3 to acidify the above solution. Finally add 5 cm^3 of aqueous $AgNO_3$.	A thick cream-yellow precipitate is formed.	Br^{1-} ions are indicated.
Take 2 g of solid sample and dissolve it in 5 cm^3 of distilled waler. Add a few drops of dil. HNO_3 to make it acidic. Finally add 5 cm^3 aqueous $AgNO_3$.	A bright yellow precipitate is formed.	I^{1-} ions are indicated.

Reactions involved in the above tests.

$$Ag^+_{(aq)} + C\ell^-_{(aq)} \longrightarrow \underset{\text{white ppt}}{AgC\ell_{(s)}}$$

$$Ag^+_{(aq)} + Br^-_{(aq)} \longrightarrow \underset{\text{cream yellow ppt}}{AgBr_{(s)}}$$

$$Ag^+_{(aq)} + I^-_{(aq)} \longrightarrow \underset{\text{bright yellow ppt}}{AgI_{(s)}}$$

Did You Know?

In the above tests for the detection of halide ions, dilute nitric acid is added to prevent the precipitation of carbonate ions along-with halide ions.

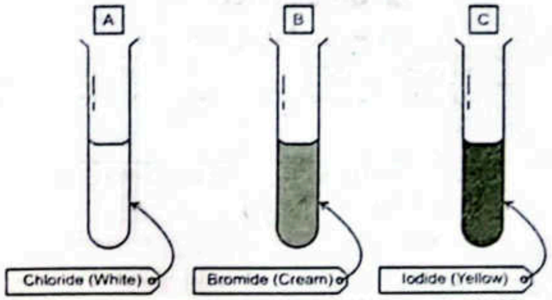


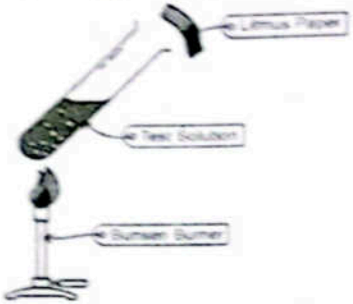
Figure: Observation of reactions of halide ions with $AgNO_3$

c) Identification of Nitrate (NO_3^{1-}) Radical

Experiment	Observation	Inference
Take 2 g of solid sample in a clean test tube and dissolve it in 5 cm^3 distilled water. Add to it 5 cm^3 of sodium hydroxide solution. Finally add 3 g of powdered aluminium metal.	A characteristic smell of NH_3 gas is felt near the mouth of test tube. This gas turns red litmus paper blue.	NO_3^{1-} ions are indicated.

Aluminium metal reduces nitrate ions to ammonium ions which then react with aqueous NaOH to evolve ammonia gas. The reduction of NO_3^{-} with aluminium metal is a redox reaction in which Al metal acts as a cathode and reduces nitrate ions to ammonia gas.

$$3NO_{3(aq)}^{-} + 8Al_{(s)} + 5OH_{(aq)}^{-} + 18H_2O_{(l)} \rightarrow 3NH_{3(g)} + 8[Al(OH)_{4(aq)}]^{-}$$



(d) **Identification of Sulphate (SO_4^{2-}) Radical**

Experiment	Observation	Inference
Take 3 g of solid sample in a clean test tube. Dissolve it in 5 cm^3 of distilled water. Acidify the solution with a few drops of dil. HNO_3 and then add 5 cm^3 barium nitrate solution.	A heavy white precipitate of $BaSO_4$ is formed.	SO_4^{2-} ions are indicated.

$$SO_{4(aq)}^{2-} + Ba_{(aq)}^{2+} \longrightarrow \underset{\text{white ppt.}}{BaSO_{4(s)}}$$

Did You Know?

Dilute nitric acid is added to destroy any carbonate ions present in the solution as an impurity.

QUICK CHECK 16.3

a) **Distinguish carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{1-}) radicals.**

Ans.

Experiment	Observation (CO_3^{2-})	Observation (HCO_3^-)	Inference
Add dilute HCl	Brisk effervescence (CO_2 gas)	Slower effervescence (CO_2 gas)	CO_3^{2-} reacts faster due to higher alkalinity.
$MgSO_4$ test	White ppt. ($MgCO_3$) forms immediately	No ppt. (unless heated)	CO_3^{2-} precipitates directly; HCO_3^- needs heating to form CO_3^{2-}.
Phenolphthalein test	Turns pink (strongly alkaline)	Remains colorless (weakly alkaline)	CO_3^{2-} shows higher pH.
Heat solid sample	No change (stable)	Releases CO_2, turns to CO_3^{2-} (loses H_2O + CO_2)	HCO_3^- decomposes on heating.

b) **What is ring test? Give equation for this test.**

Ans. The ring test is a qualitative chemical (confirmatory) test used to detect the presence of nitrate ions (NO_3^-) in a solution.

Procedure & Observations:

Prepare the test solution containing nitrate (e.g., $NaNO_3$). Now, Add freshly prepared ferrous sulphate ($FeSO_4$) solution to it. Carefully add concentrated sulphuric acid (H_2SO_4) along the test tube walls (sides of test tubes) without shaking.

Observation: A brown ring forms at the junction of the two layers.

Chemical Equation:

The brown ring is due to the formation of **Nitroso ferrous sulfate** complex:

$$NO_3^- + 3Fe^{2+} + 4H_2SO_4 \longrightarrow [Fe(NO)(H_2O)_5]SO_4 + 2SO_4^{2-} + 2H_2O$$

(Simplified: Brown ring = $[Fe(NO)]SO_4$ complex)

Inference:

- The brown ring confirms nitrate (NO_3^-) in the sample.

c) **Give names and formulas of some water insoluble sulphates.**

Ans.

- **Barium sulfate** – $BaSO_4$
- **Lead(II) sulfate** – $PbSO_4$
- **Strontium sulfate** – $SrSO_4$

TESTS FOR IDENTIFICATION OF BASIC RADICALS

a) **Identification of Aluminium (Al^{3+}) radical**

Take 4 g of solid sample in a clean test tube. Dissolve it in about 10 cm^3 distilled water. Divide this solution into two parts for further tests.

Experiment	Observation	Inference
To one part, add about 5 cm^3 NaOH solution.	A white gelatinous precipitate is formed.	Al^{3+} ions are indicated.
To the second part of the above solution, add a few drops of aqueous ammonia.	A white precipitate is formed.	Al^{3+} ions are indicated.

$$Al_{(aq)}^{3+} + 3OH_{(aq)}^{-} \longrightarrow \underset{\text{white ppt}}{Al(OH)_{3(s)}}$$

Rack Your Mind!

9. **How can aqueous NaOH and NH_3 help identify metal ions?**

b) **Identification of Ammonium (NH_4^{1+}) radical**

Experiment	Observation	Inference
Take 4 g of sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Add NaOH solution and gently heat it.	Ammonia gas is evolved with a distinct smell. Ammonia gas turns moist red litmus blue.	NH_4^{1+} ions are indicated.

$$NH_{4(aq)}^{1+} + OH_{(aq)}^{1-} \longrightarrow NH_{3(g)} + H_2O_{(l)}$$

c) **Identification of Calcium (Ca^{2+}) radical**

Take 4 g solid sample in a clean test tube. Dissolve it in 10 cm^3 distilled water.
Make two parts of this solution for further tests.

Experiment	Observation	Inference
To one part, add NaOH solution.	White precipitate is formed which does not dissolve in excess of NaOH solution.	Ca^{2+} ions are indicated.
To the second part of the above solution, add aqueous ammonia.	Only a slight turbidity appears or No precipitate is formed.	Ca^{2+} ions are indicated.

$$Ca_{(aq)}^{2+} + 2OH_{(aq)}^{-} \longrightarrow \underset{\text{white ppt}}{Ca(OH)_{2(s)}}$$

d) Identification of Chromium radical (Cr^{3+})

Add 4 g sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Make two parts of the above solution for further tests.

Experiment	Observation	Inference
To one part, add NaOH solution.	A green precipitate appears which turns into green solution when excess of NaOH is added	Cr^{3+} ions are indicated.
To the second part of the above solution, add aqueous ammonia.	A green precipitate appears which is insoluble in excess of aqueous ammonia.	Cr^{3+} ions are indicated.

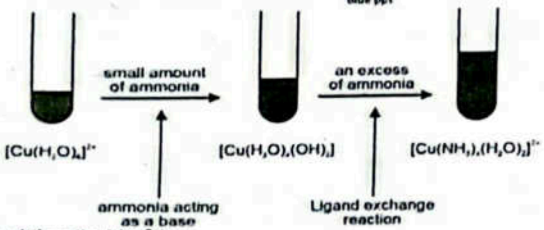
$$Cr^{3+}_{(aq)} + 3OH^-_{(aq)} \longrightarrow \underset{\text{Green ppt}}{Cr(OH)_{3(s)}}$$

e) Identification of Copper radical (Cu^{2+})

Add 4 g solid sample in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two parts of the above solution for further tests.

Experiment	Observation	Inference
To first part, add NaOH solution.	A light-blue precipitate is formed.	Cu^{2+} ions are indicated.
To the second part of the above solution, add aqueous ammonia.	Deep blue solution is formed.	Cu^{2+} ions are indicated.

$$Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{Blue ppt}}{Cu(OH)_{2(s)}}$$



f) Identification of Iron (II) radical (Fe^{2+})

Take 4 g sample in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two portions of the solution for further tests.

Experiment	Observation	Inference
To one portion, add NaOH solution.	A green precipitate is formed which is turned into orange brown precipitate after some time.	Fe^{2+} ions are indicated.
To second portion of the above solution, add aqueous ammonia.	A white gelatinous precipitate of $Fe(OH)_2$ is formed which quickly oxidizes to form red brown precipitate of $Fe(OH)_3$.	Fe^{2+} ions are indicated.

$$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{Green ppt}}{Fe(OH)_2}$$

g) Identification of Fe (III) radical (Fe^{3+})

Take 2 g $FeCl_3$ in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two portions of the solution for further tests.

Experiment	Observation	Inference
To one portion, add NaOH solution.	Orange brown precipitate is formed.	Fe^{3+} ions are indicated.
To the second portion of the above solution, add aqueous ammonia.	Orange brown precipitate is formed.	Fe^{3+} ions are indicated.

$$Fe^{3+}_{(aq)} + 3OH^-_{(aq)} \longrightarrow \underset{\text{Orange brown ppt}}{Fe(OH)_{3(s)}}$$

h) Identification of Zinc radical (Zn^{2+})

Take 4 g solid sample in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two portions of the above solution for further tests.

Experiment	Observation	Inference
To one portion add NaOH solution.	White precipitate is formed which is soluble in excess of NaOH solution.	Zn^{2+} ions are indicated.
To second portion of the above solution add aqueous ammonia.	White precipitate is formed which dissolves in excess of ammonia.	Zn^{2+} ions are indicated.

$$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{white ppt}}{Zn(OH)_{2(s)}}$$

QUICK CHECK 16.4

a) What is lake test? Give equation.

Ans. Lake Test

Purpose: To detect aluminium (Al^{3+}) or other metal ions by forming a colored "lake" (adsorption complex) with an organic dye.

Experiment	Observation	Inference
O.S + few drops of HCl + litmus solution + excess of NH_4OH.	A blue lake (blue ppt. in colourless solution) is formed.	Al^{3+} is confirmed.

$$Al^{+}_{3} + 3NH_4OH \longrightarrow Al(OH)_3 \downarrow + 3NH_4^+$$

Inference:

- Blue colour floats over colourless solution.

b) How ammonium ion is indicated?

Ans. Identification of Ammonium (NH_4^{1+}) radical

Experiment	Observation	Inference
Take 4 g of sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Add NaOH solution and gently heat it.	Ammonia gas is evolved with a distinct smell. Ammonia gas turns moist red litmus blue.	NH_4^{1+} ions are indicated.

$$NH^{1+}_{4(aq)} + OH^{1-}_{(aq)} \longrightarrow NH_{3(g)} + H_2O_{(l)}$$

c) How will you distinguish ferrous (Fe^{2+}) and ferric (Fe^{3+}) radicals?

Ans.

Test	Observation for Fe^{2+}	Observation for Fe^{3+}	Inference
Potassium ferricyanide ($K_3[Fe(CN)_6]$)	Deep blue precipitate (Turnbull's blue)	Brownish solution (no ppt)	Fe^{2+} confirmed by blue ppt.
Potassium ferrocyanide ($K_4[Fe(CN)_6]$)	White/blue ppt (if dilute)	Deep blue precipitate (Prussian blue)	Fe^{3+} confirmed by intense blue ppt.

NaOH solution	Dirty green precipitate ($Fe(OH)_2$)	Red-brown precipitate ($Fe(OH)_3$)	Fe^{3+} gives reddish-brown ppt.
NH_4SCN (Thiocyanate)	No colour change (pale green)	Blood-red colour $[Fe(SCN)]^{2+}$	Fe^{3+} confirmed by red complex.
$KMnO_4$ (in acid)	Decolourizes (oxidized to Fe^{3+})	No reaction (already Fe^{3+})	Fe^{2+} reduces $KMnO_4$.

d) What happens when aq. NH_3 is added to Cu^{2+} solution in limited and excess quantities?

Ans. When aqueous NH_3 (ammonia) is added to a Cu^{2+} (copper(II)) solution in limited and excess amounts we observe:

1. Limited NH_3 (Pale Blue Precipitate)

Reaction: $Cu^{2+} + 2NH_3 + 2H_2O \longrightarrow Cu(OH)_2 \downarrow (\text{pale blue}) + 2NH_4^+$

Observation: A pale blue gelatinous precipitate of copper(II) hydroxide ($Cu(OH)_2$) forms.

2. Excess NH_3 (Deep Blue Solution)

Reaction: $Cu(OH)_2 + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+} + (\text{deep blue}) + 2OH^-$

Observation: The precipitate dissolves, forming a deep blue solution due to the tetraamminecopper (II) complex ion $[Cu(NH_3)_4]^{2+}$.

In short:

- **Limited NH_3:** Forms insoluble $Cu(OH)_2$.
- **Excess NH_3:** Forms **soluble $[Cu(NH_3)_4]^{2+}$ complex** (used in qualitative analysis).

Solution File — Rack Your Brain!

Sr. #	Option	Explanation
1.	B	Testing prevents accidents caused by faulty apparatus.
2.	S.Q	Keep the workspace organized and not overcrowded to avoid hazards, and maintain a safe distance from others handling apparatus to prevent accidents.
3.	S.Q	By understanding the properties of chemicals used, reading labels and safety data sheets, and knowing the risks associated with spills, fumes, and reactions during the experiment.
4.	A	Chemical hazards can cause burns, poisoning, respiratory issues, and skin irritation.
5.	S.Q	To ensure all apparatus works properly and safely, preventing accidents or injuries during the experiment.
6.	B	Burette allows precise delivery of titrant drop by drop to find the exact end point.
7.	S.Q	By observing a clear color change of the indicator, which signals that the titration reaction is complete.
8.	A	Carbonate reacts with acid to produce CO_2 gas, confirming its presence.
9.	S.Q	They react with specific metal ions to form characteristic precipitates or soluble complexes, helping to distinguish ions like Al^{3+}, Cu^{2+}, Fe^{2+}, etc.

Exercise

MULTIPLE CHOICE QUESTIONS (MCQs)

Q.1 Four choices are given for each question. Select the correct choice.

I. While taking a reading with a burette, why it is always advisable to read the lower meniscus for the colourless liquids and the upper meniscus for the coloured liquids?

a) because it is more convenient
b) because colourless liquids have more surface tension than coloured liquids
c) because lower meniscus does not exist for coloured liquids
d) because of the parallax effect

II. Why phenolphthalein indicator is more appropriate to use during the titrations which involve a strong acid and a strong base?

a) because it is itself weakly acidic
b) because the pH at the equivalence point as well as the pH over where the colour of phenolphthalein changes match each-other.
c) because the solution at the end of titration is acidic.
d) because the solution at the end of titration is basic.

III. Which cation gives a white gelatinous precipitate upon the addition of aqueous ammonia?

a) Cr^{3+} b) Cr^{2+} c) Zn^{2+} d) Al^{3+}

IV. Addition of NH_4OH to an aqueous solution of a cation gives a green precipitate which turns brown upon standing. Which basic radical is indicated?

a) Cu^{2+} b) Cr^{3+} c) Fe^{2+} d) Fe^{3+}

V. On dry heating test for salt analysis, the evolution of a colourless, odorless gas that turns limewater milky suggests the presence of:

a) Chloride ion (Cl^-) b) Sulfate ion (SO_4^{2-}) c) Carbonate ion (CO_3^{2-}) d) Nitrate ion (NO_3^-)

VI. The chromyl chloride test is a specific confirmatory test for:

a) Bromide ions (Br^-) b) Iodide ions (I^-) c) Chloride ions (Cl^-) d) Sulfate ions (SO_4^{2-})

VII. The brown ring test is a confirmatory test for which acid radical?

a) Chloride (Cl^-) b) Nitrate (NO_3^-) c) Sulfate (SO_4^{2-}) d) Carbonate (CO_3^{2-})

Answer Key with Explanations

Sr.No.	Option	Answer	Explanation
I.	d	Parallex effect	• It is a visual technique where background images move slower than foreground images, creating an illusion of depth in a 2D scene.
II.	b	because the pH at the equivalence point as well as the pH over where the colour of phenolphthalein changes match each-other.	• Phenolphthalein changes color between pH 8.2–10, which matches the equivalence point pH of strong acid–strong base titrations.
III.	d	Al^{3+}	$Al^{3+}_{(aq)} + 3OH^{1-}_{(aq)} \longrightarrow Al(OH)_3$ White gelatinous material
IV.	c	Fe^{2+}	• Fe^{2+} forms a green precipitate with NH_4OH, which oxidizes to Fe^{3+}, giving a brown colour on standing.

			$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{Green ppt}}{Fe(OH)_2} \xrightarrow{\text{oxidation}} \underset{\text{Brown ppt}}{Fe(OH)_3}$
V.	c	Carbonate ion (CO_3^{2-})	• Heating carbonates produces CO_2 gas, which turns lime water milky due to formation of $CaCO_3$. $\underset{\text{Lime water}}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{White ppt (milky solution)}}{CaCO_3} + H_2O$
VI.	c	Chloride ions (Cl^-)	• The chromyl chloride test gives red vapours of CrO_2Cl_2 when chloride reacts with potassium dichromate and concentrated sulfuric acid.
VII.	d	Nitrate (NO_3^-)	• The brown ring test confirms nitrate ions by forming a brown ring of $[Fe(H_2O)_5(NO)]^{2+}$ complex.

SHORT ANSWER QUESTIONS

Q.2 Attempt the following short-answer questions:

a. For which type of titration, methyl orange is used as an indicator?

Ans. Methyl orange is used as an indicator in strong acid–weak base titrations.
Methyl orange changes colour in the pH range of 3.1 to 4.4, making it ideal for titrations where the equivalence point is acidic, as is the case when a strong acid (e.g., HCl) is titrated against a weak base (e.g., NH_4OH).

b. Explain why phenolphthalein is a suitable indicator for the titration of a weak acid with a strong base but not for the titration of a strong acid with a weak base.

Ans. Phenolphthalein is suitable for weak acid–strong base titrations because the equivalence point is basic (pH ≈ 8.5), which falls within phenolphthalein's colour change range (pH 8.2–10).
It is not suitable for strong acid–weak base titrations because the equivalence point is acidic (pH < 7), outside phenolphthalein's range, so it would not show a clear endpoint.

c. Explain why different indicators change colour over different pH ranges.

Ans. Different indicators change colour over different pH ranges because each has a unique acid-base equilibrium and changes structure (and thus colour) at a specific pH range where its conjugate acid and base forms are present in comparable amounts.
Examples:

1. **Phenolphthalein:**
   - **Colour change range:** pH 8.2 – 10
   - **Colour:** Colourless in acid, pink in base
2. **Methyl Orange:**
   - **Colour change range:** pH 3.1 – 4.4
   - **Colour:** Red in acid, yellow in base

d. It is always advisable to use dilute solutions while performing experiments in volumetric analysis? Give a reason.

Ans. Yes, it is advisable to use dilute solutions in volumetric analysis because they reduce the risk of large heat changes and allow for more precise volume measurements, minimizing errors and improving the accuracy of the titration results.

e. White precipitates are formed when Ca^{2+}, Al^{3+} and Zn^{2+} all react separately with NaOH solution. How will you detect which basic radical is present?

Ans. To distinguish between Ca^{2+}, Al^{3+}, and Zn^{2+} ions when all form white precipitates with NaOH, excess NaOH can be used:

1. **Add excess NaOH** to each white precipitate formed:
   - **$Ca(OH)_2$:** Insoluble in excess NaOH → White ppt remains
   - **$Al(OH)_3$:** Dissolves in excess NaOH forming a colorless solution
   - **$Zn(OH)_2$:** Dissolves in excess NaOH forming a colorless solution
2. **Differentiate Al^{3+} and Zn^{2+} using ammonium hydroxide (NH_4OH):**
   - **$Al(OH)_3$:** Insoluble in excess NH_4OH → White ppt remains
   - **$Zn(OH)_2$:** Soluble in excess NH_4OH → Colorless solution forms

f. How Fe^{2+} can be distinguished from Fe^{3+} chemically?

Ans. Identification of Iron (II) radical (Fe^{2+})

Take 4 g sample in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two portions of the solution for further tests.

Experiment	Observation	Inference
To one portion, add NaOH solution	A green precipitate is formed which is turned into orange brown precipitate after some time.	Fe^{2+} ions are indicated.
To second portion of the above solution, add aqueous ammonia.	A white gelatinous precipitate of $Fe(OH)_2$ is formed which quickly oxidizes to form red brown precipitate of $Fe(OH)_3$.	Fe^{2+} ions are indicated.

$$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{Green ppt}}{Fe(OH)_2}$$

Identification of Fe(III) radical (Fe^{2+})

Take 2 g $FeCl_3$ in a clean test tube. Dissolve it in 10 cm^3 of distilled water. Make two portions of the solution for further tests.

Experiment	Observation	Inference
To one portion, add NaOH solution.	Orange brown precipitate is formed.	Fe^{3+} ions are indicated.
To the second portion of the above solution, add aqueous ammonia.	Orange brown precipitate is formed.	Fe^{3+} ions are indicated.

$$Fe^{3+}_{(aq)} + 3OH^-_{(aq)} \longrightarrow \underset{\text{Orange brown ppt}}{Fe(OH)_{3(s)}}$$

g. Why does Ca^{2+} not give precipitate with aqueous ammonia?

Ans. Ca^{2+} does not give a precipitate with aqueous ammonia because calcium hydroxide ($Ca(OH)_2$), formed by the reaction of Ca^{2+} with ammonia, is sparingly soluble in water. The amount of hydroxide formed is insufficient to exceed the solubility product (K_{sp}) and produce a visible precipitate under normal conditions.
In contrast, other metal ions like Al^{3+} and Zn^{2+} form insoluble hydroxides that precipitate in the presence of ammonia.

h. How will you find out the concentration of acetic acid in vinegar solution?

Ans. To find the concentration of acetic acid (CH_3COOH) in a vinegar solution, we can perform a titration using a strong base (such as NaOH) and an appropriate indicator (such as phenolphthalein).

Procedure:

1. **Prepare a Sample of Vinegar:** Measure a known volume (e.g., 10 cm^3) of the vinegar solution.
2. **Titration Setup:**
   - **Titrant:** Prepare a standard solution of NaOH of known concentration (e.g., 0.1 M).
   - **Indicator:** Add a few drops of phenolphthalein (which changes from colorless to pink as the solution goes from acidic to slightly basic).
3. **Perform the Titration:**
   - Slowly add the NaOH solution from the burette to the vinegar solution while stirring.
   - **End point:** The titration is complete when the solution turns **light pink** (indicating neutralization).
4. **Calculate the Concentration of Acetic Acid:**
   - Use the formula:

$$C_1V_1 = C_2V_2$$

where:

- C_1 = concentration of acetic acid (required),
- V_1 = volume of vinegar used,
- C_2 = concentration of NaOH,
- V_2 = volume of NaOH used to reach the endpoint.

5. **Final Calculation**: Solve for C_1, the concentration of acetic acid in vinegar.

Example Calculation:

- If 25 cm^3 of NaOH (0.1 M) neutralizes 10 cm^3 of vinegar, the calculation would be:

$$C_1 \times 10.0\ cm^3 = 0.1\ M \times 25\ cm^3$$
$$C_1 = 0.1 \times 25.0 / 10 = 0.25\ M$$

So, the concentration of acetic acid is **0.25 M**.
This gives the molarity of acetic acid in the vinegar.

i. What precautions you need to observe while diluting a concentrated acid?

Ans. Precautions to Observe while Diluting a Concentrated Acid:

(i) Always add acid to water, never water to acid — this prevents splashing due to the exothermic reaction.
(ii) Use protective gear — wear gloves, goggles, and a lab coat to prevent burns and injuries.
(iii) Perform the dilution slowly, while stirring continuously, to control heat release.
(iv) Use heat-resistant glassware — to prevent breakage from the heat generated.
(v) Work in a well-ventilated area or fume hood — to avoid inhaling harmful vapours.
(vi) Keep neutralizing agents (like baking soda) nearby in case of spills.

j. Why does an aqueous solution of Na_2CO_3 behave like a base?

Ans. An aqueous solution of Na_2CO_3 (sodium carbonate) behaves like a base because the carbonate ion (CO_3^{2-}) undergoes hydrolysis in water:

$$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$$

This reaction produces hydroxide ions (OH^-), which increase the pH of the solution, making it basic in nature. Na_2CO_3 is a salt of a strong base (NaOH) and a weak acid (H_2CO_3), so its solution is basic due to the weak conjugate acid (HCO_3^-) not fully neutralizing OH^- formation.

k. If an aqueous solution of NaOH is kept in an open container, what changes do you expect to take place with the passage of time?

Ans. If an aqueous solution of NaOH is kept in an open container, the following changes occur over time:

1. **Absorption of CO_2 from the air:**
   NaOH reacts with carbon dioxide in the atmosphere:
   $$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$
   This reaction forms sodium carbonate (Na_2CO_3) and water.
2. **Decrease in alkalinity:**
   As NaOH is gradually converted into Na_2CO_3, the concentration of OH^- ions decreases, reducing the solution's basic strength (pH).
3. **Formation of precipitates (if concentration is high):**
   If the solution becomes saturated, precipitates of sodium carbonate hydrate may form.

So, by the passage of time the NaOH solution becomes less basic and transforms into a carbonate solution.

DESCRIPTIVE QUESTIONS

Q.3 Describe common types of the Chemistry lab hazards with two examples in each case.

Ans. See Page No. (510)

Q.4 What are common accidents in the Chemistry lab? How they are managed in first aid treatment.

Ans. See Page No. (511)

Q.5 How the following acid radicals are indicated and confirmed in salt analysis:

i) CO_3^{2-} ii) Cl^- iii) NO_3^- iv) SO_4^{2-}

Ans. See above acid radicals in Theory.

Q.6 How the following basic radicals are indicated and confirmed in salt analysis:

i) Cu^{2+} ii) Al^{3+} iii) Fe^{3+} iv) Zn^{2+}

Ans. See above acid radicals in Theory.

ADDITIONAL SLOs BASED MCQs

1. **Which of the following is used as an indicator in the titration of a strong acid and a weak base?**
   A. Methyl orange B. Phenolphthalein C. Thymol blue D. Fluorescein
2. **The ideal indicator for the titration of strong acid and weak base should have a pH range between ______.**
   A. 3-5 B. 4-6 C. 6-8 D. 7-9
3. **Find the concentration of HCl, if 10 cm^3 of 0.5 M $Ca(OH)_2$ is required to titrate 50 cm^3 of HCl.**
   A. 1/10 M B. 1/5 M C. 5 M D. 10 M
4. **What is the concentration of the sulphuric acid solution, if 100 cm^3 of the solution is neutralized by 50 cm^3 of 0.5 M $Ba(OH)_2$ solution?**
   A. 0.25 M B. 0.5 M C. 25 M D. 50 m
5. **Which of the following is a buffer solution?**
   A. $CH_3COOH + CH_3COONH_4$ B. $H_2SO_4 + CuSO_4$
   C. $CH_3COONa + CH_3COOH$ D. $NaCl + NaOH$
6. **Which of the following is used as an indicator in the titration of a weak acid and a strong base?**
   A. Methyl orange (3 to 4.6) B. Bromothymol blue (6 to 7.5)
   C. Phenolphthalein (8 to 9.6) D. Methyl red (5 to 6.9)
7. **What is the molarity of the solution of barium hydroxide, if 35 cm^3 of 0.1 M HCl is used in the titration of 25 cm^3 of the barium hydroxide solution?**
   A. 0.28 B. 0.21 C. 0.14 D. 0.07
8. **A difference between strong and weak acid is ______.**
   A. proton donation and electron acceptance B. complete and partial ionization
   C. negative and positive pH D. presence and absence of halogen ions
9. **Which of the following titrations will have the equivalence point at a pH more than 8?**
   A. CH_3COOH and NaOH B. HCl and NaOH
   C. CH_3COOH and NH_3 D. HCl and NH_3
10. **What is the primary purpose of adding silver nitrate in the identification of non-metal anions?**
    A. To produce a gas B. To form precipitates C. To induce a colour change D. To neutralize acidity
11. **Which reagent is commonly used to test for the presence of chloride ions in a solution?**
    A. Iodine solution B. Silver nitrate C. Hydrochloric acid D. Sodium hydroxide
12. **What observation indicates the presence of sulphite ions in a solution during the identification of non-metal anions with $BaCl_2$ solution?**
    A. Formation of a white precipitate B. Evolution of a gas smelling like ammonia
    C. Formation of a yellow precipitate D. Absence of any visible change
13. **Which non-metal anion is typically identified through a starch-iodine reaction?**
    A. Chloride B. Bromide C. Iodide D. Sulphite

14. What safety measure is crucial when working with reagents during the identification of non-metal anions?

A. Wearing safety goggles B. using a fume hood C. Wearing gloves D. All of the above

15. Which cation gives a white gelatinous precipitate upon the addition of aqueous ammonia?

A. Cr^{3+} B. Cr^{2+} C. Zn^{2+} D. $A\ell^{3+}$

Answer Key

1. A	2. B	3. B	4. A	5. C	6. C	7. D	8. A	9. A	10. B	11. B	12. A
13. C	14. D	15. C									

ADDITIONAL SHORT ANSWER QUESTIONS

Q.1 What is meant by standardization?

Ans. Determination of exact concentration of a solution by titrating it against a solution of known strength is called standardization.

Q.2 What is the volumetric analysis?

Ans. A quantitative analysis based upon the measurement of volume is called as volumetric analysis.

Q.3 What is Titration?

Ans. The process of determination the exact volume of a solution which reacts completely with the definite volume of another solution.

Q.4 How carbonate (CO_3^{2-}) radicals are identified?

Ans.

Experiment	Observation	Inference
Take about 2 g of solid carbonate sample in a clean test tube and then add about 5 cm^3 of dilute HCℓ solution. Pass the gas evolved in the above step through a solution of lime water.	Effervescence takes place during which a gas evolves briskly, that turns lime water milky.	Carbonate (CO_3^{2-}) are indicated ions.

Reactions involved in the above steps

$$CO_{3(aq)}^{2-} + 2H^+_{(aq)} \rightarrow H_2O_{(\ell)} + CO_{2(g)}$$

$$\underset{\text{Lime water}}{Ca(OH)_{2(aq)}} + CO_{2(g)} \rightarrow \underset{\text{(white ppt)}}{CaCO_{3(s)}} + H_2O_{(\ell)}$$

Confirmatory Test

Experiment	Observation	Inference
Original Solution + $MgSO_4$	White ppt. of $MgCO_3$	CO_3^{2-} is confirmed.

Q.5 How Chloride ($C\ell^{1-}$) radicals are identified?

Ans.

Experiment	Observation	Inference
Take 2 g of solid sample in a test tube and add 5 cm^3 of distilled water to make the aqueous solution. Add a few drops of dil. HNO_3 solution to acidify the solution of the salt, finally add about 5 cm^3 of aqueous $AgNO_3$.	A thick white precipitate is formed which dissolves in aq. NH_3. In other words, White ppt. (AgCℓ) soluble in dil. NH_4OH.	$C\ell^{-1}$ ions are indicated.
Confirmatory Test		
O.S + Silver Nitrate ($AgNO_3$) solution.	White ppt. (AgCℓ) soluble in dil. NH_4OH.	$C\ell^-$ is confirmed.

Result: Acid Radical = Chloride $C\ell^-$

Q.6 Give the chemistry of Chromyl Chloride test.

Ans. It is a confirmatory test of $C\ell^-$. In this test reddish brown chromyl fumes are evolved when solid salt, solid $K_2Cr_2O_7$ and Conc.H_2SO_4 are heated together.

$$4NaC\ell + K_2Cr_2O_7 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2CrO_2C\ell_2 + H_2O$$

Q.7 How Aluminium ($A\ell^{3+}$) radical is identified?

Ans. Take 4 g of solid sample in a clean test tube. Dissolve it in about 10 cm^3 distilled water. Divide this solution into two parts for further tests.

Experiment	Observation	Inference
To one part, add about 5 cm^3 NaOH solution.	A white gelatinous precipitate is formed.	$A\ell^{3+}$ ions are indicated.
To the second part of the above solution, add a few drops of aqueous ammonia.	A white precipitate is formed.	$A\ell^{3+}$ ions are indicated

$$A\ell^{3+}_{(aq)} + 3OH^{1-}_{(aq)} \longrightarrow \underset{\text{white ppt}}{A\ell(OH)_{3(s)}}$$

Confirmatory Test (Lake Test):

Experiment	Observation	Inference
O.S + few drops of HCℓ + litmus solution + excess of NH_4OH.	A blue lake (blue ppt. in colourless solution) is formed.	$A\ell^{3+}$ is confirmed.

Q.8 How Calcium (Ca^{2+}) radical is identified?

Ans. Take 4 g solid sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Make two parts of this solution for further tests.

Experiment	Observation	Inference
To one part, add NaOH solution.	White precipitate is formed which does not dissolve in excess of NaOH solution.	Ca^{2+} ions are indicated.
To the second part of the above solution, add aqueous ammonia.	Only a slight turbidity appears or No precipitate is formed.	Ca^{2+} ions are indicated.

$$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow \underset{\text{white ppt}}{Ca(OH)_{2(s)}}$$

Confirmatory Test:

Experiment	Observation	Inference
O.S + $NH_4C\ell$ + $K_4[Fe(CN)_6]$	White ppt. of $Ca_2[Fe(CN)_6]$ formed.	Ca^{2+} is confirmed.

Result: Basic Radical = Calcium (Ca^{2+})

Q.9 How Ammonium (NH_4^{1+}) radical is identified?

Ans.

Experiment	Observation	Inference
Take 4 g of sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Add NaOH solution and gently heat it.	Ammonia gas is evolved with a distinct smell. Ammonia gas turns moist red litmus blue.	NH_4^{1+} ions are indicated.

$$NH^{1+}_{4(aq)} + OH^{1-}_{(aq)} \longrightarrow NH_{3(g)} + H_2O_{(\ell)}$$

Confirmatory Test:

Experiment	Observation	Inference
To the O.S added Picric acid solution.	Yellow needle like crystals are obtained.	NH_4^+ is confirmed.

Result: Basic Radical = Ammonium NH_4^+

Q.10 How Chromium radical (Cr^{3+}) is identified?

Ans. Add 4 g sample in a clean test tube. Dissolve it in 10 cm^3 distilled water. Make two parts of the above solution for further tests.

Experiment	Observation	Inference
To one part, add NaOH solution.	A green precipitate appears which turns into green solution when excess of NaOH is added	Cr^{3+} ions are indicated.
To the second part of the above solution, add aqueous ammonia.	A green precipitate appears which is insoluble in excess of aqueous ammonia.	Cr^{3+} ions are indicated.

$$Cr^{3+}_{(aq)} + 3OH^{-}_{(aq)} \longrightarrow \underset{\text{Green ppt}}{Cr(OH)_{3_s}}$$

Confirmatory Test:

O.S + Na_3PO_4	Pale green ppt. of $CrPO_4$ formed.	Cr^{3+} is confirmed.

SELF-ASSESSMENT Chapter # 16

Total Mark: 30

Q.1 Encircle the correct option. **(1 × 6 = 6)**

(i) What color phenolphthalein turn in a basic solution:
a) Red b) Blue c) Pink d) Colourless

(ii) Which cation gives a white gelatinous precipitate upon the addition of aqueous ammonia?
a) Cr^{3+} b) Cr^{2+} c) Zn^{2+} d) $A\ell^{3+}$

(iii) Addition of NH_4OH to an aqueous solution of a cation gives a green precipitate which turns brown upon standing. Which basic radical is indicated?
a) Cu^{2+} b) Cr^{3+} c) Fe^{2+} d) Fe^{3+}

(iv) On dry heating test for salt analysis, the evolution of a colourless, odorless gas that turns limewater milky suggests the presence of:
a) Chloride ion ($C\ell^-$) b) Sulfate ion (SO_4^{2-}) c) Carbonate ion (CO_3^{2-}) d) Nitrate ion (NO_3^-)

(v) The chromyl chloride test is a specific confirmatory test for:
a) Bromide ions (Br^-) b) Iodide ions (I^-) c) Chloride ions ($C\ell^-$) d) Sulfate ions (SO_4^{2-})

(vi) The brown ring test is a confirmatory test for which acid radical?
a) Chloride ($C\ell^-$) b) Nitrate (NO_3^-) c) Sulfate (SO_4^{2-}) d) Carbonate (CO_3^{2-})

Q.2 Write short answers of the following questions. **(2 × 8 = 16)**

(i) What are different types of burns?
(ii) What is meant by concordant reading?
(iii) What is ring test? Give equation for this test.
(iv) If an aqueous solution of NaOH is kept in an open container, what changes do you expect to take place with the passage of time?
(v) What precautions you need to observe while diluting a concentrated acid?
(vi) Why does an aqueous solution of Na_2CO_3 behave like a base?
(vii) Why Ca^{2+} does not give precipitate with aqueous ammonia?
(viii) Explain why different indicators change colour over different pH ranges.

Q.3 Extensive Questions. **(2 × 4 = 8)**

(a) How the following acid radicals are indicated and confirmed in salt analysis:
i) CO_3^{2-} ii) $C\ell^-$ iii) NO_3^- iv) SO_4^{2-}

(b) How the following basic radicals are indicated and confirmed in salt analysis:
i) Cu^{2+} ii) $A\ell^{3+}$ iii) Fe^{3+} iv) Zn^{2+}

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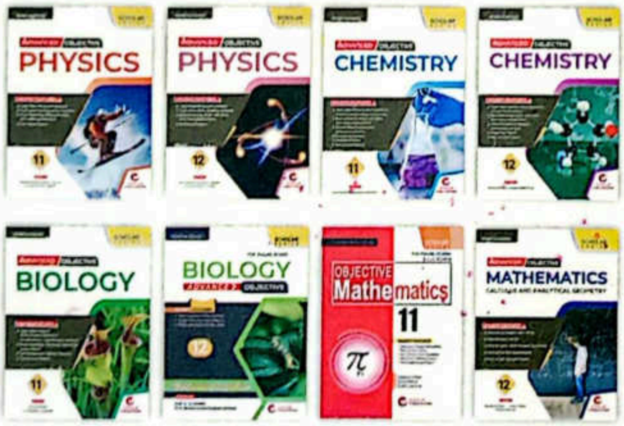

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