Unit 7

Properties of Matter

Q1. Describe briefly about matter?

Ans: Matter exists in three states, solid, liquid and gas. There are many properties associated with matter. For example, matter has weight and occupies space.

There are some other properties which are associated with one state of matter but not with other. For example, solids have shape of their own while liquids and gases do not. Liquids on the other hand have definite volume while gases do not have. Various materials differ in their hardness, density, solubility, flow, elasticity, conductivity and many other qualities. Kinetic molecular model helps in understanding the properties of matter in a simplified way.

Q2. How kinetic molecular model of matter is helpful in differentiating various states of matter?

Ans: See Q # 7.2 from Exercise.

USEFUL INFORMATION

Density of various substance	
Substances	**Density in kgm^{-1}**
Air	1.3
Foam	89
Petrol	800
Cooking Oil	920

Ice	920
Water	1000
Glass	2500
Aluminum	2700
Iron	7900
Copper	8900
Lead	11200
Mercury	13600
Gold	19300
Platinum	21500

USEFUL INFORMATION

1 metre cube(1 m^3) = 1000 litre

1 litre = 10^{-3}

1 cm^3 = 10^{-6}

1000 kgm^{-3} = 1 gcm^{-3}

Q3. Is an iron object heavier than that of wood?

OR

Why is 1cm cubed of wood lighter than 1 cm cubed of iron?

Ans: Because centimeters cubed is a unit of volume, not weight. The two might take up the same amount of space, but iron is much dense and as such weighs more.

$$\text{Density} = \frac{\textbf{Mass of a substance}}{\textbf{volume of the substance}} \quad OR \quad D = \frac{m}{v}$$

Q4. What is meant by density? What is its SI unit?

Ans: See Q # 7.4 from Exercise

Q5. Calculate the density of 5 litre of water?

Solution:

The mass of 5 litre of water is 5 kg.

Since 1 litre = $10^{-3} m^3$

5 litre = $5 \times 10^{-3} m^3$

$$\text{Density} = \frac{\textbf{Mass of a substance}}{\textbf{volume of the substance}} \quad OR \quad D = \frac{m}{v}$$

$$\text{Density} = \frac{5 \text{ kg}}{5 \times 10^{-3} m^3}$$

$$= 1000 \text{ kg m}^{-3}$$

The density of water is 1000 kg m^{-3}

Q6. Write down the density equations?

Ans: Density Equations:

(i) $\text{Density} = \frac{\textbf{Mass}}{\textbf{Volume}}$

(ii) Mass = Density x Volume

(iii) $\text{Volume} = \frac{\textbf{Mass}}{\textbf{Density}}$

DO YOU KNOW?

Earth's atmosphere extends upward about a few hundred kilometers with continuously decreasing density. Nearly half of its mass is between sea level and 10 km. Up to 30 km from sea level contains about 99% of the mass of the atmosphere. The air becomes thinner and thinner as we go up.

Q7. Define the term pressure?

Ans: See Q # 7.6 from Exercise.

Q8. Show that atmosphere exerts pressure.

Ans: See Q # 7.7 from Exercise.

Q9. How soap bubbles are produced. Why the soap bubbles so formed have spherical shapes?

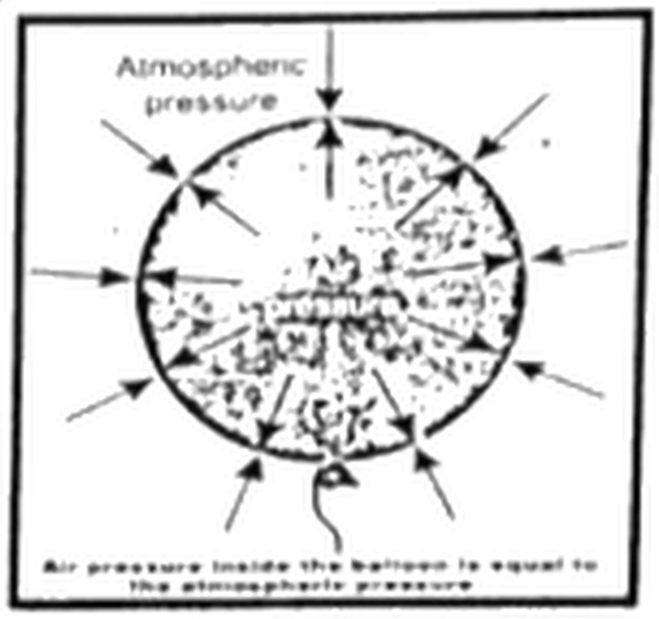
Ans: Formation of soap bubbles:

A soap bubble is a very thin sheet of water sandwiched between two layers of soap molecules. The film of soapy water surrounds a bubble of air. Soap molecules have one end that repels water, and one that attracts it, and these molecules move to the inner and outer surfaces, thrusting their water-repelling ends out in the air, and their "heads" inwards. Without such molecules on the surface, the bubble would spontaneously break apart into tiny water droplets.

Spherical shape of soap bubbles:

Surface tension causes bubble to be spherical, which is the shape that gives the minimum surface energy – the lowest ratio of surface area to volume.

Soap bubbles expand till the pressure of air in them is equal to the atmospheric pressure.



Q10. Write about the factors affecting pressure?

Ans: Factors Affecting Pressure $P = \frac{F}{A}$

i. The size of the force – the greater the force the greater the pressure.
ii. The area of contract – the smaller the area the greater the pressure.

Q11. Write any three examples of pressure?

Ans: Examples of Pressure:

(i) Skis have a large area to hold up the weight of the skier on the snow.

(ii) Flat bottomed shoes are comfortable to wear due to reduced pressure acting on our feet.

(iii) A sharp knife can cut easily because the very high pressure under the cutting surface is more than the object can withstand.

(iv) In some situations, a highly concentrated force is useful so a small area of contact is desirable e.g. scissors, knife edge, nail point, cheese wire, spikes on golf shoes, sharp edge of spade.

(v) In other situations, low pressure is better and so a large area of contact is part of the design e.g. wide tyres, school bag straps, suitcase handle, broad feet of elephant and camel.

Q12. What is barometer?

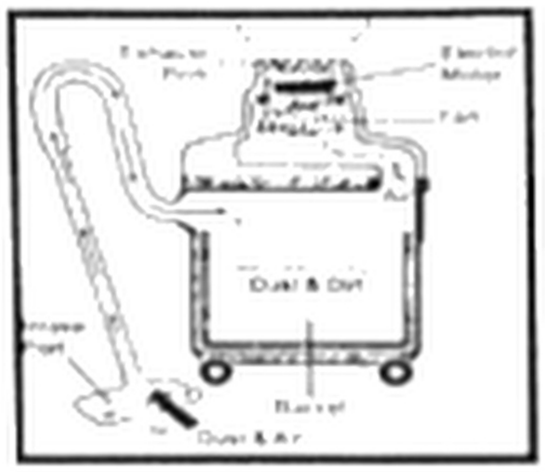
OR

Write the procedure for measuring atmospheric pressure with the help of barometer?

Ans: See Q # 7.9 from Exercise.

DO YOU KNOW

The fan in a vacuum cleaner lowers air pressure in its bucket. The atmospheric air rushes into it carrying dust and dirt with it through its intake port. The dust and dirt particles are blocked by the filter while air escapes out.



Q13. Why does the atmospheric pressure vary with height?

Ans: Variation in atmospheric pressure:

The atmospheric pressure decreases as we go up. The atmospheric pressure on mountains is lower than at sea level. At a height of about 30 km, the atmospheric pressure becomes only 7 mm of mercury which is approximately 1000

Pa. It would become zero at an altitude where there is no air. Thus, we can determine the altitude of a place by knowing the atmospheric pressure at that place.

Atmospheric pressure may also indicate a change in the weather. On a hot day, air above the Earth becomes hot and expands. This causes a fall of atmospheric pressure in that region. On the other hand, during cold chilly nights, air above the Earth cools down. This causes an increase in atmospheric pressure.

Q14. What does it mean when the atmospheric pressure at a place fall suddenly?

Ans: See Q # 7.13 from Exercise.

Q15. What change are expected in weather if the barometer reading shows a sudden increase?

Ans: See Q 7.14 from Exercise.

Q16. Why does atmospheric pressure changes with altitude?

Ans: See Q # 7.12 from Exercise.

DO YOU KNOW?

When air is sucked through straw with its other end dipped in a liquid, the air pressure in the straw decreases. This causes the atmospheric pressure to push the liquid up the straw.

Q17. State relation for pressure beneath a liquid surface to depth and to density?

OR

Prove that ($P = \rho gh$)

Ans: Pressure in Liquids:

Consider a surface of area A in a liquid at a depth *h*. The length of the cylinder of liquid over this surface will be h.

The force acting on this surface will be the weight w of the liquid above this surface. If ρ is the density of the liquid and *m* is mass of liquid above the surface, then

Mass of the liquid cylinder = m = volume x density

$$= (A \times h) \times \rho$$

Force acting on Area $F = w = mg$

$$= A h \rho g$$

As Pressure $P = \frac{F}{A}$

$$= \frac{A h \rho g}{A}$$

Liquid pressure at depth h = $P = \rho g h$ .....(i)

Equation i) gives the pressure at a depth h in a liquid of density ρ. It shows that its pressure in a liquid increase with depth. ($P \propto h$)

DO YOU KNOW?

The piston of the syringe is pulled out. This lowers the pressure in the cylinder. The liquid from the bottle enters into the piston through the needle.

Q18. State Pascal's law.

Ans: See Q # 7.15 from Exercise.

Q19. Explain the working of hydraulic press.

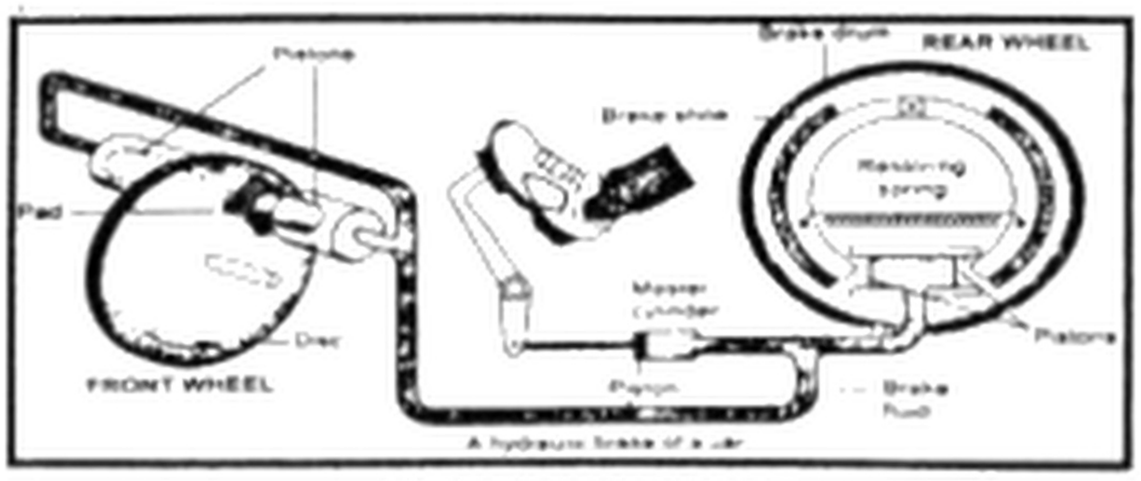
OR

Small force applied on the smaller piston, results into a large force on the larger piston. Why?

Ans: See Q # 7. 16 from Exercise.

Q20. Explain the braking system in vehicle?

Ans: The braking systems of cars, buses, etc. also work on Pascal's law. The hydraulic brakes allow equal pressure to be transmitted throughout the liquid. When brake pedal is pushed, it exerts a force on the master cylinder, which increases the liquid pressure in it. The liquid pressure is transmitted equally through the liquid in the metal pipes to all the pistons of other cylinders. Due to the increase in liquid pressure, the pistons in the cylinders move outward pressing the brake pads with the brake drums. The force of friction between the brake pads and the brake drums stops the wheels.



A hydraulic brake of a car

Q21. State Archimedes principle.

Ans: See Q # 7.18 from Exercise.

DO YOU KNOW?

Hydrometer:

Hydrometer is a glass tube with a scale marked on its stem and heavy weight in the bottom. It is partially immersed in a fluid, the density of which is to be measured. One type of hydrometer is used to measure the concentration of acid in a battery. It is called acid meter

Q22. Determine the density of an object using Archimedes principle?

Ans: Density of an object:

Archimedes principle is also helpful to determine the density of an object. The ratio in the weights of a body with an equal volume of liquid is the same as in their densities.

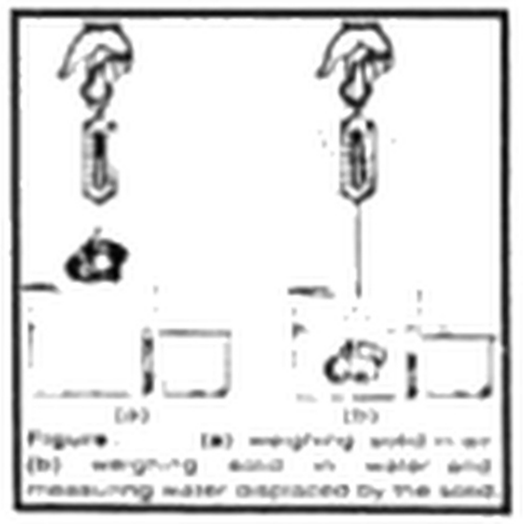


Figure. (a) weighing solid in air (b) weighing solid in water and measuring water displaced by the solid.

Let Density of the object = D

Density of the liquid = ρ

Weight of the object = w_1

Weight of equal volume of liquid = $w = w_1 - w_2$

Here w_2 is the weight of the solid in liquid. According to Archimedes principle, w_2 is less than its actual weight w_1 by an amount w.

Since $$\frac{D}{\rho} = \frac{w_1}{w}$$

$$D = \frac{w_1}{w} \times \rho$$

Or $$D = \frac{w_1}{w_1 - w_2} \times \rho \quad \text{.....(i)}$$

Thus, finding the weight of the solid in air w_1 and its weight in water w_2, we can calculate the density of the solid by using equation (i) as illustrated in the following example.

Q23. What is up thrust? Explain the principle of floatation.

Ans: See Q # 7.19 from Exercise.

Q24. Explain how a wooden block, ships and boats moves up the water surface.

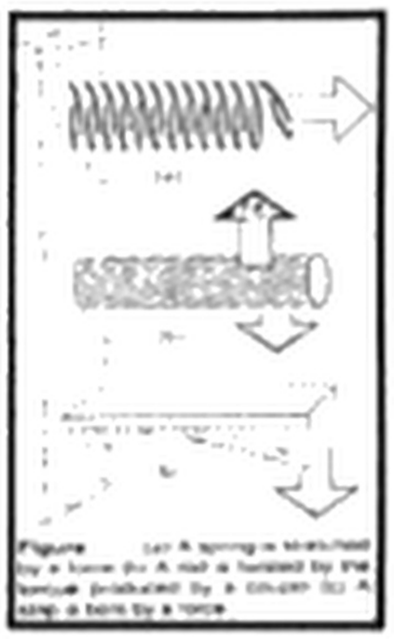
Ans: A wooden block floats on water. It is because the weight of an equal volume of water is greater than the weight of the block. According to the principle of floatation, a body floats if it displaces water equal to the weight of the body when it is partially or completely immersed in water.

Ships and boats are designed on the same principle of floatation. They carry passengers and goods over water. It would sink in water if its weight including the weight of its passengers and goods becomes greater than the up thrust of water.

Q25. Explain how a submarine moves up the water surface down into water.

Ans: See Q # 7.20 from Exercise.

Q26. What is meant by deforming force?



Ans: Deforming force:

We know that the length of a rubber band increases on stretching it. Similarly, the pointer of a spring balance is lowered when a body is suspended from it. It is because the length of the spring inside the balance increases depending upon the weight of the suspended body.

The applied force that changes shape, length or volume of a substance is called deforming force. In most of the cases, the body returns to its original size and shape as soon as the deforming force is removed.

Q27. What is meant by elasticity?

Ans: Elasticity:

The property of a body to restore its original size and shape as the deforming force ceases to act is called elasticity.

Due to elasticity we can determine the strength of a material and the deformation under the action of a force.

Q28. Differentiate between stress and strain?

Ans: Stress:

The force acting on unit area at the surface of a body is called stress.

Thus stress $= \frac{Force}{Area}$

Unit: In SI, the unit of stress is newton per square metre (Nm^{-2}).

Strain:

A comparison of such a change caused by the stress with the original length, volume or shape is called as strain.

If stress produces a change in the length of an object then the strain is called tensile strain.

$$\textbf{Tensile strain} = \frac{\textbf{Change in length}}{\textbf{Original length}}$$

Strain has no units as it is simply a ratio between two similar quantities.

Q29. What is Hook's law? What is meant by elastic limit?

Ans: See Q # 7.22 from Exercise

Q30. What do you know about Young's modulus? How would you determine young's modulus of an object?

Ans: Young's modulus:

The ratio of stress to tensile strain is called Young's modulus.

Determination of young's modulus:

Consider a long bar of length L_0 and cross-sectional area A. Let an external force F equal to the weight w stretches it such that the stretched length becomes L. According to Hooke's law, the ratio of this stress to tensile strain is constant within the elastic limit of the body.

$$\text{Young's modulus} \quad Y = \frac{Stress}{Tensile\ strain}$$

Let ΔL be the change in length of the rod, then

$$\Delta L = L - L_0$$

$$\text{Since} \quad \text{Stress} = \frac{Force}{Area} = \frac{F}{A}$$

$$\text{And} \quad \text{Tensile strain} = \frac{L - L_0}{L_0} = \frac{\Delta L}{L_0}$$

$$\text{As} \quad Y = \frac{Stress}{Tensile\ strain}$$

$$= \frac{F}{A} \times \frac{L_0}{\Delta L}$$

$$Y = \frac{FL_0}{A\Delta L}$$

Unit: SI unit of Young's modulus is newton per square metre (Nm^{-2}).

SUMMARY

1. **Kinetic molecular model:** Kinetic molecular model explains the three states of matter assuming that

- matter is made up of particles called molecules.
- the molecules remain in continuous motion.
- molecules attract each other.

2. **Plasma:** At very high temperature, the collision between atoms and molecules tears off their electrons. Atoms become positive ions. This ionic state of matter is called plasma-the fourth state of matter.
3. **Density:** Density is the ratio of mass to volume of a substance. Density of water is 1000 kgm^{-3}.
4. **Pressure**: Pressure is the normal force acting per unit area. Its SI unit is Nm^{-2} or pascal (Pa).
5. Atmospheric pressure acts in all directions.
6. **Barometer**: The instruments that measure atmospheric pressure are called barometers.
7. The atmospheric pressure decreases as we go up. Thus, knowing the atmospheric pressure of a place, we can determine its altitude.
8. The changes in atmospheric pressure at a certain place indicate the expected changes in the weather conditions of that place.
9. Liquids also exert pressure given by: $P = \rho g h$
10. **Pascal's law:** Liquids transmit pressure equally in all directions. This is called Pascal's law.
11. **Archimedes principle:** When a body is immersed wholly or partially in a liquid, it loses its weight equal to the weight of the liquid displaced. This is known as Archimedes principle.
12. For an object to float, its weight must be equal or less than the up thrust of the liquid acting on it.
13. **Elasticity:** The property of matter by virtue of which matter resists any force which tries to change its length, shape or volume is called elasticity.
14. **Stress:** Stress is the deforming force acting per unit area.

15. **Tensile strain:** The ratio of change of length to the original length is called tensile strain.
16. **Young's modulus**: The ratio between stress and tensile strain is called Young's modulus.