Chapter 2 The Three States of Matter Gases, Liquids and Solids

Multiple Choice Questions (M.C.Qs)

Choose the correct answer for each from the given options:

01 **The vapour pressure of water at 100°C is:**
(a) 766 torr (b) 760 torr (c) 14.2 psi (d) 760 atm

02 **The process in which a solid directly changes into vapours without passing through liquid phase is called:**
(a) evaporation (b) condensation (c) sublimation (d) melting

03 **In S.I system, the unit of pressure is:**
(a) Kg/ms^2 (b) Kg/ms (c) Kg/m (d) Kg/m^2s

04 **The volume of gas would theoretically be zero at:**
(a) 0°C (b) 273K (c) -273°C (d) 273°C

05 **The internal resistance of a liquid to flow is called:**
(a) surface tension (b) viscosity (c) resistance (d) density

06 **This is an intensive property:**
(a) length (b) mass (c) mole (d) volume

07 **An ideal gas obeys gas laws at:**
(a) high pressure (b) high temperature
(c) all temperature and pressure (d) low temperature

08 **The instrument used to measure atmospheric pressure is:**
(a) spectrometer (b) lactometer (c) barometer (d) voltmeter

09 **The total pressure of a mixture of gases is the sum of the partial pressure of each gas present in the mixture. This is stated by:**
(a) Boyle (b) Dalton (c) Graham (d) Charles

10 **At S.T.P., 0.1 mole of a gas occupies the volume:**
(a) 22.4 dm^3 (b) 2.24 dm^3 (c) 2.4 ft^3 (d) 100 cm^3

11 **The unit of viscosity is:**
(a) milli-poise (b) milligram (c) joule (d) N/s-m

12 **It is a cooling process:**
(a) viscosity (b) surface tension (c) evaporation (d) vapour pressure

13 **As the temperature of a liquid is increased, its viscosity:**
(a) increases (b) decreases
(c) remains constant (d) first increases than decreases

14 ***The quantity of matter present in a body is called:***
(a) weight *(b) mass* *(c) energy* *(d) momentum*

15 ***Mathematically, Boyle's law can be represented as:***
(a) $V \propto T$ *(b)* $T \propto P$ *(c)* $T \propto \frac{1}{P}$ *(d)* $V \propto \frac{1}{P}$

16 ***The meniscus of mercury in a glass tube is:***
(a) plane *(b) concave* *(c) convex* *(d) zig-zag*

17 ***The three states of matter are due to the:***
(a) chemical properties *(b) physical properties*
(c) different arrangements of atoms *(d) different sizes of atoms*

18 ***Absolute zero is equal to:***
(a) -273.16°C *(b) 273.16°C* *(c) -100°C* *(d) 173K*

19 ***Which one of the following is amorphous solids?***
(a) Glass *(b) Rubber* *(c) Plastic* *(d) All of these*

20 ***An ideal gas is defined as the gas which obeys:***
(a) Boyle's law *(b) Charles's law* *(c) Gas laws* *(d) Avogadro's law*

21 ***The pressure of a gas increases when:***
(a) the volume is increased *(b) more molecules are added*
(c) the temperature is decreased *(d) molecules are removed*

22 ***Rising of liquid in a capillary tube is called:***
(a) ascent *(b) pull* *(c) capillary action* *(d) all of these*

23 ***Capillary action of liquids is due to:***
(a) viscosity *(b) surface tension* *(c) density* *(d) pull*

24 ***The unit of surface tension is:***
(a) $dynes/cm^2$ *(b)* erg/cm^2 *(c)* j/m^2 *(d) F/a*

25 ***Gases expand on:***
(a) subliming *(b) cooling* *(c) heating* *(d) condensing*

26 ***Charles's law shows the direct relation between:***
(a) $V \propto P$ *(b)* $V \propto n$ *(c)* $V \propto T$ *(d) none of these*

27 ***Graham's law of diffusion of gases, mathematically expressed as:***
(a) $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{m_2}{m_1}}$ *(b)* $\frac{r_1}{r_2} = \sqrt{\frac{d_1}{d_2}} = \sqrt{\frac{m_2}{m_1}}$
(c) $\frac{r_1}{r_2} = \sqrt{\frac{d_1}{d_2}} = \sqrt{\frac{m_1}{m_2}}$ *(d) None*

28 ***PV = nRT is called:***
(a) energy equation *(b) general gas equation*
(c) pressure equation *(d) volume equation*

29 ***Which gas has the lowest density?***
(a) CO *(b)* NH_3 *(c)* N_2 *(d)* O_2

30 ***Which one of the following is a pure compound?***
(a) Ethanol *(b) Petrol* *(c) Steel* *(d) Tap water*

31 ***Water has maximum density at:***
(a) 0°C *(b) 4°C* *(c) 25°C* *(d) 100°C*

14 ***The quantity of matter present in a body is called:***

(a) weight *(b) mass* *(c) energy* *(d) momentum*

15 ***Mathematically, Boyle's law can be represented as:***

(a) $V \propto T$ *(b)* $T \propto P$ *(c)* $T \propto \frac{1}{P}$ *(d)* $V \propto \frac{1}{P}$

16 ***The meniscus of mercury in a glass tube is:***

(a) plane *(b) concave* *(c) convex* *(d) zig-zag*

17 ***The three states of matter are due to the:***

(a) chemical properties *(b) physical properties*

(c) different arrangements of atoms *(d) different sizes of atoms*

18 ***Absolute zero is equal to:***

(a) -273.16°C *(b) 273.16°C* *(c) -100°C* *(d) 173K*

19 ***Which one of the following is amorphous solids?***

(a) Glass *(b) Rubber* *(c) Plastic* *(d) All of these*

20 ***An ideal gas is defined as the gas which obeys:***

(a) Boyle's law *(b) Charles's law* *(c) Gas laws* *(d) Avogadro's law*

21 ***The pressure of a gas increases when:***

(a) the volume is increased *(b) more molecules are added*

(c) the temperature is decreased *(d) molecules are removed*

22 ***Rising of liquid in a capillary tube is called:***

(a) ascent *(b) pull* *(c) capillary action* *(d) all of these*

23 ***Capillary action of liquids is due to:***

(a) viscosity *(b) surface tension* *(c) density* *(d) pull*

24 ***The unit of surface tension is:***

(a) $dynes/cm^2$ *(b)* erg/cm^2 *(c)* j/m^2 *(d) F/a*

25 ***Gases expand on:***

(a) subliming *(b) cooling* *(c) heating* *(d) condensing*

26 ***Charles's law shows the direct relation between:***

(a) $V \propto P$ *(b)* $V \propto n$ *(c)* $V \propto T$ *(d) none of these*

27 ***Graham's law of diffusion of gases, mathematically expressed as:***

(a) $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{m_2}{m_1}}$ *(b)* $\frac{r_1}{r_2} = \sqrt{\frac{d_1}{d_2}} = \sqrt{\frac{m_2}{m_1}}$

(c) $\frac{r_1}{r_2} = \sqrt{\frac{d_1}{d_2}} = \sqrt{\frac{m_1}{m_2}}$ *(d) None*

28 ***PV = nRT is called:***

(a) energy equation *(b) general gas equation*

(c) pressure equation *(d) volume equation*

29 ***Which gas has the lowest density?***

(a) CO *(b)* NH_3 *(c)* N_2 *(d)* O_2

30 ***Which one of the following is a pure compound?***

(a) Ethanol *(b) Petrol* *(c) Steel* *(d) Tap water*

31 ***Water has maximum density at:***

(a) 0°C *(b) 4°C* *(c) 25°C* *(d) 100°C*

32 ***If $a = b = c$ and $\alpha = \beta = \gamma = 90°$, then the crystal structure is:***
(a) cubic (b) triclinic (c) orthorhombic (d) tetragonal

33 ***The value of gas constant 'R' in dm^3 atmosphere / K - mole is:***
(a) 0.082 (b) 8.20 (c) 1.987 (d) 0.028

34 ***The gas molecules exert pressure on the walls of container because of:***
(a) attraction (b) adhesion (c) collision (d) repulsion

35 ***The force of attraction between a liquid molecule and another surface is called:***
(a) adhesive forces (b) cohesive forces (c) London forces (d) none

36 ***The gases diffuse rapidly because of:***
(a) free movement of molecules (b) random motion of molecules
(c) molecules are widely separated (d) all of them

37 ***Two solids having the same crystal structure are called:***
(a) Isomorphous (b) Polymorphous (c) Isotopes (d) Allotropes

38 ***The number of crystal systems on the basis of unit cell is:***
(a) 5 (b) 6 (c) 7 (d) 8

39 ***Real gases are nearer to ideality at:***
(a) high temperature and high pressure (b) high temperature and low pressure
(c) low temperature and low pressure (d) low temperature and high pressure

40 ***If $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$ then crystal structure is:***
(a) cubic (b) tetragonal (c) orthorhombic (d) triclinic

41 ***Theoretically, a gas at zero Kelvin, :***
(a) becomes liquid (b) becomes solid
(c) its volume becomes zero (d) freezes

42 ***$CaCO_3$ exists in more than one crystalline form. This property is called:***
(a) isomorphism (b) polymorphism (c) allotropes (d) isotopes

43 ***Amorphous solids do not have:***
(a) sharp melting point (b) regular structure (c) geometrical shape (d) all of these

44 ***Gases contract on:***
(a) heating (b) subliming (c) cooling (d) none of these

45 ***The S.I unit for measurement of pressure is:***
(a) Newton (b) Pascal (c) both (d) none of these

46 ***The S.I unit of temperature is:***
(a) Celsius (b) Fahrenheit (c) Kelvin (d) none of these

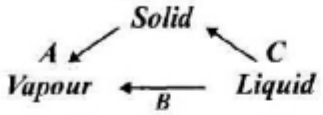
47 ***Normal body temperature is:***
(a) 37°C (b) 98.6°F (c) 310 K (d) all of these

48 ***Rate of diffusion of a gas is inversely proportional to:***
(a) its mass (b) its density
(c) square root of the density (d) none of these

49 ***Effusion is the escape of gas molecules through:***
(a) semi permeable membrane (b) permeable membrane
(c) porous container (d) tiny hole

50 ***Volume of a gas depands upon the:***
(a) nature of gas (b) mass of gas (c) size of container (d) none of these

51 *In the diagram below, the name of the reverse process of B is :*



(a) sublimation *(b) condensation* *(c) evaporation* *(d) fusion*

52 *If $a = b \neq c$ and $\alpha = \beta = \gamma = 90°$, the crystal structure is :*

(a) cubic *(b) tetragonal* *(c) orthorhombic* *(d) triclinic*

53 *The atmospheric pressures recorded in different places at the same time are given below :*

Nathiagali	Hunza	Murree	Gilgit
700 torr	650 torr	710 torr	600 torr

Water will boil first in:

(a) Nathiagali *(b) Hunza* *(c) Murree* *(d) Gilgit*

Answer Key

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

Short / Detailed Answer Questions

Q.01 ***Define matter.***

Ans. Matter is defined as anything which occupies space and has mass. Matter is composed of tiny particles, atoms or molecules, e.g, water, oxygen, rock, the sun etc.

Q.02 ***What are the states of matter?***

Ans. Matter exists in three physical states:

(i) gas (ii) liquid (iii) solid

These three states are inter-convertible into one another. Plasma is the fourth state of matter. It is the matter of the sun and other stars.

Q.03 ***Describe the properties of gases.***

Ans. ***(i)*** Gases occupy all the available space, therefore they do not have definite volume.

(ii) They do not have a definite shape. They attain the shape of the container in which they are kept.

(iii) Gases can diffuse and effuse.

(iv) Since there are large empty spaces between gaseous molecules, therefore, gases can be compressed by applying pressure.

(v) The molecules of gases are in state of constant random motion. They collide with each other and with the walls of container and exert pressure.

(vi) The attractive forces between the molecules of gases are very weak.

Q.04 ***Describe the properties of liquids.***

Ans. *(i)* Liquids have definite volume. But they do not have definite shape they attain the shape of container in which they are kept.

(ii) The molecules of liquids are in state of constant motion. The evaporation and diffusion of liquids is the result of their motion.

(iii) The densities of liquids are much greater than those of gases but are closer to those of solids.

(iv) The spaces among the liquid molecules are negligible as compared to gases.

(v) The attractive forces between the molecules of liquids are greater than those of gases.

(vi) It can be compressed to a negligible extent even at high pressure.

Q.05 ***Describe the properties of solids.***

Ans. *(i)* The attractive forces among the particles of solids are very strong. Therefore, they have definite volume and shape.

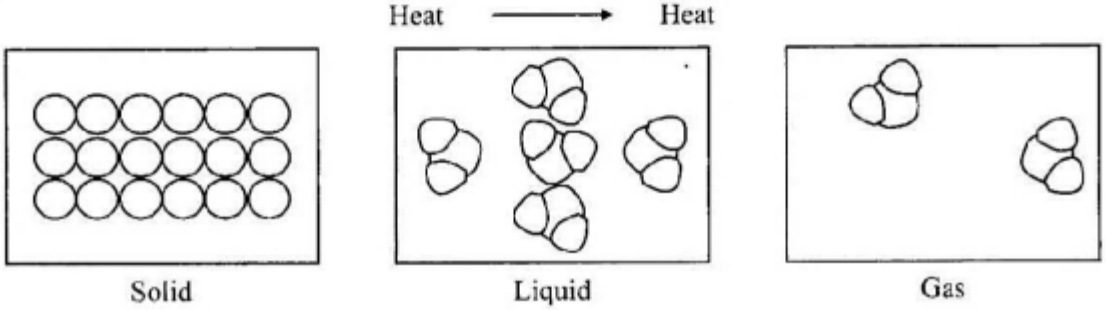
(ii) The particles of solids are very close to each other and they are tightly packed. That is why they are non-compressible and they cannot diffuse into each other.

(iii) Solid particles possess vibrational motion only.

Q.06 ***Describe the inter-conversion of states of matter.***

Ans. The phenomenon due to which the matter changes from one state to another state and back to the original state, on altering the conditions of temperature and pressure, etc. is called inter-conversion of matter. Conditions for altering the state of matter are:

(i) temperature *(ii)* pressure



(ii) They do not have a definite shape. They attain the shape of the container in which they are kept.

(iii) Gases can diffuse and effuse.

(iv) Since there are large empty spaces between gaseous molecules, therefore, gases can be compressed by applying pressure.

(v) The molecules of gases are in state of constant random motion. They collide with each other and with the walls of container and exert pressure.

(vi) The attractive forces between the molecules of gases are very weak.

Q.04 ***Describe the properties of liquids.***

Ans. *(i)* Liquids have definite volume. But they do not have definite shape they attain the shape of container in which they are kept.

(ii) The molecules of liquids are in state of constant motion. The evaporation and diffusion of liquids is the result of their motion.

(iii) The densities of liquids are much greater than those of gases but are closer to those of solids.

(iv) The spaces among the liquid molecules are negligible as compared to gases.

(v) The attractive forces between the molecules of liquids are greater than those of gases.

(vi) It can be compressed to a negligible extent even at high pressure.

Q.05 ***Describe the properties of solids.***

Ans. *(i)* The attractive forces among the particles of solids are very strong. Therefore, they have definite volume and shape.

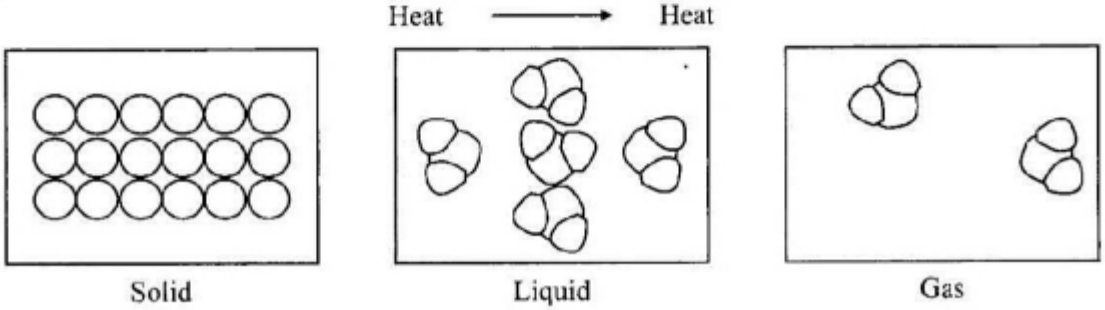
(ii) The particles of solids are very close to each other and they are tightly packed. That is why they are non-compressible and they cannot diffuse into each other.

(iii) Solid particles possess vibrational motion only.

Q.06 ***Describe the inter-conversion of states of matter.***

Ans. The phenomenon due to which the matter changes from one state to another state and back to the original state, on altering the conditions of temperature and pressure, etc. is called inter-conversion of matter. Conditions for altering the state of matter are:

(i) temperature *(ii)* pressure



Q.07 ***State the main postulates of kinetic molecular theory of gases.***

Karachi Board:2005, 2008, 2015

Ans. ***(i)*** Gases are made up of molecules, which are far apart from each other e.g. H_2, He and CO_2

(ii) Spaces between gas molecules are very large as compared to their sizes.

(iii) The actual volume of the molecules is negligible as compared to the total volume of the gas in the container.

(iv) The molecules of gases neither attract nor repel each other.

(v) The molecules of gases are always in a continuous state of haphazard motion but in a straight line.

(vi) The collisions of gas molecules with each other and with the walls of the container are perfectly elastic.

(vii) The pressure of a gas is the result of the collisions between the molecules and the walls of the container.

(viii) Due to motion, molecules of gases posses kinetic energy equal to $\frac{1}{2}mv^2$.

(ix) The average kinetic energy and average speed of the molecules of a gas is directly proportional to its absolute temperature (K).

(x) At the same temperature, molecules of all the gases have same average kinetic energy.

Q.08 ***Describe kinetic theory of liquids.*** ***Karachi Board: 2011***

Ans.

- Particles of a liquid (as in a gas) are randomly arranged.
- They consists of "clusters" in which they are very close together.
- Liquids have no shape but take the shape of container. They occupy definite volume.
- The force of attraction between liquid molecules is greater than gases.
- The particles in a liquid are fairly free to move and they can be poured from one container to another.

Q.09 ***Describe the kinetic theory of solids.***

Ans.

- The particles of solids are very closely packed due to the strong forces of attraction between them.
- Solids have definite shape and volume.
- Solids particles can not move freely; they just vibrate.
- In solids the particles are arranged in a fixed pattern.

Q.10 ***Explain the behaviour of gases on the basis of kinetic molecular theory.***

Karachi Board: 2011

Ans. The behavior of gases on the basis of kinetic molecular theory are discussed as under:

Diffusibilty: The process of spreading of gas molecules throughout the vessel is known as diffusion. ***Or*** The process of mixing of gases with one another to form a homogenous mixture is called diffusion and this property is called as diffusibility. In terms of kinetic theory, the molecules of a gas are widely separated and there are large empty spaces due to which they are free to move and mix each other, e.g. diffusion of perfume through the air.

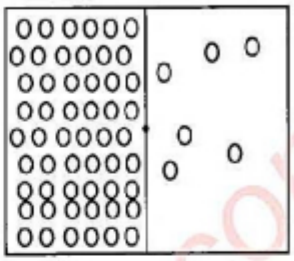


Fig. 2.1 Effusion

Effusion: A process in which gas molecules escape through minute pores or tiny holes in the vessel. For example, the air effuses from the tyre as a result of which they loses pressure gradually.

Compressibility: The decrease in volume with an increase of pressure is called compressibility'.

Gases can be compressed easily by exerting pressure. According to kinetic molecular theory this is so because there is large distances between particles of gases. They come closer by applying the pressure, so volume of the gas decreases.

Expansibility: 'Increase of gas volume with the decrease of pressure is called expansibility. According to kinetic theory when temperature of a gas increases, the average kinetic energy and the velocity of molecules also increases, so the gas expands fast at constant pressure.

Volume is measured in cubic decimeters, dm^3 or cubic centimeters cm^3 ($1dm^3 = 1000cm^3$).

Pressure: All gases exert pressure. The force exerted by gaseous particles per unit area is called gas pressure.

$$P = \frac{\text{Force}}{\text{Area}} = \frac{F}{A}$$

According to kinetic molecular theory gas particles are in constant random motion and when they collide with the walls of the container result is gas pressure.

Unit of pressure: Pressure can be measured by the following units

(i)	psi = pounds per square inch	($lb / inch^2$)
(ii)	Kilogram per square meter	(kg / m^2)
(iii)	Newton per square meter	(N / m^2 or pascal, pa)

Thus S.I. units of pressure are:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{Newton}}{m^2} = \frac{\frac{kg\text{-}m}{s^2}}{m^2} = kg / ms^2.$$

Q.11 ***Define gas laws and name some gas laws.***

Ans. ***Definition:*** The law which describes the behaviour of gases towards pressure, temperature, volume, molar amount, partial pressure and diffusion is called gas law.

Names of gas laws:

(i)	Boyle's law	*(ii)*	Charles's law	*(iii)*	General gas law
(iv)	Avogadro's law	*(v)*	Dalton's law	*(vi)*	Graham's law

Q.12 ***State Boyle's law and give its mathematical form.*** ***Karachi Board: 2006, 2012, 2016***

Ans. ***Introduction:*** In 1662, Robert Boyle gave a relationship between volume and pressure of gases. He announced this relationship in the form of a law known as Boyle's law.

Statement: At constant temperature, volume of a given mass of a gas is inversely proportional to the pressure exerted on it.

$$V \propto \frac{1}{P} \qquad (T \text{ is constant})$$

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

$$PV = K$$

The above expression shows that the product of pressure and volume of a given mass of a gas is constant provided the temperature remains constant.

If pressure of a given mass of a gas is P_1 and volume V_1, then changing the pressure to P_2, the volume will change to V_2.

$$P_1V_2 = K \quad \text{(a)}$$

$$P_2V_2 = K \quad \text{(b)}$$

By combining the above equations (a) and (b) we get:

$$P_1V_1 = P_2V_2$$ (the second form of Boyle's law)

Q.13 ***Describe the experimental verification of Boyle's law.***

Ans. This law can be verified by using the apparatus as shown in the diagram 2.2. It is clear from the diagram, that vessel contains 1 dm^3 of a gas at 2 atm pressure and 25°C temperature. If the pressure is increased from 2 atm to 4 atm at the same temperature, volume of the gas becomes $\frac{1}{2}$ dm^3.

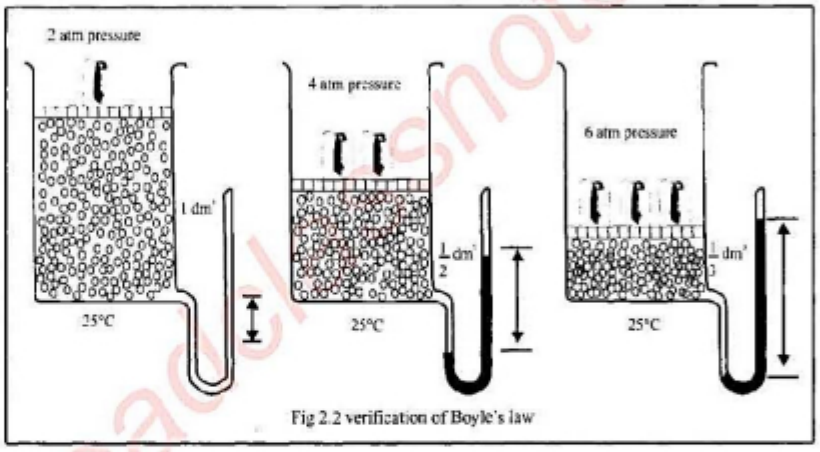


Fig 2.2 verification of Boyle's law

Similarly, when the pressure is increased from 4 atm to 6 atm at the same temperature, volume of the gas becomes $\frac{1}{3}$ dm^3. It means that volume of the given mass of the gas is decreasing with the increase in pressure at the same temperature.

Mathematically:

$$P_1V_1 = 2\text{ atm} \times 1\text{ dm}^3 = 2\text{ atm dm}^3 = K$$

$$P_2V_2 = 4\text{ atm} \times \frac{1}{2}\text{ dm}^3 = 2\text{atm dm}^3 = K$$

$$P_3V_3 = 6\text{ atm} \times \frac{1}{3}\text{ dm}^3 = 2\text{ atm dm}^3 = K$$

The above calculation verifies Boyle's law.

Q.14 ***Describe graphical explanation of Boyle's law.***

Ans. ***(i)*** When the volume along (y-axis) of a given gas plotted against reciprocal of pressure (1/P) along x-axis, straight line passes near the origin.

(ii) When the values P × V are plotted against corresponding values of 'P' we get horizontal lines. The straight line shows that K is a constant quantity.

(iii) When the volume of a gas (at y-axis) is plotted against the total pressure , a parabolic curve is obtained. This graph shows the decrease in volume with the increase in pressure.

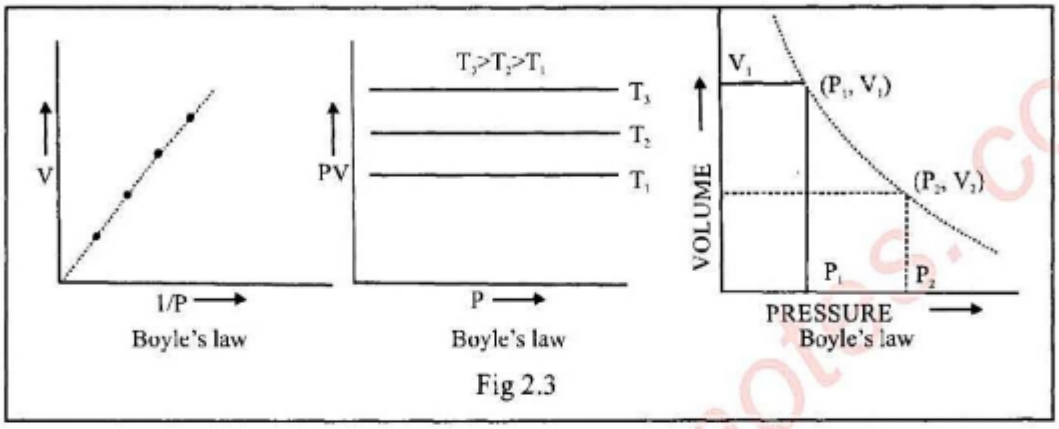


Fig 2.3

Q.15 ***Explain Boyles's laws with the help of Kinetic theory of gases.*** ***Karachi Board: 2012***

Ans. ***Boyles's Law:*** This law states that "The volume of a given mass of a gas is inversely proportional to the pressure exerted on it at a given temperature."

According to this law, at constant temperature, if pressure is doubled, volume will be reduced to half, if pressure is reduced to half, the volume will be doubled. Boyle's law can be explained in terms of kinetic theory as follows:

If the volume of a gas is decreased at constant temperature, the average velocity of the gas molecules remains constant, so they collide more frequently with the walls of smaller vessel. The more frequent collisions cause higher pressure.

Q.16 ***State Charles's law and give its mathematical form.*** ***Karachi Board: 2006, 2012, 2013, 2016***

Ans. ***Introduction:*** In 1787, Charles gave a relationship between volume and temperature of gases. He announced this relationship in the form of a law called Charles's law.

Statement: "Volume of a given mass of a gas is directly proportional to the absolute temperature at constant pressure".

Mathematical form: Mathematically, Charles's law can be expressed as:

$$V \propto T \qquad \text{(when 'P' is constant)}$$

$$\frac{V}{T} = \text{constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{constant}$$

Q.17 ***Explain the Charles's law in the light of kinetic theory.*** ***Karachi Board: 2004, 2006, 2012***

Ans. If the temperature is decreased, the average kinetic energy of the gas molecules decreases. At constant pressure the decreased velocity causes the gas to shrink, therefore the volume occupied will be small and vice versa. This is Charles's law.

Q.18 ***Give the graphical explanation of Charles's law.***
Or
What is absolute zero or Kelvin scale temperature?

Ans. When a graph is plotted between the absolute temperature on x-axis and the volume of one mole of a gas on y-axis. A straight line is obtained which shows that V/T is constant. When this is plotted as shows in figure 2.4, it intercepts the x-axis i.e. the temperature axis at -273°C. At this temperature the volume of a given mass of a gas becomes zero. Actually all gases convert into liquid before this temperature (-273.16°C) This temperature is called absolute zero or zero degree of the absolute scale (Kelvin scale). At absolute zero the motion of the molecules ceases to exist.

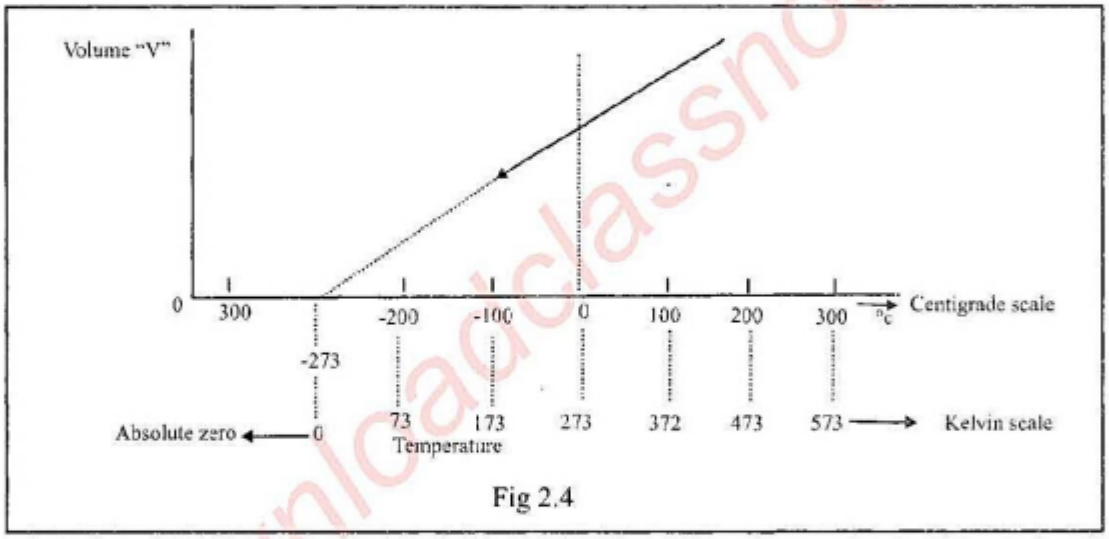


Fig 2.4

Q.19 ***Explain the term "Avogadro's law".*** ***Karachi Board: 2013, 2016***

Ans. ***Introduction:*** The ratios of the volumes and ratios of the molecules of reactant and product gases are identical. In 1811, Amadeo Avogadro worked out this relationship which is now called Avogadro's law.

Statement: "Equal volumes of all gases at the same temperature and pressure contain the same number of molecules."

Mathematical formula: Since equal number of moles of different gases contain equal number of molecules, which occupy equal volumes at the same temperature and pressure, therefore

$$V \propto n \text{ (at constant T and P)}$$

It means one mole of all gases occupy the same volume at the same temperature and pressure.

Examples:

At STP one mole of a gas occupies 22.4 dm^3 volume

1 mole of H_2 = 6.02×10^{23} molecules = 22.4 dm^3 volume at S.T.P.

1 mole of CO_2 = 6.02×10^{23} molecules = 22.4 dm^3 volume at S.T.P.

Q.20 ***Define general gas equation and also give its derivation.***

Karachi Board: 2005-2006-2012-2016-2018-2019

Ans. The equation which shows the effect of simultaneous changes in pressure and temperature on the volume of given mass of a gas is called ideal gas equation or general gas equation.

Mathematical form:

Mathematically, it is expressed as

$$PV = nRT$$

This equation is derived by combining Boyle's law, Charles's law and Avogadro's law as given below:

According to:

(i) Boyle's law $V = \text{constant} \times \frac{1}{P}$ (at constant T and n)

(ii) Charles's law $V = \text{constant} \times T$ (at constant P and n)

(iii) Avogadro's law $V = \text{constant} \times n$ (at constant T and P)

On combining (i), (ii) & (iii), we get:

$$V = \text{constant} \times \frac{nT}{P}$$

$$V = R \times \frac{nT}{P}$$

$$PV = nRT \quad \text{\_\_\_\_\_ (i)}$$

Where R is known as universal gas constant, the value of which is independent of the nature of the gas but depends on the initial values of P, V and T. The equation (i) is known as ideal gas equation.

For one mole of a gas equation (i) can be written as:

$$PV = RT$$

$$\text{or} \quad \frac{PV}{T} = R$$

$$\text{or} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \text{\_\_\_\_\_ (ii)}$$

The equation (ii) is another form of ideal gas equation.

Q.21 ***Calculate the value of ideal gas constant (R).*** ***Karachi Board: 2007, 2010, 2016***

Ans. Ideal gas equation is used to calculate the different units and value of R.

The volume of one mole of a gas at S.T.P. i.e., 0°C and 1 atm pressure is 22.4 dm^3.

$n = 1.0$ mol

$T = 0°C + 273 = 273$ K

$P = 1$ atm

$V = 22.4\ dm^3$

$PV = nRT$

$$R = \frac{PV}{nT} = \frac{1 \text{ atm} \times 22.4 \text{ dm}^3}{1 \text{ mol} \times 273 \text{ k}}$$

$$R = 0.08205 \text{ atm dm}^3 \text{ mol}^{-1} \text{ K}^{-1}$$

Q.22 ***Determine the value of gas constant R in two different units.***

Ans. **The value of R (The gas constant):**

(i) When P is expressed in atmospheres, V in litres or dm³

$$R = \frac{PV}{nT}$$

P = 1 atmosphere
V = 22.4 dm³ (Molar volume)

$$= \frac{1 \text{ mole} \times 22.4 \text{ dm}^3}{1 \text{ mole} \times 273 \text{ K}}$$

Since n = 1
T = 273 K

$$= 0.0821 \text{ dm}^3 \text{. atmosphere K}^{-1} \text{ mole}^{-1}$$

(ii) When P is expressed in newtons per square metre Nm^{-2}. V in cubic metres:

P = 101300 N m⁻².
V = 0.0224 m³ (since 1 dm³ = 10^{-3} m³)
n = 1
T = 273 K

$$R = \frac{PV}{nT} = \frac{101300 \text{ (Nm}^{-1}\text{)} \times 0.0224 \text{ (m}^3\text{)}}{1 \text{ (mole)} \times 273 \text{ (K)}}$$

$$= 8.3143 \text{ N mK}^{-1} \text{ mole}^{-1} = 8.3143 \text{ J K}^{-1} \text{ mole}^{-1}$$
$$= 8.3143 \text{ J / (mole K)}$$

Q.23 ***State Graham's law of diffusion and its mathematical formula.*** ***Karachi Board: 2010, 2013***

Ans. ***Defination of diffusion:***

"The spontaneous mixing of molecules of different gases by random motion and collision until the mixture becomes homogenous is called diffusion of gases."

Graham (1881) established a quantitative relationship between the rates of diffusion of gases and their densities and is termed as Graham's law of diffusion.

Statement of the law:

"Rate of diffusion of a gas is inversely proportional to the square root of the density of that gas provided the pressure and temperature are the same for the two gases."

$$r \propto \frac{1}{\sqrt{d}}$$

where "r" is the rate of diffusion and 'd' is the density of the gas.
We consider two gases with densities d_1 and d_2 then

$$r_1 \propto \frac{1}{\sqrt{d_1}}$$

or

$$r_1 = k_1 \propto \frac{1}{\sqrt{d_1}} \quad \text{(i)}$$

For the second gas, $r_2 \propto \frac{1}{\sqrt{d_2}}$

$$r_2 = k_2 \propto \frac{1}{\sqrt{d_2}} \quad \text{_____ (ii)}$$

From the equation (i) and (ii) we get:-

$$\frac{r_1}{r_2} = \frac{k}{\sqrt{d_1}} \div \frac{k}{\sqrt{d_2}}$$

$$\frac{r_1}{r_2} = \frac{\cancel{k}}{\sqrt{d_1}} \times \frac{\sqrt{d_2}}{\cancel{k}}$$

$$\frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}} \quad \text{_____ (iii)}$$

As the density of a gas is directly proportional to its molecular mass, the above equation becomes.

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} \quad \text{_____ (iv)}$$

Q.24 ***Describe Dalton's law of partial pressure.*** ***Karachi Board: 2004, 2012, 2013, 2014***

Ans. ***Statement:***

"The total pressure exerted by a mixture of gases is the sum of the partial pressure of all the gases present in the mixture."

Mathematical formula:

$$P = p_1 + p_2 + p_3 + \text{----------}$$

where p_1, p_2 and p_3 are the partial pressures of different gases and P is the total pressure of the gases present in the gases mixture.

The pressure exerted by each gas in the gaseous mixture is called the partial pressure of the gas.

In terms of kinetic theory, Dalton's law can be explained as, " in a non-reactive mixture each gas exerts a seperate pressure on the container because of collisions of its molecules with the walls of container.

Thus the total pressure in the container is caused by the sum of all the collision.

$$\frac{\text{Partial pressure of gas}}{\text{Total pressure}} = \frac{\text{Moles of the gas}}{\text{Total moles}}$$

$$P_{gas} = \frac{P \times n_{gas}}{n_{total}}$$

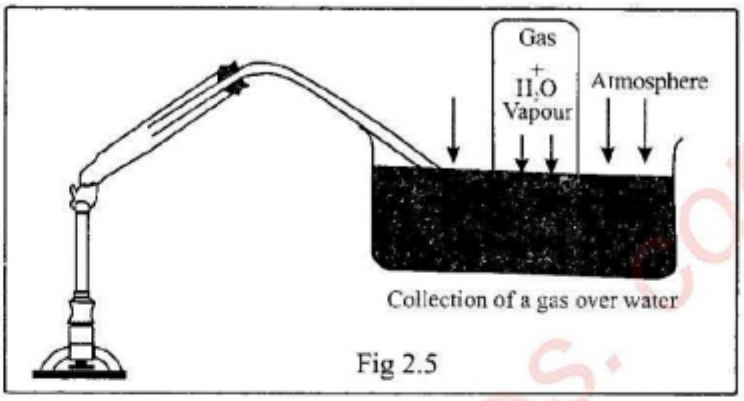
Q.25 ***Describe the application of Dalton's law of partial pressure.*** ***Karachi Board: 2014***

Ans. Gases collected over water contain some water vapours. Partial pressure of such gases is calculated by using the following mathematical expression of Dalton's law of partial pressure.

$$P_{total} = P_{gas} + P_{watervapour}$$

$$P_{gas} = P_{total} - P_{watervapour}$$

The partial pressure of water vapours in gases is called aqueous tension or vapour pressure of water.



Collection of a gas over water

Fig 2.5

Q.26 ***Explain Dalton's law of partial pressure with the help of Kinetic theory of gases.***

Ans. In terms of kinetic theory, Dalton's law can be explained as follows:
In a non-reactive mixture, each gas exerts a separate pressure on the container because of collisions of its molecules with the walls of container. Thus the total pressure in the container is caused by the sum of all the collisions.

Q.27 ***Define ideal and non-ideal gas.*** ***Karachi Board: 2008-2014-2018-2019***

Ans. ***Ideal gas:***
Gases which obey gas laws at all temperatures and pressures are called ideal gases. Two properties of an ideal gas are that the molecules do not attract each other and they occupy no space. Actually no such gas exists. Only H_2 and O_2 do not greatly deviate from ideal behavior at moderate temperature and pressure.

Non-ideal gases (Real gases):
These are the gases which obey gas laws but only at high temperature and low pressure.
These gases do not obey gas laws at low temperature and high pressure, under these conditions they deviate from ideal behaviour.

Q.28 ***Explain the causes of non-ideal behaviour of gases especially at high pressures and low temperature.*** ***Karachi Board: 2009, 2014***

Ans. ***Non-ideal behavior of gases:***

At high pressure:
When the pressure on the gas is increased, the molecules come close to each other leaving small empty spaces among themselves. It means the volume of a gas no longer remain negligible. Hence at high pressure, decrease in volume is not according to general gas equation and the value of the product $\frac{PV}{RT}$ has increased from accepted value. Graph of a real gas lie above the graph of an ideal gas.

At low temperature:
When the temperature is decreased, kinetic energy of molecules become less, volume of the gas decreases, the molecules come close to each other and force of attraction became significant. Therefore, the product $\frac{PV}{RT}$ does not remain constant and the gas shows marked deviation at low temperature.

Q.29 ***Correct the underlined statements and name the gas laws concerned :***

(i) H_2 has the rate of diffusion twice that of O_2.

(ii) The mass of gas expands twice if its temperature is raised from 27°C to 54°C at the same pressure.

Ans. ***(i)*** H_2 has the rate of diffusion 4 times that of O_2 (compared at the same temperature and pressure) according to the Graham's Law of Diffusion.

(ii) The volume of a gas expands twice if its temperature is raised from 27°C to 54°C at the same pressure according to Charle's law.

Q.30 ***Define liquefaction.*** ***Karachi Board: 2014***

Ans. "A process by which a gas converts into liquid state at low temperature is known as liquefaction."

$$\text{Gas} \xrightarrow[\text{- temp}]{\text{P}} \text{liquid}$$

According to kinetic theory at low temperature the kinetic energy of the molecules is less and the attractive forces are capable of holding the molecules to one another and the gas changes to liquid.

Q.31 ***What is liquid state.*** ***Karachi Board: 2014***

Ans. ***Definition:*** "The liquid state is the intermediate between gaseous and the solid state."

$$\text{gas} \xrightarrow{\text{cool}} \text{liquid} \xrightarrow{\text{cool}} \text{solid}$$

A liquid is a physical state of matter which has a definite volume but no definite shape. Liquids assume the shape of the container in which it is placed.

Q.32 ***Describe behavior of liquids in terms of kinetic theory.***

Ans. ***(i)*** ***Diffusibility:*** Liquids can mix with each other to form a homogeneous mixture but the rate of diffusion is slow than that of gases. e.g., a drop of ink spreads in water and form homogenous mixture.

Diffusibility in terms of kinetic energy:

The molecules of liquid are in clusters, they are very close to one another. They are bonded by strong intermolecular forces. The intermolecular distances are smaller and collision frequency is higher, as a result, the diffusion is slower.

(ii) ***Compressibility:*** There is little space between the molecules of liquid as compared to gases. Therefore when pressure applied, they can be compressed but to a very little extent.

Compressibility in terms of molecular model:

The space between liquid molecules are very small due to strong Vander Waals forces. When pressure is applied, practically there is no effect on the volume of liquid.

(iii) ***Expansion:*** Volume of liquids generally increases with the rise of temperature is called expansion.

(iv) ***Contraction:*** Decrease in volume with the lowering of temperature is called contraction. A liquid normally contracts on cooling.

Q.33 ***Define and explain viscosity.*** ***Karachi Board: 2007, 2008, 2009, 2010***

Ans. Liquids have the property to flow because molecules of liquid can slide over each other and the resistance of a liquid to flow is called "viscosity". Viscosity is denoted by a greek letter η (eata).

Explanation:

Consider a liquid in a tube consist of series of layers. The layer of the liquid in contact with the walls of the tube remains stationary. The layer in the center of the tube has highest velocity. Each layer exerts a drag on the next layer and cause resistance to flow.

Example: Honey , glycerine etc. flow slowly are called viscous liquids while gasoline , ether etc. which flow quickly are called less viscous liquids.

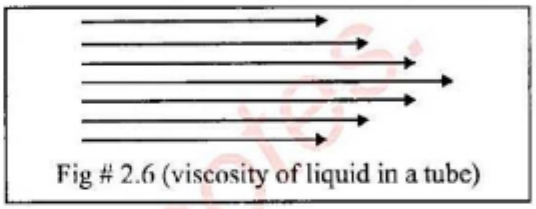


Fig # 2.6 (viscosity of liquid in a tube)

Q.34 ***State units of viscosity.***

Ans. Visosity is measured in poise, centipoise or millipoise. The S.I unit is newton x seconds per square meter ($N.S.m^{-2}$)

1 poise = 10^{-1} $N.S.m^{-2}$
1 centipoise = 10^{-2} $N.S.m^{-2}$
1 millipoise = 10^{-3} $N.S.m^{-2}$

Q.35 ***Discuss factors on which viscosity depends.*** ***Karachi Board: 2011***

Ans. ***Following are the factors which effect the viscosity of a liquid:***

(i) ***Intermolecular forces:*** Greater the intermolecular forces of attraction in a liquid, greater will be the viscosity of the liquid.

(ii) ***Size of molecules:*** Greater the size of the liquid molecules greater will be the viscosity of the liquid.

(iii) ***Shape of molecules:*** Irregular shaped molecules causes more resistance to flow as compared to regular shaped molecules.

(iv) ***Temperature:*** With the rise of temperature, the viscosity of liquid decreases (2% per degree) because of higher temperature the kinetic energy of molecules increases and the attractive forces between the molecules decreases.

Q.36 ***Define surface tension (γ).*** ***Karachi Board: 2005, 2007, 2009***

Ans. ***Definition:*** ***"The force in dynes acting upon a line of 1cm length on the surface of the liquid."***

Or

"It is the force per unit length or energy per unit area of the surface of liquid."

Surface tension is denoted by the greek letter γ (gamma).

Unit of surface tention:

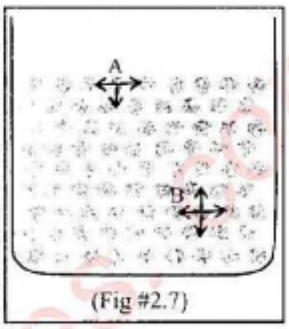
(i) dynes/cm (ii) $ergs/cm^2$ at 20°C

Q.37 ***Explain the process of surface tension.***

Ans. ***Illustration:***

Consider a liquid in a beaker (as shown in figure 2.7) The molecules (B) inside the liquid are surrounded by like molecules and therefore are attracted equally from all directions as compared to the molecules (A) on the surface of the liquid.

The molecule 'A' lying on surface will be attracted inwardly and all the molecules on the surface will be subjected to an inward pull. As a result of this inward pull, the surface of the liquid behaves as a stretched membrane and causing a tension on the surface of the liquid.



(Fig #2.7)

Q.38 ***Describe the factors which effect the surface tension.*** ***Karachi Board: 2011***

Ans. Following are factors which effect the surface tension.

(i) ***Intermolecular forces:***

Liquids having higher intermolecular forces have high surface tension. Intermolecular forces are directly proportional to surface tension.

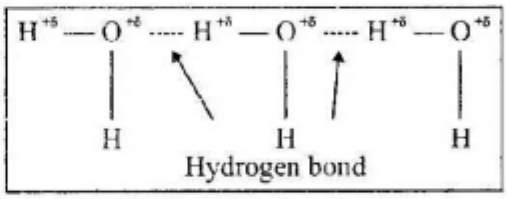
Example: Surface tension of water is higher than most of the organic liquids due to presence of hydrogen bonds. Mercury has the highest surface tension.

(ii) ***Temperature:***

Surface tension of liquids decreases by increasing the temperature. This is due to decrease in intermolecular attractions.

(iii) ***Molecular structure of liquids:***

If there is hydrogen bonds among liquid molecules then the surface tension value will be higher.



Hydrogen bond

Q.39 ***Define capillary action.***

Ans. If a capillary tube is placed in liquids (e.g. water) which wets the wall of container, the surface area of liquid is decreased by rising in the capillary tube because of surface tension. This rise of liquid in a capillary tube is called capillary action, as shown in figure 2.8.


(Fig # 2.8)

Q.40 ***What are cohesive and adhesive forces?***

Ans. ***(i)*** ***Cohesive forces:***

Cohesive forces or cohesion are forces of attraction among the molecules of a liquid.

Example: The attractive forces among water molecules.

(ii) ***Adhesive forces:***

The forces of attraction between liquid e.g water molecules and particles of glass or any other surface are called adhesive forces or adhesion.

Example: The force of attraction between the water molecules and the particles of glass is adhesion.

Q.41 ***What is meniscus? Explain types of meniscus.*** *Karachi Board: 2013*

Ans. ***Meniscus:*** The shape of the surface of a liquid in a cylindrical vessel is called meniscus.

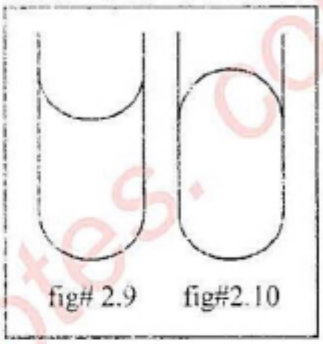
Types of meniscus:

(i) ***Concave meniscus:*** Liquids which wet the glass form a concave meniscus. It is formed when the adhesive forces are stronger than cohesive forces.

For example: Water forms concave meniscus when water rises on the walls of the container (as shown in figure 2.9).

(ii) ***Convex meniscus:*** Liquids which do not wet the glass forms a convex meniscus. It is formed when cohesive forces are stronger than adhesive forces.

For example: Mercury forms convex meniscus. Liquid surface falls few millimeter from the walls of the container. (as shown in fig# 2.10)



fig# 2.9 fig#2.10

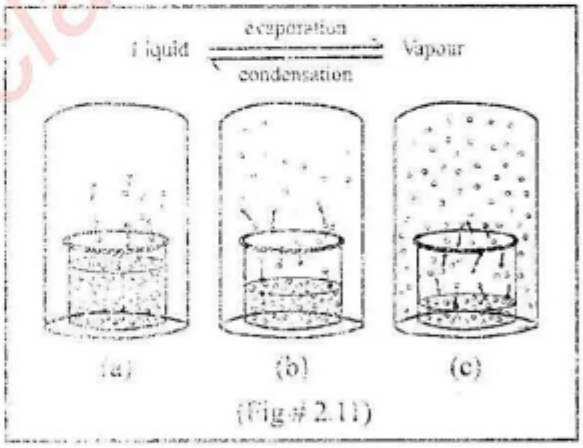
Q.42 ***Define and explain vapour pressure.*** *Karachi Board: 2005*

Ans. ***Definition:*** It is the pressure exerted by the vapours above the surface of a liquid in a closed vessel. When the equilibrium is established between the liquid and its vapours at a given temperature is called equilibrium vapour pressure or simply vapour pressure.

Explanation of vapour pressure:

When a vessel containing a liquid is closed as a result of evaporation, molecules begin to evaporate in the space above the surface of the liquid such molecules return back to the liquid as a result of condensation. In the beginning, rate of condensation is less than the rate of evaporation.

However, after some time both these rates become equal and equilibrium is established between the liquid and vapour states.



(Fig # 2.11)

Q.43 ***Explain the evaporation and vapour pressure in terms of kinetic theory.***

Ans. When high energy molecules at the surface of liquid break away from their neighbours and escape into the gas phase called evaporation.

During evaporation, the escape of high energy molecules lowers the average kinetic energy of the remaining molecules. During this process the temperature of the liquid and surrounding falls down. Thus evaporation is a cooling process.

Q.44 ***Define boiling and boiling point.*** *Karachi Board: 2013, 2015*

Ans. ***Boiling:*** When a liquid starts producing vapour at a definite temperature is called boiling.

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

Q.45 ***Discus the mechanism of boiling point.***

Ans. When a liquid is heated, its vapour pressure increases. With the increase in temperature, a stage is reached when its vapour pressure becomes equal to the pressure exerted on the liquid, it may be the atmospheric pressure. If heating is being done in an open container or it may be any other external pressure placed on the lid of the closed container, it is found that at this stage many bubbles inside the liquid appear. This means that process of boiling is taking place. It is clear from the graph that 100°C is the temperature at which pressure of water becomes equal to atmospheric pressure, 760 mm of Hg or 760 torr, hence it is the boiling point of water. The figure 2.12 shows the variation of vapour pressure of water, ethyl alcohol, di-ethyl ether with temperature. Different liquids have different boiling points due to difference in the strength of their intermolecular forces.

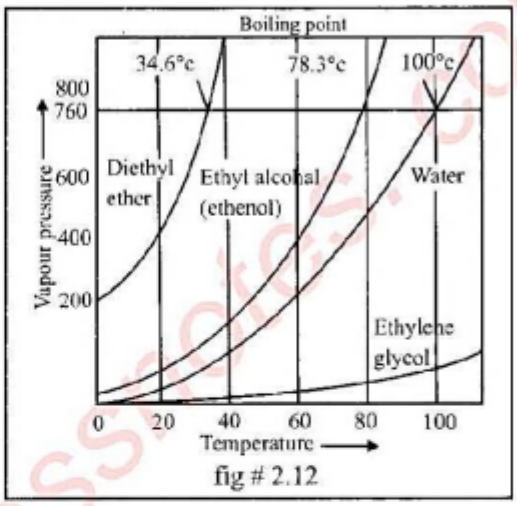


fig # 2.12

Q.46 ***Define solids.***

Ans. The substances which are rigid, hard and have definite shape and definite volume are called solids. Particles of solids cannot move, however they possess some vibrational energy.

Q.47 ***Write down the general properties of solids.***

Ans. ***The following are the general properties of solids:***

(i) ***Rigidity of Solids:*** The atoms, ions or molecules of a solid do not possess sufficient energy to move about nor take up different positions. The rigidity of a solid may be changed under stress. Due to stress a solid can shatter and such solids are called brittle. Glass is one of the best examples. Alternatively, a stress can make the solids to spread out into a thin sheet and such solids are malleable.

(ii) ***Definite Volume:*** The particles of a solid are close to each other and are held together by intermolecular forces. There is not much free space between them, enabling them to have definite shape.

(iii) ***Low Compressibility:*** The particles in solids are tightly held, as a result they are difficult to compress.

(iv) ***High Density:*** The close packing of the particles in the solids eliminate the free space between them to show high density.

(v) ***Diffusion:*** The diffusion of a solid into another solid is very slow as compared to liquids; the reason is that atoms of solids have fixed position from which they cannot move appreciably.

(vi) ***Melting:*** When a solid is heated, the particles present in a solid start vibrating at a higher frequency and transfer kinetic energy throughout the solid. At the melting point of the solids, their vibrational frequency increases so much that they leave their fixed positions and collapse to become a liquid.

Q.48 ***Define the types of solids on the basis of arrangement of particles.***

Ans. ***Solids are classified mainly as:***

(i) Crystalline solid (ii) Amorphous solid

(i) ***Crystalline Solid:*** The solids in which structural units are arranged in a regular, repeating, three dimensional manner are called crystalline solids. They have faces, axis and angles.

Examples: Sugar, alum, diamond, metals etc.

(ii) ***Amorphous Solids:*** Amorphous means "without definite shape". They do not have definite geometrical shape. Their particles are not regularly arranged are called amorphous solids. If a substance in liquid state is cooled rapidly, the particles are unable to arrange themselves in an orderly fashion.

Examples: Glass, plastic, rubber etc.

Q.49 ***Define anisotropy and give its example.***

Ans. ***Definition:*** The crystals show variation in physical properties depending upon the direction are called anisotropic properties and this phenomenon is called anisotropy.

Example: The physical properties of crystalline solids like refractive index, coefficient of thermal expansion, electrical and thermal conductivities and sometime anisotropic in nature for some crystals.

For example, electrical conductivity of graphite is greater in one direction than in another.

Q.50 ***Name the types of crystalline solids.***

Ans. ***Types of crystalline solids according to types of bonds:***

A unit cell contains a definite number of atoms , ions or molecules are held together by different types of cohesive forces. These forces may be chemical bonds or some types of interaction between the particles of the solid. There are four types of such bonds present in different crystalline solids depending upon the types of bonds present in them:

(i) Ionic solids (ii) Covalent solids
(iii) Molecular solids (iv) Metallic (Atomic) solids

Q.51 ***Define and explain metallic (atomic) solids.***

Ans. ***Definition:*** ***"The solids having metallic bonds in them are called metallic solids."***

Atoms in atomic crystal are joined together by a special type of bond called metallic bond. In metals, the valence electrons move freely in crystal lattice and are said to form an electrons sea in which positive ions are immersed. These crystals show properties such as malleability, ductility, conductivity and high melting point.

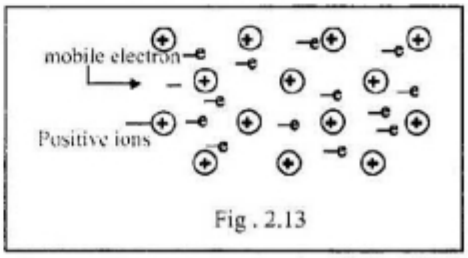


Fig . 2.13

Q.52 ***Define and explain ionic crystal.*** ***Karachi Board : 2018***

Ans. ***Definition:*** Ionic solids are those crystalline solids in which the particles forming the crystals are positively and negatively charged ions, held together by strong electrostatic forces of attraction (ionic bond).

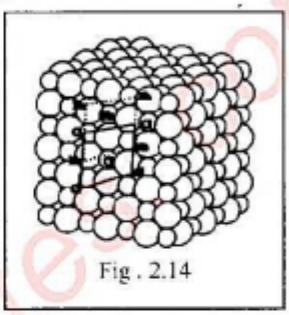


Fig . 2.14

Example: The crystals of NaCl, KBr, etc.

They are characterized by

(a) high melting point
(b) conduction of electricity in molten and in aqueous solution
(c) brittleness and hardness
(d) indefinite growth of crystal, until it is broken or is stopped from growing.

Q.53 ***Define and explain covalent crystals.***

Ans. ***Definition of covalent solids:*** Covalent solids are composed of neutral atoms of the same or of different elements. Their atoms are held together by covalent bonds.


Fig . 2.15 Diamond

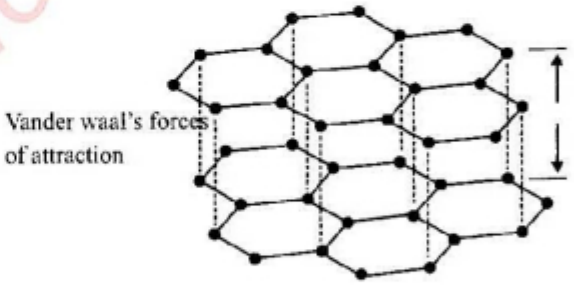


Fig . 2.16 Graphite

Examples of covalent crystals are diamond, graphite, silica and carborundum.

Explanation:

In diamond each carbon atom is attached by covalent bonds to each of the other four carbon atoms situated around it tetrahedrally. Due to close packing of atoms and large number of covalent bonds, diamond is hard and has high melting point.

In graphite each carbon atom is attached by covalent bonds to three other carbon atoms. Carbon atoms are arranged in a number of layer composed of hexagonal rings. Adjacent layers are held together by weak Vander Waal's forces due to large distances between them the layers can easily slip over the other so graphite has greasy texture. Graphite conducts electricity as each carbon has one free electron.

Covalent crystals are characterized by:

(a) high melting point (b) low density (c) high refractive index

Q.54 ***Write a short note on molecular solids.***

Ans. ***Molecular solids:***

Definition: "The crystals consisting of molecules, which are held together through Vander Waal's forces are called molecular crystals."

Explanation: Since Vander Waal's forces are weaker, therefore molecular crystals are soft and have low melting points and low lattice energies. These crystals are poor conductors of electricity. This is because electrons are not able to move freely through solids.

Examples are ice, CO_2, I_2 etc.

Fig. 2.17 unit cell of solid CO_2

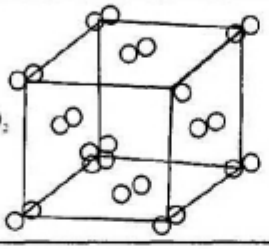
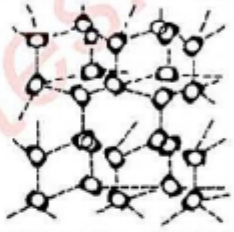


Fig. 2.17 Structure of ice



Q.55 ***Define and explain isomorphism.***

Ans. ***Meaning of isomorphism is "same structure".***

Defination: Isomorphism is the phenomenon in which two different substances exist in the same crystalline form. These different substances are called isomorphous of each other.

For example: NaF and MgO both form cubic crystals hence are isomorphous.

Fig. 2.18 A cube

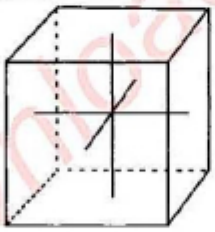
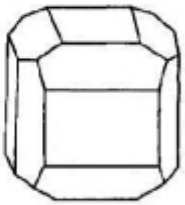


Fig. 2.18 A cube crystal



Other Examples are:

Formula	*Ratio*	*Crystal system*
$CaCO_3$ and $NaNO_3$	1:1:3	Trigonal
$ZnSO_4$ and $NiSO_4$	1:1:4	Orthorhombic

Isomorphous substances show different physical and chemical properties.

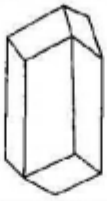
Q.56 ***Define polymorphism. Give its explanation with examples.***

Ans. ***Meaning of polymorphism is "many structures".***

Definition: The substances which exist in more than one crystalline forms under different conditions is called polymorphous. This property is called polymorphism.

Explanation: Polymorphous crystals have same chemical properties but they differ in the physical properties. The difference in the physical properties is due to different structural arrangement of particles in space.

Fig 2.19 Trigonal crystal



Orthorhombic crystal

Example:

Substance	*Crystalline form*
$AgNO_3$	Rhombohedral, orthorhombic
$CaCO_3$	Trigonal, orthorhombic

Q.57 ***Define unit cell and give its explanation.*** ***Karachi Board: 2015-2017-2019***

Ans. ***Definition:*** ***"Unit cell is the smallest part of the crystal lattice which possesses all the characteristics feature of the space lattice, that if repeated in three dimension generates the entire lattice."***

Example: As brick is the unit cell of a wall. A unit cell has a definite geometric shape. The unit cell of all different lattices are similar in having eight corners, however they differ by the length of their edges (a, b, c) and by the angles (α, β, γ) opposite to them.

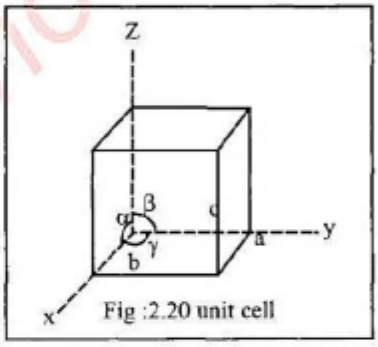


Fig :2.20 unit cell

Q.58 ***Define crystal lattice and write down its structure.***

Ans. ***Definition:*** A crystal lattice is defined as an array of points representing atoms, ions or molecules of a crystal, arranged at different sites in three dimensional space.

Structure: A crystal is made up of atoms, ions or molecules. In crystalline solids, these atoms, ions or molecules are located at definite positions in space . These are represented by points in a crystal. These points are called as lattice points or lattice sites. Their arrangement of points in a crystal is called crystal lattice or space lattice.

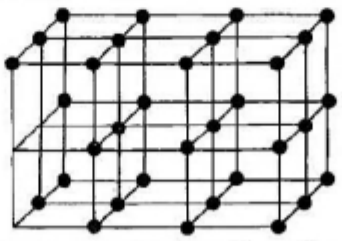


Fig :2.21 crystal lattice with a unit cell

Q.59 ***Briefly describe about the classification of crystal systems.***

Karachi Board: 2006, 2009, 2011, 2017

Ans. In 1850, a French mathematician August Bravis observed that crystal lattice of substances can be categorized into seven types.

A crystal system may be identified by the dimensions of a unit cell along its three edges or axes a, b, c and three angles between the axis. These seven crystal systems are described as follows:

(i) ***Cubic system:*** *Karachi Board: 2019*
In cubic system, all axes are of equal length and all angles are of 90° i.e,

$a = b = c$

$\alpha = \beta = \gamma = 90°$

Examples: NaCl, ZnS, diamond, Cu.

(ii) ***Tetragonal system:*** *Karachi Board: 2019*
It has two axes of equal length, the third is different. All angels are of 90°.

$a = b \neq c$

$\alpha = \beta = \gamma = 90°$

Examples: Sn, SnO_2, $BaSO_4 . 4H_2O$

(iii) ***Orthorhombic system:***
In this system, all three axes are of different length, but all angles are of 90°.

$a \neq b \neq c$

$\alpha = \beta = \gamma = 90°$

Examples: I_2, $FeSO_4 . 7H_2O$, KNO_3

(iv) ***Trigonal or rhombohedral system:***
It has three axes of equal length. All angels are equal but more than 90° and less than 120°.

$a = b = c$

$\alpha = \beta = \gamma \neq 90°$

(Angels $> 90°, < 120°$)

Examples: KNO_3, $AgNO_3$, ice, Al_2O_3

(v) ***Hexagonal system:***
In this system, two axes are of equal length, but the third is different. Two angles are of 90° and third is of 120°.

$a = b \neq c$,

$\alpha = \beta = 90°$

$\gamma = 120°$

Examples: Graphite, quartz (SiO_2), Z_nO.

(vi) **Monoclinic system:**
It has all three axes of uncqual lengths. One of the axes is at right angle to the other two.

$a \neq b \neq c$

$\alpha = \gamma = 90°$

$\beta \neq 90°$

Examples:
Cane sugar, $CuSO_4 . 5H_2O$, sulphur

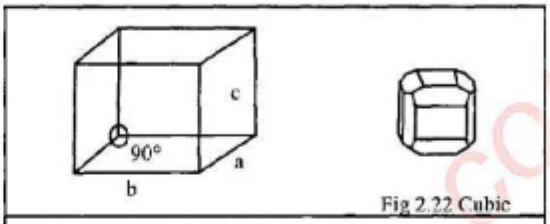


Fig 2.22 Cubic

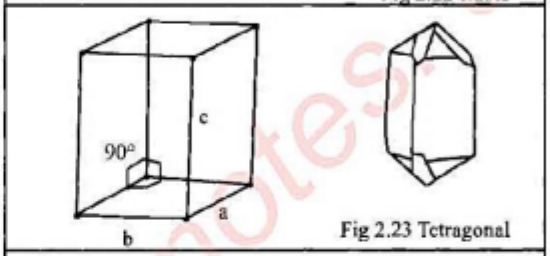


Fig 2.23 Tetragonal

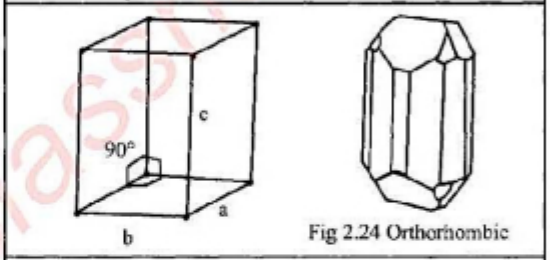


Fig 2.24 Orthorhombic

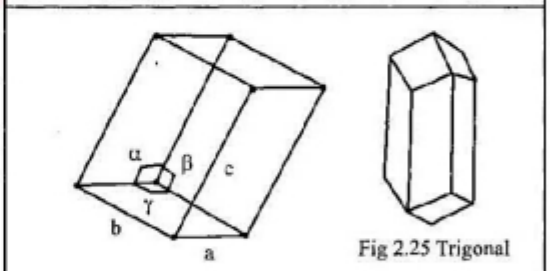


Fig 2.25 Trigonal

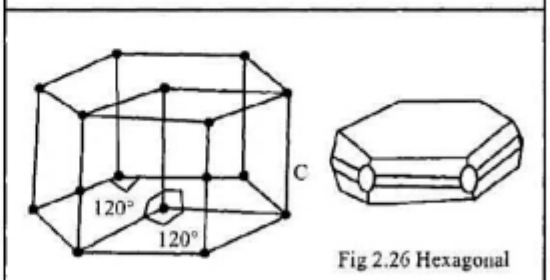


Fig 2.26 Hexagonal

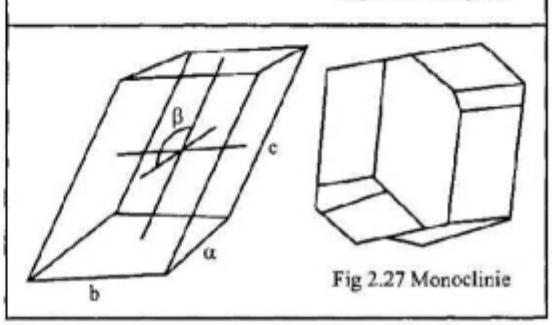


Fig 2.27 Monoclinie

(vii) ***Triclinic system:***
In this system all axes are at ... to each other and lengths and angles are also different.
Axes: $a \neq b \neq c$
Angles: $\alpha \neq \beta \neq \gamma \neq 90°$
Examples: $K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, H_3BO_3

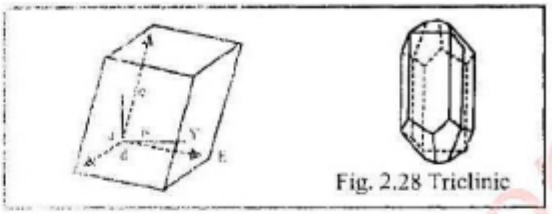


Fig. 2.28 Triclinic

Q.60 ***Explain the deformity in solids in terms of the kinetic molecular theory.***

Ans. ***Deformity:*** Solids are deformed or shattered by high pressure. This is because when ... particles are dislocated the force of attraction is so strong that the rearranged atoms are held equally well to their new neighbours as shown in Fig. 2.29

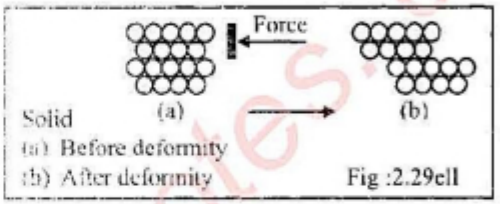


Fig :2.29ell

Q.61 ***What is change of state (melting or fusion)?***

Ans. When the crystalline solids are heated, their particles vibrate more vigorously and their kinetic energy also increases. Ultimately a point is reached when the vibration overcomes the attractive forces and thus particles became mobile. At this stage solid melts and changes into liquid.
Melting point: The temperature at which both liquid and solid state co-exist in equilibrium.
Crystalline solids have sharp melting points and can be identified from their definite melting point.

Q.62 ***Define the latent heat of fusion.*** ***Karachi Board: 2014***

Ans. ***Definition:*** It is the heat energy required to change 1 gram of a solid into liquid at its melting point.
Even though heat is being supplied during melting but temperature remains constant because all of the energy is used up by the molecules to overcome the intermolecular forces.
Latent heat of fusion of ice is ... joules/gm at 0°C.

Scientific Reasons

Q.01 ***A drop of ink spreads over blotting paper.*** ***Karachi Board: 2013, 2005***

Ans. A blotting paper consists of numerous pores acts like a small capillary tube. Ink is a liquid which has low surface tension. Due to capillary action drop, of ink spreads over blotting paper.

Q.02 ***The boiling point of water is greater than that of HF even though fluorine has greater electronegativity than oxygen.*** ***Karachi Board: 2013***

Ans. In water molecule there are two partially positive hydrogen atoms so chances of hydrogen bonding as compare to HF are higher due to three dimensions create high attraction among water molecules therefore high amount of energy is required.

Q.03 ***Ethyl alcohol (C_2H_5OH) has greater viscosity than Diethyl ether (C_2H_5-O-C_2H_5)***

Karachi Board: 2012 , 2018

Ans. Alcohol possess hydrogen bond between the molecules which attracts the molecules which increases viscosity. On the other hand, ether does not have hydrogen bonding or stronger intermolecular force.

Q.04 ***A freely falling drop of liquid is spherical.*** *Karachi Board: 2004, 2007, 2010, 2011, 2012*

Ans. Due to surface tension liquids try to contract to occupy the smallest surface area. As in a sphere ratio of surface to volume is smallest. Therefore a falling drop of liquid adopts shape of sphere due to surface tension.

Q.05 ***A liquid is less viscous at high temperature.*** *Karachi Board: 2011*

Ans. When the liquid is at a high temperature, the molecules of the liquid have more energy and spread further apart, and lesser resistance is offer, to their flow. Therefore viscosity of the liquid decreases with the increase in temperature.

Q.06 ***Pressure cooker is used for rapid cooking.*** *Karachi Board: 2011*

Ans. In pressure cookers, by increasing the external pressure the boiling point of water is increased to cook the food in less time.

Q.07 ***Evaporation is a cooling process.*** *Karachi Board: 2005-2011-2018-2019*

Ans. During evaporation, as the molecules possessing high kinetic energy leave from the surface of liquid. Average kinetic energy of the remaining molecules decreases. This causes to decrease the temperature of the liquid (cooling).

Q.08 ***The density of ice is less than that of water or ice floats in water.*** *Karachi Board: 2010*

Ans. It is due to the chemical bonds between the H_2O molecules are forced into being longer, expanding the water and forming a crystal (ice). When something at constant mass increases in volume, its density decreases. Thus,ice is less dense than water, causing it to float.

Q.09 ***On heating sublime substances like iodine and camphor, directly change from solid to gas.*** *Karachi Board: 2010*

Ans. On heating iodine and camphor directly converted into gases and no liquid state is appears in between this process because the intermolecular forces between the molecules in such types of solid is less than ordinary solids, therefore high energy molecules at solid surface overcame the attractive forces and directly converted into vapours.

Q.10 ***The liquids have capillary action or water rises in a capillary tube.*** *Karachi Board: 2009*

Ans. Liquids rise in a capillary tube, this effect is called capillary action. Capillary action of liquid is due to their surface tension. The surface area to volume ratio of a small bore capillary tube is much smaller than a container due to this liquid rises in a capillary tube.

Q.11 ***100 cm³ of O_2 and 100 cm³ of NH_3 contain the same number of molecules at S.T.P.***

Karachi Board: 2008

Ans. The relationship of volume and number of molecules was given by Avogadro. According to him "Equal volume of all gases at same temperature and pressure contains same number of molecules".

Q.12 ***The ratio of diffusion of CO_2 and C_xH_x gases are the same.*** *Karachi Board: 2008, 2016*

Ans. The rate of diffusion of both gases are same because of same molecular masses of the two gases. i.e., molecular mass of CO_2 = 44 a.m.u., molecular mass of C_xH_x = 44 a.m.u.

Q.13 ***$FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ are isomorphous or NaF and MgO isomorphous.***

Karachi Board: 2008, 2004

Ans. $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ are isomorphous substances because both compounds have same empirical formula ratio (1:1:4) and both have different physical and chemical properties.

Q.14 ***The boiling point of a liquid remains constant although heat is continuously supplied to the liquid.***

Karachi Board: 2008

Ans. The boiling point of a liquid remains constant although heat is continuously supplied because excess heat which is supplied is consumed to overcame the intermolecular forces and taken away by escaping vapours.

Q.15 ***Water expands when cooled below 4°C.*** *Karachi Board: 2007, 2015*

Ans. The arrangement of ice is an open structure and due to larger volume, when ice melts some of the hydrogen bonds are broken and the molecules pack more closely together so that water has higher density. This breaking down process is not complete until the temperature of 4°C is reached at which water has maximum density on this bases the anomalous behavior of water can be explained i.e. water contracts when heated from 0°C to 4°C and expands when cooled from 40° to 0°C.

Q.16 ***The process of diffusion occurs more rapidly in gases less rapidly in liquids and very slowly in solids.***

Karachi Board : 2005, 2011

Ans. The molecules of a gas are widely separated and there are large empty spaces due to which they are free to move. Due to this free movement the molecules of gases intermingle and spread out rapidly throughout the vessel. The freedom of liquid molecules permits diffusion to take place but the closeness of molecules and resulting large number of collisions cause diffusion less rapidly. There is no translational movement of molecules in solids, but nevertheless particles are vibrating at their mean positions. This vibrational motion is responsible for very slow diffusion in solids.

Q.17 ***Glycerine is distilled at a reduced pressure.*** *Karachi Board: 2005, 2017*

Ans. Glycerine has a strong intermolecular forces. The boiling point is 290°C at 760 torr, at this temperature glycerine is decomposed, therefore, glycerine is distilled under reduced pressure i.e. 50 torr and it boils at 210°C.

Q.18 ***It is easier to pour water than honey. Or Honey is more viscous than water.***

Ans. The resistance of liquids to flow is called viscosity. The size of honey molecule is larger and viscosity is greater, hence they resist flowing. Due to this reason, honey is more viscous than water or it is easier to pour water than honey.

Q.19 ***Steam produces more severe burns than boiling water.***

Ans. When water boils at 100°C it absorbs 40.7 k.j / mol heat energy and convert into steam at 100°C. It means steam contain more calories than boiling water. This is why steam produces severe burns than boiling water.

Q.20 ***At Mount Everest water boils at 71°C. Why?***

Ans. The boiling point is the temperature at which the vapour pressure is equal to the atmospheric pressure or some other external pressure. In mountain regions, the atmospheric pressure is below 760 torr. Therefore water boils at 71°C.

Q.21 ***Mercury forms convex meniscus while water forms concave meniscus.***

Karachi Board: 2013

Ans. In Hg cohesive forces are stronger than adhesive forces. Hence it forms convex meniscus.
In H_2O adhesive forces are greater than cohesive forces. Hence it forms concave meniscus.

Q.22 ***Surface tension of water is greater than that of ethyl alcohol.***

Ans. Surface tension depends upon intermolecular forces of attraction of a liquid. Surface tension of water is greater than ethyl alcohol because water possesses stronger intermolecular forces of attraction (hydrogen bonding) as compared to ethyl alcohol.

Q.23 ***The boiling point of a liquid remains constant although heat is continuously supplied to the liquid.***

Ans. When continuous heat is supplied to the liquid, its temperature does not rise further on reaching the boiling point of the liquid. The reason for this is that the heat which is constantly supplied is used up to convert the state of the liquid into the gaseous state (vapours). This supply of heat which is used up in changing the state of liquid, cannot be measured by the thermometer. This heat is known as latent heat of vapourization.

Q.24 ***Surface tension of water is greater than that of ethyl alcohol.*** *Karachi Board: 2015*

Ans. Surface tension depends upon intermolecular forces of attraction of a liquid. Surface tension of water is greater than ethyl alcohol because water possesses stronger intermolecular forces of attraction (hydrogen bonding) as compared to ethyl alcohol.

Q.25 ***State the relevant gas laws which explain the following observations of gases:***

(i) When a balloon filled with air is kept in cold place at constant pressure, its volume is reduced.

(ii) When the pressure on a gas kept in an airtight cylinder at constant temperature is doubled, its volume becomes half.

Karachi Board: 2017

Ans. ***When a balloon filled with air is kept in cold place at constant pressure, its volume is reduced.***

This is according to Charle's Law, which states that the volume os the given mass of the gas is directly proportional to the temperature.

$$V \propto T$$

So if temperature is reduced the volume is also reduced.

When the pressure on a gas kept in an airtight cylinder at constant temperature is doubled, its vlume becomes half.

This is according to Boyle's Law which states that the volume of the given mass of the gas is inversely proportional to the pressure.

Va

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

So if pressure is increased the volume is decreased.

Differences

Q.01 ***Differentiate between crystalline solid and amorphous solid.*** *Karachi Board: 2005, 2013, 2015*

S. No.	*Crystalline Solids*	*Amorphous Solid*
1.	They have specific geometric shape.	Their particles are arranged randomly.
2.	They have sharp melting points.	They do not have sharp melting points.
3.	They are symmetrical.	They are non-symmetrical.
4.	They have cleavage plane.	They do not have cleavage plane.
5.	They are anisotropic i.e they have different properties in different direction.	They are isotropic i.e they have same properties in all directions.

Q.02 ***Differentiate between isomorphism and polymorphism.*** *Karachi Board: 2011, 2016, 2018*

S. No.	*Isomorphism*	*Polymorphism*
1.	When two substance have same crystal structure, they are said to be isomorphous and phenomenon is called isomorphism.	The substance which can exist in more than one crystalline form is called polymorphous and this property is called polymorphism.
2.	Isomorphic substances have different physical and chemical properties.	Polymorphic substances have similar physical and chemical properties.
3.	Isomorphic substances show property of over growth.	Polymorphous substances do not show property of over growth.
4.	**For example:** NaF and MgO both have cubic crystals.	**For example:** $CaCO_3$ exists in two crystalline form: (i) calcite, trigonal. (ii) arogonite, orthorhombic

Q.03 ***Differentiate between ideal gases and real gases.***

S. No.	*Ideal gases*	*Real gases*
1.	Gases which obey gas laws at all temperature and pressure are called ideal gases	Gases which obey gas laws at high temperature and low pressure are called real gases.
2.	These are non-existant gases.	These are real gases.
3.	The actual volume of gas molecules is negligible as compared to volume of vessel at all temperature and pressure.	The actual volume of gas molecules is negligible as compared to volume of vessel at high temperatures and low pressures.
4.	They obey general gas equation at all temperatures and pressures.	They obey general gas equations at high temperature and low pressure.

Solved Problems of Textbook

Behaviour of Gases

Problem 1: ***What is the pressure in torr of 3.5 atm?***

Solution :

$$1 \text{ atm} = 760 \text{ torr}$$

$$3.5 \text{ atm} = \frac{760 \text{ torr} \times 3.5 \text{atm}}{1 \text{ atm}} = 2660 \text{ torr}$$ **Ans.**

Problem 2: ***How many atmospheres correspond to 950 torr?***

Solution :

760 torr = 1atm

$$950 \text{ torr} = \frac{1 \text{ atm} \times 950 \text{ torr}}{760 \text{ torr}} = 1.25 \text{ atm}$$ **Ans.**

Gas Laws

Problem 3: ***What volume does 400cm³ sample of a gas at 700 torr occupy when the pressure is changed to 2 atm?***

Solution :

Data:

$V_1 = 400 \text{ cm}^3$

$P_1 = 700 \text{ torr} = \frac{700}{760} = 0.92 \text{ atm}$

$P_2 = 2 \text{ atm}$

$V_2 = ?$

According to the Boyle's law

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{0.92 \text{ atm} \times 400 \text{ cm}^3}{2 \text{ atm}}$$

Volume $= V_2 =$ **184 cm³** **Ans.**

Problem 4: ***A child's balloon has a volume of 3.80 dm³ when the temperature is 35°C. What is the volume if the balloon is put into a refrigerator and cooled to 5°C? Assume that pressure inside the balloon is equal to atmospheric pressure at all times.***

Solution:

Data:

$V_1 = 3.80 \text{ dm}^3$

$T_1 = 35°C = 35 + 273 = 308 \text{ K}$

$V_2 = ?$

$T_2 = 5°C = 5 + 273 = 278 \text{ K}$

According to Charles's Law:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_2 = \frac{V_1T_2}{T_1} = \frac{3.8 \text{ dm}^3 \times 278 \text{ K}}{308 \text{ K}} = 3.42 \text{ dm}^3$$

Volume $= V_2 =$ **3.42 dm³** **Ans.**

Problem 5: ***What will be the volume occupied by 14 g of nitrogen at 20°C and 740 torr pressure?***

Solution:

Data:

$P = 740 \text{ torr} = \frac{740}{760} = 0.974 \text{ atm}$

$V = ?$

$n = \frac{\text{given mass}}{\text{molar mass}} = \frac{14\text{g}}{28\text{g}} = 0.5 \text{ mole}$

$R = 0.0821 \text{ dm}^3 \text{ - atm } K^{-1} \text{ mole}^{-1}$

$T = 20°C = 20 + 273 = 293 \text{ K}$

$PV = nRT$

$V = \frac{nRT}{P}$

$V = \frac{0.5 \times 0.0821 \times 293}{0.974}$

$V = \mathbf{12.345 \text{ dm}^3}$ **Ans.**

Problem 6: ***A certain mass of nitrogen gas at 20°C and at 740 torr pressure occupies 12.345 dm³. Calculate the volume that it will occupy at S.T.P.***

Solution:

$V_1 = 12.345 \text{ dm}^3$

$V_2 = ?$

$P_1 = 740 \text{ torr}$

$P_2 = 760 \text{ torr}$

$T_1 = 20°C = 20 + 273 = 239 \text{ K}$

$T_2 = 273 \text{ K}$

We know that

$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1}$

$V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$

$= \frac{740 \text{ torr} \times 12.345 \text{ dm}^3}{293 \text{ K}} \times \frac{273 \text{ K}}{760 \text{ torr}}$

$= 11.12 \text{ dm}^3$ **Ans.**

Problem 7: ***Calculate the volume that will be occupied by 0.8 moles of oxygen gas taken at 30°C and at 800 torr of Hg pressure?***

Solution:

$V = ?$
$n = 0.8$ mole
$R = 0.0821\ dm^3\ atm / k\ mole$
$T = 30°C = 30 + 273 = 303\ K$
$P = \frac{800\ torr}{760\ torr} = 1.053\ atm$
$PV = nRT$
$V = \frac{nRT}{P}$
$V = \frac{0.8 \times 0.0821 \times 303}{1.053}$
$V = \mathbf{18.899\ dm^3}$ **Ans.**

Graham's Law of Diffusion

Problem 8: ***The ratio of the rates of diffusion of two gases A and B is 1.5:1. If the relative molecular mass of gas A is 16, find out the relative molecular mass of gas B.***

Solution:

$r_A = 1.5$ $\quad r_B = 1$
$M_A = 16$ $\quad M_B = ?$

According to Graham's law:

$$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$$

$$\frac{1.5}{1} = \sqrt{\frac{M_B}{16}}$$

By talking square of both sides:

$$\left(\frac{1.5}{1}\right)^2 = \left(\sqrt{\frac{M_B}{16}}\right)^2$$

$M_B = (1.5)^2 \times 16$
$M_B = 2.25 \times 16 = 36$
Molecular mass of gas B $= 36$ **Ans.**

Problem 9: ***Compare the rates of helium and sulphur dioxide.***

Solution:

The molecular masses of helium and sulphur dioxide are 4 and 64 respectively. Hence,

$$\frac{r_{He}}{r_{SO_2}} = \sqrt{\frac{M_{SO_2}}{M_{He}}} = \sqrt{\frac{64}{4}} = \frac{8}{2} = 4$$

Helium diffuses four times as fast as SO_2.

Dalton's Law of Partial Pressure

Problem 10: ***In the preparation of oxygen in the laboratory, 500 cm³ of the moist gas was collected over water at 25°C and 724 torr. What volume of dry oxygen at S.T.P. was produced?***
(Pressure of water vapours at 25°C = 24 torr)

Solution:

$V_1 = 500\ cm^3$ $T_1 = 25°C = 25 + 273 = 298\ K$
$V_2 = ?$ $T_2 = 273\ K$ $P_2 = 760\ torr$

Pressure of dry O_2 is calculated by using Dalton's law:

$$P_{dry\ oxygen} = P_{moist\ gas} - P_{water}$$
$$= 724\ torr - 24\ torr$$
$$= 700\ torr$$

Now calculate the volume of dry gas at S.T.P.:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \text{ (Gas equation)}$$
$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$
$$= \frac{700\ torr \times 500\ cm^3 \times 273\ K}{760\ torr \times 298\ k}$$
$$= \mathbf{421.9\ cm^3} \qquad \textbf{Ans.}$$

Problem 11: ***A mixture of gases at 760 torr contains 2 moles nitrogen and 4 moles carbon dioxide. What is the partial pressure of each gas in torr?***

Solution:

Total moles (n) = 6 moles total pressure = 760 torr

$$P_{gas} = \frac{P_{(total)} \times n_{(gas)}}{n_{(total)}}$$
$$P_{N_2} = \frac{760\ torr \times 2\ mol}{6\ mol} = 253.33\ torr$$
$$P_{CO_2} = \frac{760\ torr \times 4\ mol}{6\ mol} = 506.67\ torr$$

Check: Total pressure = sum of partial pressure = 760 torr

Solved Problems From Past Papers

Problem 1: *At 30°C, 500cm³ of H_2 at 400 torr pressure and another 1 dm³ of N_2 at 600 torr pressure are transferred into a 1500 cm³ flask. Calculate the total pressure of the mixture of gases.*

Karachi Board: 2013-2019

Solution:

Initial pressure of H_2 gas = P_1 = 400 torr
Final pressure of H_2 gas = P_2 = ?
Initial volume of H_2 gas = V_1 = 500 cm³ = $\frac{500}{1000}$ = 0.5 dm³

Final volume of H_2 gas = V_2 = 1500 cm³ = $\frac{1500}{1000}$ = 1.5 dm³
Initial pressure of N_2 gas = P_1 = 600 torr
Final pressure of N_2 gas = P_2 = ?
Initial volume of N_2 gas = V_1 = 1 dm³

Final volume of N_2 gas = $V_2 = \frac{1500}{1000}$ = 1.5 dm³

For H_2 gas:

$P_1 V_1 = P_2 V_2$

$P_2 = \frac{P_1 V_1}{V_2}$

$P_2 = \frac{400 \times 0.5}{1.5} = 133.33$

Pressure of H_2 = 133.3 torr

$P_{(total)} = P_{(hydrogen)} + P_{(nitrogen)}$
$= 133.33 + 400$
$P_{(total)}$ = **533.33 torr** **Ans.**

Problem 2: *1.40 dm³ volume of a gas collected at a temperature of 27°C and pressure of 900 torr was found to have a mass 2.273g. Calculate the molecular mass of the gas.*

Karachi Board: 2012

Solution:

V = 140 dm³
mass = m = 2.273g
P = 900 torr = $\frac{900}{760}$ = 1.184 atm

PV = nRT

PV = $\frac{\text{Mass}}{\text{Molecular mass}}$ × RT

molecular mass = $\frac{\text{Mass} \times RT}{PV}$

= $\frac{2.273 \times 0.0821 \times 298}{1.184 \times 1.40}$ = 33.88 a.m.u.

molecular mass = 33.88 a.m.u. **Ans.**

Problem 3: ***At certain temperature and pressure NH_3 diffuses 1.48 times more than HCl. If the density of NH_3 is 0.66g / litre. Find the density of HCl.***

Karachi Board: 2010

Solution:

Density of NH_3 = 0.66 gm / lit
Density of HCl = ?
Rate of diffusion = 1.48

$$\frac{r_{NH_3}}{r_{HCl}} = \sqrt{\frac{d_{HCl}}{d_{NH_3}}}$$

$$1.48 = \sqrt{\frac{d_{HCl}}{0.66}}$$

Taking square on both sides:

$$(1.48)^2 = \left(\sqrt{\frac{d_{HCl}}{0.66}}\right)^2$$

$$2.19 = \frac{d_{HCl}}{0.66}$$

$$d_{HCl} = 2.19 \times 0.66$$

$$d_{HCl} = \textbf{1.44 gm/lit} \qquad \textbf{Ans.}$$

Problem 4: ***Helium takes 5 seconds to effuse from a hole of 10 dm^3 container. How long would it take for oxygen to effuse from the same container at the same temperature and pressure?***

Karachi Board: 2009

Solution:

$r_{He} = \frac{1}{5}$

t_o = ?

$r_o = \frac{1}{t_o}$

$M_{O_2} = 16$

$M_{He} = 4$

$$\frac{r_{He}}{r_o} = \sqrt{\frac{M_{O_2}}{M_{He}}}$$

$$\frac{1/5}{1/t_o} = \sqrt{\frac{32}{4}}$$

$$\frac{1/5}{1/t_o} = \sqrt{8}$$

$$\frac{t_o}{5} = 2.82$$

$$t_o = 5 \times 2.82 = 14.1 \text{ sec} = 14.1 \text{ sec}$$

Problem 5: ***Calculate the value of R when the pressure is expressed in atmosphere and volume in dm^3.***

Karachi Board: 2009

Solution:

For answer see Q 21 on page 56.

Problem 6: *A 500 cm^3 vessel contains 2 gm of He and 8 gm of CH_4. What is the total pressure of the mixture of these gases at -3°C.*

Karachi Board: 2008

Solution:

Volume of vessel = V = 500 cm^3 = 0.5 dm^3

Mass of He = m_H = 2 gm

No. of moles of He = n = $\frac{2}{4}$ = 0.5 moles

Mass of CH_4 = 8 gm

No. of moles of CH_4 = $\frac{8}{16}$ = 0.5 moles

Total no. of moles = 0.5 + 0.5 = 1 mole

R = 0.0821 atm. dm^3. mol^{-1}. K^{-1}

Pressure = P = ?

Temperature = T = -3°C = -3 + 273 = 270 K

Formula: $PV = nRT$

$$P = \frac{nRT}{V}$$

$$P = \frac{1 \times 0.0821 \times 270}{0.5}$$

$$P = \mathbf{44.334\ atm}$$ **Ans.**

Problem 7: *100 gram of KNO_3 are heated to redness. What volume of oxygen at 39°C and 765mm pressure will evolve?*

Karachi Board: 2006, 2018

Solution:

Mass of KNO_3 = 100 gm

Pressure = 765 mm = $\frac{765}{760}$ = 1.0065 atm

Volume = V = ?

$$2KNO_3 \longrightarrow 2KNO_2 + O_2$$

202gm 32gm

202 gm of KNO_3 gives 32 gm of O_2

1 gm of KNO_3 gives $\frac{32}{202}$ gm of O_2

100 gm of KNO_3 give $\frac{32 \times 100}{202}$ = 15.84 gm

Moles of O_2 = $\frac{15.84}{32}$ = 0.495 moles

Formula: $PV = nRT$

$$V = \frac{nRT}{P} = \frac{0.495 \times 0.0821 \times 312}{1.0065}$$

$$V = 12.59\ dm^3$$ **Ans.**

Problem 8: ***What will be the volume occupied by 14 gm of nitrogen at 20°C and 740 torr pressure?***

Solution: ***Karachi Board: 2005***

Temperature = T = 20°C = 20 + 273 = 293 K
Volume of nitrogen = ?
Mass of nitrogen = 28 gm

$$\text{No. of moles} = \frac{14}{28} = 0.5 \text{ moles}$$

$R = 0.0821 \text{ atm. dm}^3\text{. mole}^{-1}\text{. K}^{-1}$

$$P = 740 \text{ torr} = \frac{740}{760} = 0.97 \text{ atm}$$

Formula: $PV = nRT$

$$V = \frac{nRT}{P} = \frac{0.5 \times 0.0821 \times 293}{0.97} = 12.39 \text{ dm}^3$$

$V = \mathbf{12.39\ dm^3}$ **Ans.**

Problem 9: ***What is the density of the methane (CH_4) gas at 127°C and 3.5 atmosphere?***

Solution: ***Karachi Board: 2004***

d = ?
Molecular mass of CH_4 = 16 gm
Pressure = P = 3.50 atm
T = 127°C = 127 + 273 = 400 K
R = 0.0821 atm. dm^3 mol^{-1}. K^{-1}
PV = nRT

$$PV = \frac{m}{M} RT$$

$$PM = \frac{m}{V} RT \qquad \left[\text{As we know, } n = \frac{m}{M}\right]$$

$$P \times M = d \times R \times T \qquad \left[\text{We know that, } d = \frac{m}{V}\right]$$

$$d = \frac{P \times M}{R \times T}$$

$$d = \frac{3.5 \times 16}{0.0821 \times 400} = \frac{56}{32.84} = 1.70$$

Density of CH_4 = 1.70 gm / dm^3 **Ans.**

Problem 10: *Name the crystal system which has the following axes and angles:*

(i)	$a = b = c$,	$\alpha = \beta = \gamma = 90°$
(ii)	$a = b \neq c$,	$\alpha = \beta = \gamma = 90°$
(iii)	$a \neq b \neq c$,	$\alpha = \beta = \gamma = 90°$
(iv)	$a = b \neq c$,	$\alpha = \beta = 90°$, $\gamma = 120°$

Answer: ***Karachi Board: 2009***

(i) Cubic system
(ii) Tetragonal system
(iii) Orthorhombic system
(iv) Hexagonal system

Problem 11: *The density of a certain gas is 1.43 gram / dm^3 at 608 torr and 27°C. Find the molecular mass of the gas.*

Solution: ***Karachi Board: 2014***

Data:

Mass of gas = m = 1.43 gm
Volume of gas = V = 1 dm^3
Temperature = T = 27°C = 27 + 273 = 300 K

Pressure = P = 608 torr = $\frac{608}{760}$ = 0.8 atm

Gas constant = R = 0.0821 atm.dm^3/mole.K
Molecular mass = ?

We know that:

$PV = nRT$ and molecular mass = $\frac{m}{n}$

$n = \frac{PV}{RT} = \frac{(0.8)(1)}{(0.0821)(300)} = \frac{0.8}{24.63} = 0.032$ moles

Molecular mass = $\frac{m}{n} = \frac{1.43}{0.032} = 44.68$ a.m.u. **Ans.**

Problem 12: *The empirical formula of compound is CO_2H. 1.8 g of this compound in gaseous state occupies 446 cm^3 at S.T.P. Find its molecular formula.*

Solution: ***Karachi Board: 2015***

Data:

Empirical formula = CO_2H
Empirical formula mass = $12 + 16 \times 2 + 1 = 12 + 32 + 1 = 45$ a.m.u.
Mass of compound = 1.8g
Volume = 448 cm^3 = 0.448 dm^3
Pressure = 1 atm
Temperature = 273 K
Molecular formula = ?
$PV = nRT$

$PV = nRT$ and molecular mass $= \frac{m}{n}$

$PV = \frac{m}{N} RT$

$M = \frac{mRT}{PV}$

$M = \frac{(1.8)(0.0821)(273)}{(1)(0.448)} = 90$ a.m.u.

$n = \frac{90}{45} = 2$

Molecular formula = $(\text{Empirical formula})_n$
Molecular formula = $(CO_2H)_2$
Molecular formula = $C_2O_4H_2$ **Ans.**

Problem 13: *A gaseous mixture contains 0.2 mole of O_2 and 0.3 mole of CO_2. If the partial pressure of oxygen is 60 torr, calculate the partial pressure of CO_2.*

Solution: ***Karachi Board: 2015***

Data:

moles of O_2 = n_{O_2} = 0.2 moles
moles of CO_2 = n_{CO_2} = 0.3 moles
Total moles = n_T = 0.2 + 0.3 = 0.5 moles
P_{O_2} = 60 torr
P_{CO_2} = ?
P_T = ?

$$P_T = \frac{P_{O_2} \times n_T}{n_{O_2}} = \frac{60 \times 0.5}{0.2}$$

P_T = 150 torr **Ans.**

$$P_{CO_2} = \frac{P_T \times n_{CO_2}}{n_T} = \frac{150 \times 0.3}{0.5} = \frac{45}{0.5}$$

P_{CO_2} = 90 torr **Ans.**

Problem 14: *H_2 gas effuses from a 10 dm^3 vessel in 10 sec. Calculate the time for effusion of O_2 gas from 20 dm^3 vessel.*

Solution: ***Karachi Board: 2015***

Data:

V_{H_2} = 10 dm^3
t_{H_2} = 10 sec
V_{O_2} = 20 dm^3
t_{O_2} = ?

$$\frac{t_{O_2}}{t_{H_2}} = \frac{\sqrt{D_2}}{\sqrt{D_1}}$$

We know that, $D = \frac{M}{V}$, therefore

$$\frac{t_{O_2}}{t_{H_2}} = \frac{\frac{\sqrt{M_{O_2}}}{\sqrt{V_{O_2}}}}{\frac{\sqrt{M_{H_2}}}{\sqrt{V_{H_2}}}} = \frac{\sqrt{M_{O_2} \times V_{H_2}}}{\sqrt{M_{H_2} \times V_{O_2}}} = \frac{\sqrt{32 \times 10}}{\sqrt{2 \times 20}}$$

$$\frac{t_{O_2}}{10} = \frac{\sqrt{320}}{\sqrt{40}} = \frac{17.89}{6.32} = 2.83$$

$$t_{O_2} = (2.83)\ (10) = 28.3 \text{ sec} \quad \textbf{Ans.}$$

Problem 15: ***1100 ml of CO_2 at a pressure of 500 torr, 1500 ml N_2 at a pressure of 400 torr and 800 ml of O_2 at a pressure of 600 torr are placed together in a container of 1000 ml capacity. Find the partial pressure of each gas.*** ***Karachi Board: 2016***

Solution:

For CO_2 gas

$P_1 = 500$ torr
$V_1 = 1100$ ml
$P_2 = ?$
$V_2 = 1000$ ml
We know that:
$P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$P_2 = \frac{(500)\ (1100)}{1000}$$

$P_2 = 550$ torr

For N_2 gas

$P_1 = 400$ torr
$V_1 = 1500$ ml
$P_2 = ?$
$V_2 = 1000$ ml
We know that:
$P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$P_2 = \frac{(400)\ (1500)}{1000}$$

$P_2 = 600$ torr

For O_2 gas

$P_1 = 600$ torr
$V_1 = 800$ ml
$P_2 = ?$
$V_2 = 1000$ ml
We know that:
$P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$P_2 = \frac{(600)\ (800)}{1000}$$

$P_2 = 480$ torr

Problem 16: ***If 16 ml of hydrogen diffuse in 30 sec, what volume of SO_2 will diffuse in the same time (30 sec.) under similar conditions?***

Solution: ***Karachi Board: 2016***

Data:

For hydrogen gas
$t_{H_2} = 30$ sec.
$M_{H_2} = 2$ a.m.u.
$V_{H_2} = 16$ ml

For SO_2 gas
$t_{SO_2} = 30$ sec.
$M_{SO_2} = 64$ a.m.u.
$V_{SO_2} = ?$

We know that:

$$\frac{\sqrt{M_{SO_2}}}{\sqrt{M_{H_2}}} = \frac{\frac{V_{H_2}}{t_{H_2}}}{\frac{V_{SO_2}}{t_{SO_2}}}$$

$$\frac{\sqrt{64}}{\sqrt{2}} = \frac{\frac{16}{30}}{\frac{V_{SO_2}}{30}}$$

$$5.65 = \frac{0.533}{\frac{V_{SO_2}}{30}}$$

$$V_{SO_2} = \frac{(0.533)(30)}{5.65}$$

$$V_{SO_2} = 2.85 \text{ ml}$$ **Ans.**

Problem 17: ***A gaseous mixture of H_2 and O_2 at 60°C and total pressure of 2.5 atmospheres contains 75 mole %H_2. What are the partial pressures of both the gases in the mixture?***

Solution: *Karachi Board: 2017*

Data:

mole of H_2 = 75 mole = n_{H_2}
mole of O_2 = 25 mole = n_{O_2}
Total no. of moles = 100 = n_t
P_{H_2} = ?
P_{O_2} = ?
P_t = 2.5 atm

$$\frac{P_{H_2}}{P_t} = \frac{n_{H_2}}{n_t}$$

$$P_{H_2} = \frac{n_{H_2} \times P_t}{n_t} = \frac{75 \times 2.5}{100}$$

$$\boxed{P_{H_2} = 1.875 \text{ atm}}$$

$$P_{O_2} = \frac{n_{O_2} \times P_t}{n_t} = \frac{25 \times 2.5}{100} \quad \boxed{P_{O_2} = 0.625 \text{ atm}}$$

Solution of Textbook Progress Test - 2

Q.1 ***In terms of the atoms, ions and molecules that comprise substances, why are some materials solid, some liquids and still others are gases at 25°C.***

Solution:

The states of matter depend upon the arrangement of particles (atoms, ions and molecules).

- A substance is in solid state if their particles are arranged in closely packed (fixed) pattern in three dimension.
- If particles of a substance have stronger forces of attraction than gases but less than solid then they are able to move in a limited area. The matter will be a liquid.
- If the forces of attraction between the particles are very weak, then particles are far a part from each other and free to move in random manner and the matter is in gaseous state.

Q.2 ***The process of diffusion occurs most rapidly in gases less rapidly in liquids and very slowly in solid. Why?***

Solution:

See Q 16 (Scientific Reasons) on page 74.

Q.3 ***Why does water spilled on a floor evaporate more rapidly than the same amount of water in a glass?***

Solution:

Process of evaporation depends upon the surface area of a liquid. Greater the surface area of a liquid, the greater will be the evaporation. Water spilled on floor has greater surface area than water in the glass therefore water spilled on the floor evaporates more rapidly.

Q.4 ***Would a pressure cooker be of any value on the Mount Everest?***

Solution:

Yes. In mountain regions the boiling point of water will be below 100°C and atmospheric pressure is also below 760 torr. Food takes longer time to cook because of low boiling point. Hence to cook food earlier they use pressure cooker.

Q.5 ***No liquid ionic compounds are known but many of the known covalent compounds are liquids and some are gases. Account for these differences.***

Solution:

Ionic compounds are solids at room temperature because the ions are arranged in three dimensional patterns with strong attractive forces between oppositely charged ions. To break these electrostatic forces, very large amount of energy would be required. Hence ionic compounds are solid at room temperature.

In case of covalent compounds, their particles are attracted by weak Vander Waal's forces. Due to these weak forces the particles are loosely held with each other, Therefore many covalent compounds are liquids and some are gases.

Q.6 ***What is kinetic theory and how does it account for the following properties of gases, liquids and solids?***

(i) Diffusibility (ii) Compression (iii) Evaporation

Solution:

See Q 10 on page 53, Q 32 on page 62 and Q 43 on page 65.

Q.7 ***1.40dm³ volume of a gas measured at a temperature 27°C and a pressure of 900 torr was found to have mass 2.273g. Calculate the molecular mass of the gas.***

Solution:

See Q 2 (Important Problems) on page 82.

Q.8 ***A 12.5 dm³ vessel contains 4.0 g CH_4, 1.8g N_2 and 10.0g Xe. What is the pressure in the vessel at 0°C?***

Solution:

It can be solved according to the pattern of Q 6 (Important Problems) on page 84.

Q.9 ***(a) State and explain the Graham's law of Diffusion.***

Solution:

See Q 23 (Short / Detailed Question and Answer) on page 59.

(b) Compare the rates of diffusion of the following pairs of gases.
(i) H_2 and D_2 (ii) CH_4 and He (iii) SF_6 and SO_2

Solution:

(i) **H_2 and D_2:**

According to Graham's law of diffusion: $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

where r_1 = rate of diffusion of H_2; r_2 = rate of diffusion of D_2
M_1 = Molecular wt. of H_2 = 2 g; M_2 = Molecular wt. of D_2 = 4g

Thus, $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{4}{2}} = \sqrt{2} = \sqrt{1.4}$

The rate of diffusion of H_2 and D_2 is in the rate of 1.4:1.

(ii) **CH_4 and He**

where r_1 = rate of diffusion of He
r_2 = rate of diffusion of CH_4
M_1 = molecular weight of He = 4g
M_2 = molecular weight of CH_4 = 16g

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{16}{4}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$

The rate of diffusion of CH_4 and He is in the rate of 2:1 (2/1).

(iii) **SF_6 and SO_2**

where r_1 = rate of diffusion of SO_2
r_2 = rate of diffusion of SF_6
M_1 = molecular weight of SO_2 = 64 g
M_2 = molecular weight of Sf_6 = 146 g

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{146}{64}} = \sqrt{\frac{2.28}{1}} = \frac{1.51}{1}$

The rate of diffusion of CH_4 and He is in the rate of 1.51:1 (1.51/1).

Q.10 ***State the following gas laws and explain in terms of kinetic theory:***
(a) Boyle's law (b) Dalton's law of partial pressure (c) Charle's law

Solution:

See Q 12 on page 54, Q 16 on page 56, Q 17 on page 56 and Q 24 on page 60.

Q.11 ***Define the following:***
(i) Melting point (ii) Boiling pont (iii) Diffusion (iv) Latent heat of fusion

Solution:

See Q 23 on page 59, Q 44 on page 65, Q 61 and Q 62 on page 72.

Q.12 ***Four containers of equal volume are filled as follows:***
(i) 2 gm H_2 at 0°C (ii) 1.0gm of H_2 at 273°C (iii) 24 gm O_2 at 0°C
(iv) 16 g CH_4 at 273°C
Which container (a) is at the greatest pressure (b) is at the lowest pressure.

Solution:

Apply the formula: $PV = nRT$

Suppose, volume of container $= 1\ dm^3$

(i) 2 gm of H_2 at 0°C

No of moles of $H_2 = \frac{2}{2} = 1$ mole; $P = ?$

$T = 0°C = 0 + 273 = 273\ K$ $R = 0.0821\ atm.\ dm^3\ .\ mole^{-1}.\ K^{-1}$

$P = \frac{nRT}{V}$

$P = \frac{1 \times 0.0821 \times 273}{1} = 22.4\ atm$ ---------- (i)

(ii) 42 gm of N_2 at 273°C

No. of moles of $N_2 = \frac{42}{28} = 1.5$ mole; $T = 273°C = 273 + 273 = 546\ K$

$P = ?$ $V = 1\ dm_3$

$R = 0.0821\ atm.\ dm^3\ ;\ mole^{-1}.\ K^{-1}$

$P = \frac{nRT}{V}$ or $P = \frac{1.5 \times 0.0821 \times 546}{1} = 67.2\ atm$ ---------- (ii)

(iii) 24 gm of O_2 at 0°C

No. of moles of $O_2 = \frac{24}{32} = 0.75$ moles; $V = 1\ dm^3$; $P = ?$

$R = 0.0821\ atm.\ dm^3\ ;\ mole^{-1}.\ K^{-1}$ $T = 0°C = 0 + 273 = 273K$

$P = \frac{nRT}{V} = \frac{0.750 \times 0.0821 \times 273}{1} = 16.8\ atm$

$P = 16.8\ atm$ ---------- (iii)

(iv) 32 gm of CH_4 at 273°C

No. of moles of $CH_4 = \frac{32}{16} = 2$ moles $V = 1\ dm^3$ $P = ?$

$R = 0.0821\ atm.\ dm^3\ .\ mole^{-1}\ .\ K^{-1}$ $T = 273 + 273 = 546\ K,$

$P = \frac{nRT}{V} = \frac{2 \times 0.0821 \times 546}{1} = 89.65\ atm$

$P = 89.65\ atm$ ---------- (iv)

Result: Thus,

(a) greatest pressure is in container ***(iv)*** = 89.65 atm

(b) lowest pressure is in container ***(iii)*** = 16.8 atm.

Q.13 ***Explain the relationship between intermolecular attraction and the kinetic energy of molecules in determining the physical state of a substance.***

Answer:

Solid: Molecules are arranged very close to each other so they are hard. The molecules, atoms and ions of solids keep vibrating on their mean position, so they have a fixed shape and a fixed volume. Their kinetic energy is the lowest than the liquids and gases.

Liquid: Molecules move randomly in all direction but they possess a cohesive force as they are not very far from one another. So liquids do not have fixed shapes but they have fixed volume.

Gas: Molecules are very far from one another, so they do not have significant cohesive forces. The molecules are widely separated, so they do not have any fixed shape and volume, so they can occupy all the available space.

The gas molecules move randomly very fast, they have the highest kinetic energy as compared to solids and liquids.

Q.14 ***Describe gases, liquid and solids on a molecular basis and explain their behaviour and change of state.***

Answer:

Behaviour of all gases is similar to each other. Gases are made up of molecules, which are far apart from each other. Space between them are very large as compared to the size of molecules. The pressure of a gas is the result of the collision between molecules and the walls of container. On cooling or applying pressure gases convert their state.

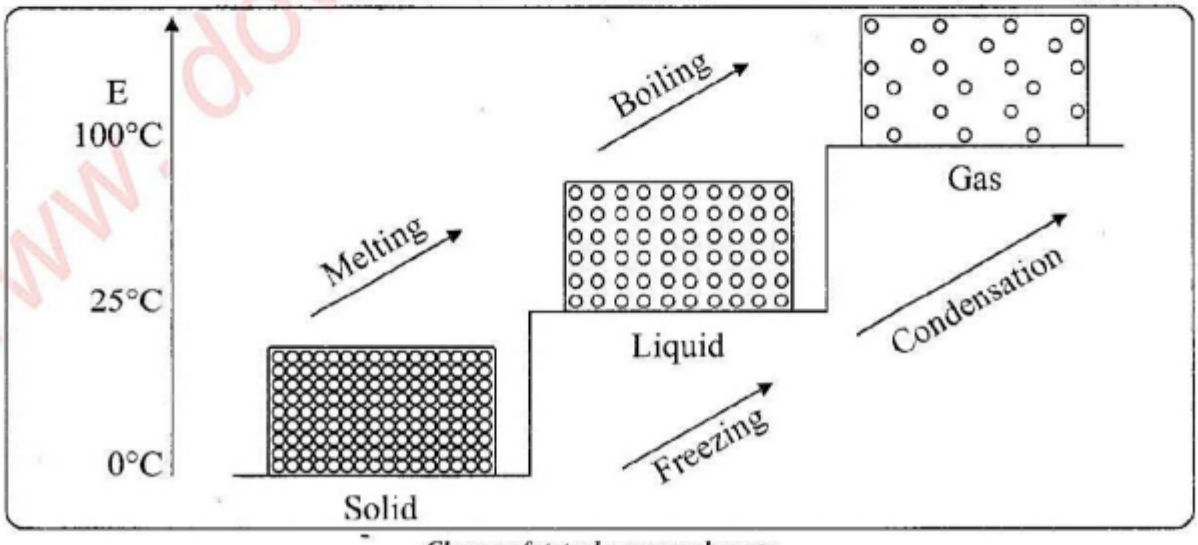
Particles of liquid are randomly arranged. They consists of clusters in which they are closer to each other. Because of this liquid has fixed volume. The particles in a liquid are fairly free to move. On cooling, they become solid and on heating change to gas.

The particles in a solid are closely packed due to strong attractive forces between them. The molecules are unable to move freely. They have definite shape because the molecules are arranged in a fixed pattern. Solids are liquefied at definite temperature called melting point.

Q.15 ***Co-relate the energy changes accompanying changes of state.***

Answer:

Change of states can be well explained by the following diagram by energy change.



Change of states by energy changes

Q.16 ***Explain in terms of kinetic molecular model:***

(a) Why liquids and solids cannot be compressed as gases can?

(b) Why solids do not flow as liquids and gas do?

(c) Why food is cooked more quickly in a pressure cooker than in a covered pot?

Answer:

(a) Liquids and solids can not be compressed like gases because in solids, molecules are closely packed and intermolecular spaces in solids are much smaller than in liquids and gases, therefore, they can not be compressed like liquids and gases.

(b) Solids do not flow like liquids and gases because intermolecular forces holding solid molecules together are much stronger than liquids and gases, so solid molecules do not move freely like liquids and gases.

(c) See Q 6 (scientific reasons) on page 73.

Q.17 ***Explain:***

(i) Viscosity (ii) Surface tention (iii) Vapour pressure

Answer:

See Q 33 and Q 36 on Page 63 and Q 42 on page 65.

Q.18 ***(a) What are crystalline and amporhous solids?***

(b) Explain different crystal system.

Answer:

See Q 48 on page 67 and Q 59 on page 70.

Q.19 ***State and explain Avogadro's law. How does it help in determining relative molecular mass?***

Answer:

See Q 19 (From short/detailed Q/A) on page 57.

Avogadro's number is one of the fundamental constants of chemistry. It permits calculation of the amount of pure substance (mole), the basis of stoichiometric relationships. It also makes possible determination of how much heavier a simple molecule of one gas is than that of another, as a result the relative molecular weights of gases can be ascertained by comparing the weights of equal volumes.

Q.20 ***What are solids? Describe atomic, ionic and molecular solids).***

Answer:

See Q 46 on page 66, Q 51 on page 67, Q 52 on page 68 and Q 54 on page 69.

Q.21 ***Explain the following:***

Answer:

(i) A falling drop of a liquid is spherical

Ans: See Q 4 (Scientific Reasons) on page 73.

(ii) A drop of ink spreads on a blotting paper.
Ans: See Q 1 (Scientific Reasons) on page 72.

(iii) Evaporation is a cooling process.
Ans: See Q 7 (Scientific Reasons) on page 73.

(iv) Boiling point of a liquid remains constant although heat is continuously supplied to the liquid.
Ans: See Q 14 (Scientific Reasons) on page 74.

(v) Honey is more viscous than water.
Ans: See Q 18 (Scientific Reasons) on page 75.

(vi) Mercury has its meniscus upward.
Ans: See Q 21 (Scientific Reasons) on page 75.

Q.22 ***40 dm^3 of hydrogen gas was collected over water at 831 torr Hg pressure at 23°C. What would be the volume of dry hydrogen at standard conditions? The vapour pressure of water at 23°C in 21 torr of Hg.***

Solution:

Volume of H_2 gas = V_1 = 40 dm^3
Pressure of dry gas = P_1 = 831 - 21 = 810 torr; P_2 = 760 torr
T_1 = 23°C = 23 + 273 = 296 K; T_2 = 273 K
V_2 = ?

Applying the gas equation, we get:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_2V_2T_1 = P_1V_1T_2$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

$$V_2 = \frac{810 \times 40 \times 273}{760 \times 296} = 39.32 \text{ dm}^3$$

Volume of gas = 39.32 dm^3 **Ans.**

Q.23 ***What is the density of the methane (CH_4) gas at 127°C and 3.5 atmosphere?***

Solution:

See Q 9 (Important Problems) on page 85.