Short Answer Type Questions – II

Q. 1. Define and explain Dalton's law of partial pressure. [DDE, 2017-18]

Ans. Dalton's law of partial pressure: According to this law, "the total pressure exerted by the mixture of non-reactive gases is equal to the sum of the partial pressures of individual gases".

$P_{Total} = P_1 + P_2 + P_3 + \ldots.$ (At constant T, V) Where P_{Total} = Total pressures exerted by the mixture of gases.

P_1, P_2, P_3 etc. = Partial pressure of gases

In a mixture of gases, the pressure exerted by the individual gas is called partial pressure.

Q. 2. 300 mL of oxygen gas at -10°C are heated to 10°C. Find the volume of gas at 10°C if pressure remains constant. [DDE, 2017-18]

Ans. Given, V_1 = 300 mL

T_1 = -10 + 273 = 263 K

V_2 = ?

T_2 = 10 + 273 = 283 K

According to Charle's law,

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

$$\therefore V_2 = \frac{V_1 T_2}{T_1} = \frac{300 \times 283}{263} = 322.8\, mL$$

Q. 3. A gas at a pressure of 5 atm is heated from o° to 546°C and is simultaneously compressed to one third of its original volume. Find the final pressure of the gas. [DDE, 2017-18]

Ans. Given, P_1 = 5 atm

T_1 = 0 + 273 = 273 K

T_2 = 546 + 273 = 819 K

V_1 = V

$V_2 = \frac{1}{3}$ V

P_2 = ?

According to ideal gas equation,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\therefore P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{5 \times V \times 819}{273 \times V/3}$$

$$= \frac{5 \times V \times 819 \times 3}{273 \times V} = 45\ atm.$$

Q. 4. A neon-dioxygen mixture contains 70.6 g dioxygen and 167.5 g neon. If pressure of the mixture of gases in the cylinder is 25 bar. What is the partial pressure of dioxygen and neon in the mixture? [DDE, 2017-18]

Ans. Number of moles of dioxygen = $\frac{70.6g}{32g\ mol^{-1}}$

= 2.21 mol

Number of moles of neon = $\frac{167.5g}{20g\ mol^{-1}}$

= 8.375 mol

Mole fraction of dioxygen

= $\frac{\text{No.of moles of dioxygen}}{\text{No.of moles of dioxygen}}$

+ No. of moles of neon

$$= \frac{2.21}{2.21 + 8.375} = \frac{2.21}{10.585} = 0.21$$

Mole fraction of neon

$$= \frac{\text{No. of moles of neon}}{\text{No. of moles of neon}}$$

+ No. of moles of dioxygen

$$= \frac{8.375}{8.375 + 2.21} = \frac{8.375}{10.585} = 0.79$$

Partial pressure of gas (dioxygen)

= mole fraction of dioxygen x total pressure

= 0.21 x 25 (bar) = 5.25 bar

Partial pressure of neon

= mole fraction of neon x total pressure

= 0.79 x 25 (bar) 19.75 bar

Q. 5. With the help of gas laws, deduce an expression for the ideal gas equation. What is the utility of the gas equation? [DDE, 2017-18]

Ans. Ideal Gas Equation:

According to Boyle's law,

At constant T and n,

$V \propto \frac{1}{P}$ …(i)

According to Charle's law,

At constant P and n,

$V \propto T$ …(ii)

According to Avogadro law,

At constant P and T,

$V \propto n$ …(iii)

∴ From equation (i), (ii) and (iii),

$V\ a \frac{nT}{P}$ …(iv)

$Or \qquad V = R\frac{nT}{P}$ …(v)

where R = Proportionality constant (Gas constant)

Or $\boxed{PV = nRT}$ … (vi)

The equation (vi) is called ideal gas equation. **Utility of the Gas Equation:** With the help of ideal gas equation, we can use the relationship between the amount of gases (in moles and their volumes (in liters) to calculate the stoichiometry of reactions involving gases, if the pressure and temperature are known. Many reactions that are carried out in the laboratory involve the formation or reaction of gas.

Q. 6. 135 mL of a gas is collected over water at 25°C and 0.993 bar. If the gas weighs 0.160 g and the aqueous tension at 25°C is 0.0317, calculate the molar mass of the gas.

Ans. Given V = 135 mL = 0.135 L

T = 25 +273 = 298 K

$P_{Total} = 0.993$ bar

$P_{H_2O} = 0.0317$ bar

M =?

m = 0.160 g

$P_{gas} = P_{Total} - P_{H_2O}$

= 0.993 - 0.0317 = 0.9613 bar

According to ideal gas equation,

PV = nRT

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

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

$$= \frac{0.160\ g\ \times 0.083\ bar\ mol^{-1}\ K^{-1} \times 298\ K}{0.9613\ bar\ \times 0.135\ L}$$

= 30.49 g mol^{-1}

Q. 7. A 2.0 L container at 25°C contain 1.25 moles of O_2 and 3.2 moles of carbon.

(i) What is the initial pressure in the container?

(ii) If the carbon and oxygen react as completely as possible to form CO, what will be the final pressure in the container?

Ans. (i) The container contains 1.25 moles of O_2 (gas) and 3.2 moles of carbon (solid). Since, only O_2, is gaseous and carbon will not exert any pressure.

So, n = 1.25 mol

V = 2.0 L

T = 25 + 273 = 298 K

According to ideal gas equation,

PV = nRT

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

$$= \frac{1.25 mol\ \times 0.0821\ L\ atm\ mol^{-1}\ K^{-1} \times 298\ K}{2.0\ L}$$

= 15.3 atm

(ii) C + $\underset{1/2 mol}{\frac{1}{2}}$ $O_2 \rightarrow$ $\underset{1\ mol}{CO}$

$\therefore$ ½ mole of O_2 gives = 1 mol of CO

$\therefore$ 1.25 moles of O_2 will give = $\frac{1 \times 1.25}{1/2}$

= 1 x 1.25 × 2 = 2.50 mol

$\therefore$ Final pressure P = $\frac{nRT}{V}$

$$= \frac{2.50\ mol\ \times 0.0821\ L\ atm\ mol^{-1}\ K^{-1} \times 298\ K}{2.0\ L}$$

= 30.6 atm.

Q. 8. A 6 L vessel contains 1.4 g of nitrogen. When heated to 1800 K, 30% of the molecules are dissociated into atoms. Calculate the pressure of the gas at 1800 K.

Ans. V = 6.0 L

T = 1800 K

$N_2 \leftrightharpoons 2N$

Initial moles $\frac{1.4}{28} = 0.05$

Final moles 0 $\frac{30}{100}$ x 0.05 = 0.015

Dissociation = 0.05 - 0.015 = 0.035

∴ Total number of moles = 0.035 + 0.030
= 0.065

N = 0.065 mol,

P =?

According to ideal gas equation,

PV = nRT

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

$$= \frac{0.065 \text{ mol } \times 0.0821\, L\, atm\ \ K^{-1} \times 1800\, K}{6\, L}$$

= 1.60 atm

Q. 9. A mixture of CO and CO_2 is found to have a density of 1.50 g L^{-1} at 20°C and 740 mm pressure. Calculate the composition of the mixture.

Ans. d = 1.50 g L^{-1}

T = 20 + 273 = 293 K

P = $\frac{740}{760}$ atm = 0.9736 atm

∴ Molar mass of the mixture = $\frac{d\,RT}{P}$

$$= \frac{1.50 \text{ gL}^{-1} \times 0.0821\, L\, atm\ \ K^{-1} mol^{-1} \times 293\, K}{0.9736\, atm}$$
= 37.06

Suppose mole % of CO in the mixture = x

And mole % of CO_2 in the mixture = (100 - x)

Average molar mass = $\frac{x \times 28 + (100 - x) \times 44}{100}$

37.06 = $\frac{28x + 4400 - 44x}{100}$

Or 16x = 4400 – 3706 = 694

$X = \frac{694}{16} = 694$

∴ Mole % of CO = 43.38

And mole % of CO_2 = 100 – 43.38 = 56.62

Q. 10. (a) State Charle's law. Give its mathematical expression.

(b) Using the equation of state PV = nRT; show that at a given temperature, density of a gas is proportional to gas pressure P. [KVS, 2014-15]

Ans. (a) Charle's Law: It states that if pressure (P) remains constant, the volume (V) of a fixed amount of gas (n) is directly proportional to its absolute temperature (T).

V ∝ T (P Constant)

Or $\frac{V}{T} =$ constant or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Charles also found that for a given mass of gas, if pressure is kept constant, the volume increases linearly with temperature.

$V = V_0 \ (1 + \propto t)$, where $\propto = \frac{1}{273}$ *and*,

V_0 is the volume at 0°C

Volume at temperature T is

$$V_T = V_0 \left(1 + \frac{t}{273}\right) = V_0 \left(\frac{273 + t}{273}\right)$$

Where t is temperature in Celsius

Or $V_T = \frac{V_0}{273} \times T$

Where, T = 273 + t, T is the temperature on Kelvin scale.

(b) PV = nRT

$or \ \frac{n}{V} = \frac{P}{RT}$

Since $n = \frac{m}{M}$

$$\therefore \frac{m}{MV} = \frac{P}{RT}$$

$$\therefore \frac{d}{M} = \frac{P}{RT}\left(\therefore d = \frac{m}{V} = density\right)$$

$$or\ d = \frac{MP}{RT}$$

$$\therefore d \propto P$$

Q. 11. (a) Write van der Waals equation for one mole of a gas.

(b) What are the conditions under which real gases show ideal behaviour?

(c) Critical temperature for CO_2, and CH_4 are 31.1°C and - 81.9P°C respectively. Which of these has stronger intermolecular forces and why? [KVS, 2014 Hyd.]

Ans. (a) $\left(P + \frac{a}{V^2}\right)(V - a) = RT$

(b) At high temperature and low pressure, real gases show ideal behaviour.

(c) Higher the critical temperature, stronger the intermolecular forces. Therefore, CO_2 has stronger intermolecular forces than CH_4.

Q. 12. Calculate root mean square and average velocity of CO_2 at 1000°c. [MSE, 2010]

Ans. T = 1000 + 273 = 1273 K

$$C_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 1273}{0.044}}$$

= 849.5 ms^{-1}

$$C_{av} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.314 \times 1273}{3.14 \times 0.044}}$$

= 782.84 ms^{-1}

Q. 13. Write important features of Maxwell's distribution of velocities. [KVS, 2010]

Ans. The important features of Maxwell distribution of velocities are:

(i) The fraction of molecules with very low or high velocities is very small.
(ii) The fraction of molecules possessing higher velocities goes on increasing till it reaches the peak and further it starts decreasing.
(iii) The maximum fraction of molecules possesses a velocity, corresponding to the peak in the curve. This velocity is referred to as most probable velocity.

Q. 14. Derive the relation between average velocity, root mean square and most probable velocity.

Ans. The relationship among velocities are :

$$C_{mp}: C_{av}: C_{rms} = \sqrt{\frac{2RT}{M}} : \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{3RT}{M}}$$

$$\sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

= 1·414 : 1·596 : 1·732

$C_{mp}: C_{av}: C_{rms} = 1 : 1 \cdot 128 : 1 \cdot 224.$

Q. 15. The average velocity of gas molecules is 400 ms^{-1}. Calculate its r.m.s. velocity at the same temperature.

Ans. $C_{av} = \sqrt{\frac{8RT}{\pi M}}$

$$C_{rms} = \sqrt{\frac{3RT}{M}}$$

$\frac{C_{rms}}{C_{av}} = \sqrt{\frac{3RT}{M}} \quad / \quad \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{3\pi}{8}}$

$$\sqrt{\frac{3\pi}{8}} = \sqrt{\frac{3 \times 3 \cdot 14}{8}} = 1 \cdot 085$$

$C_{rms} = 1 \cdot 085 \times C_{av}$

$= 1 \cdot 085 \times 400$

$= 434\, ms^{-1}.$

Q. 16. At what temperature will the root mean square velocity of SO_2 be same as that of methane at 27°C? [Imp.]

Ans. $C_{rms} = \sqrt{\frac{3RT}{M}}$

For CH_4, M = 16, T = 300 K

$$C_{rms} = \sqrt{\frac{3R \times 300}{16}}$$

For SO_2, M = 64, T = ?

$$C_{rms} = \sqrt{\frac{3R \times T}{64}}$$

$$\sqrt{\frac{300}{16}} = \sqrt{\frac{T}{64}}$$

$$T = \frac{300 \times 64}{16}$$

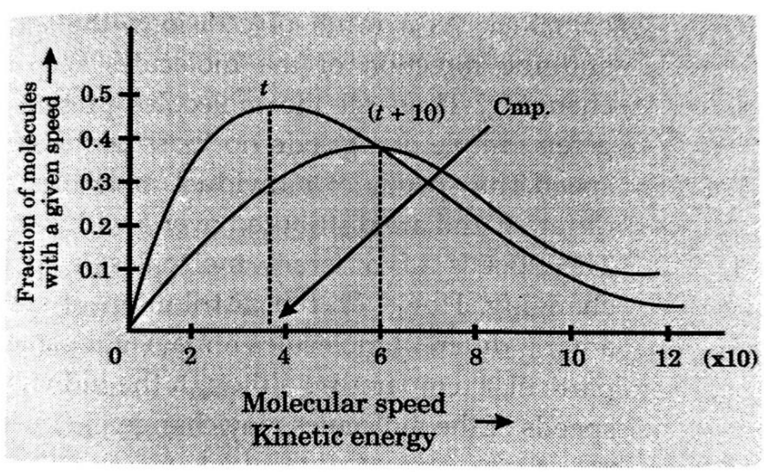
= 1200

t = 1200 – 273

= 927°C.

Q. 17. Draw Maxwell-Boltzmann's distribution curve and state the effect of temperature on distribution of velocities.

Ans.



Maxwell Boltzmann's Distribution Curve at a particular temperature

Effect of temperature: An increase in temperature of the gas results into an increase in the molecular motion. When the temperature is raised, the maximum of the curve moves to higher energy value and the curves broadens

Out, i.e., spreads to the right such that there is a greater proportion of molecules with much higher energies.

Q. 18. Calculate the total and average kinetic energy of 32 g of methane molecules at 27°c.

Ans. Average K.E. = $\frac{3}{2}$ K_bT

$$= \frac{3}{2}\frac{RT}{N_A}$$

Rs = 8·314 JK^{-1} mol^{-1}, N_A = 6·022 × 10^{23},

T = 27 + 273 = 300 K

$$K.E. = \frac{3}{2} \times \frac{8.314 \times 300}{6.022 \times 10^{23}}$$

= 6.22 x 10^{-21} J

Total K.E. = $\frac{3}{2}$ nRT

$$= \frac{3}{2} \times \frac{32}{16} \times 8.314 \times 300 = 7482.6\, J$$

Q.19. Explain

(i) Liquid at higher altitudes boils at low temperature.
(ii) In hospital, surgical instruments are sterilized in autoclaves.
(iii) Out of alcohols and ethers of comparable mass which one have higher boiling points? [DDE, 2017-18]

Ans. (i) Liquid at higher altitudes boils at low temperature because of low atmospheric pressure.
(ii) In hospital, surgical instruments are sterilized in autoclaves, due to high external pressure, in which boiling point of water is increased by using a weight to cover the vent.
(iii) Alcohols have higher boiling points due to presence of hydrogen bonding.

Q. 20. (i) Define surface energy in relation to surface tension.

(ii) Name the temperature at which the density of water is maximum.
(iii) Moist soil grains are pulled together. Explain. [DDE, 2017-18]

Ans. (i) Surface Energy: The energy required to increase the surface area of the liquid by one unit is called surface energy.

(ii) The temperature at which the density of water is maximum, is 4°C.
(iii) Moist soil grains are pulled together due to strong forces existing between soil grains i.e. coherent forces

Q. 21. (i) Define the term coefficient of viscosity. Name the unit of viscosity coefficient in cgs system.

(ii) Give the difference between boiling and evaporation. [DDE, 2017-18]

Ans. (i) Coefficient of Viscosity: It is defined as the force when velocity gradient (du/dz) and area of contact (A) both are unity.

$$F = \eta A \frac{du}{dx}$$

F = η x 1 x 1 = η

Where F = Force

η = Coefficient of viscosity

In cgs system, the unit of coefficient of viscosity is poise or g cm^{-1} s^{-1}.

(ii) Difference between boiling and evaporation:

Boiling	Evaporation
The condition of free vaporization throughout the liquid is known as boiling.	The process by which molecules of liquids go into the gaseous state is known as evaporation.

Q. 22. Explain:

(i) Tea or coffee is sipped from the saucer, when it is quite hot.
(ii) Liquids possess fluidity. [DDE, 2017-18]

Ans. (i) Tea or coffee is sipped from the saucer, when it is quite hot because it has larger surface area than the cup. In larger surface area, the rate of evaporation is faster due to which tea or coffee cools rapidly.

(ii) Liquids have indefinite shape. They take the shape of the container in which they are placed. This is due to the fact that the molecules of liquids are in a state of constant random motion and therefore they can move freely. So, the liquids possess fluidity.

Q. 23. Which among the following will have?

(i) HCI or H2O (Higher boiling point)
(ii) Ether or water (Higher viscosity)

(iii) $Br_{2(1)}$ or water (Lower surface tension) [DDE, 2017-18]

Ans. (i) Among HCI and H_2O, H_2O possesses higher boiling point due to presence of intermolecular hydrogen bonding in H_2O

(ii) Among ether or water, water has higher viscosity which is due to presence of inter molecular hydrogen bonding in water.

(iii) Among $Br_{2(l)}$ or water, Bran has lower surface tension. Because, water has strong intermolecular hydrogen bonding and also possesses higher surface tension. While $Br_{2(l)}$ does not show hydrogen bonding.

Q. 24. What is the cause of cooling the atmosphere?

Ans. Evaporation is the main cause of cooling the atmosphere. The process of changing liquid into vapors is called evaporation. There are some molecules in liquid which have relatively high kinetic energy which are at liquid surface, they overcome force of attraction and change into vapour state. When high energy molecules leave the surface, the average kinetic energy decreases leading to a fall in temperature of the liquid, that is why evaporation causes cooling.

Q. 25. LPG cylinder contains 14·2 kg gas and exerts a pressure of 2·5 atm. If half of its gas is consumed what will be the pressure of the gas inside the cylinder?

Ans. In a LPG cylinder, the gas is held as a liquid. There is an equilibrium between the LPG (Liquid) and its vapour. The equilibrium vapour pressure does not depend upon the quantity of liquid present there, as long as liquid $\rightleftharpoons$ vapour equilibrium is maintained. Therefore, even when half the gas has been used, the liquid changes to vapour to attain the equilibrium and the pressure exerted by gas remains 2·5 atm.