1st YEAR CHAPTER 3
GASES

1. Why do we feel in expressing the densities of gases in the units of g/dm^3 rather than g/cm^3.

On gases, particles are very far away from each other as compared to solids and liquids. So appreciable mass of a gas is not present in the smaller volume i.e 1 cm^3. Therefore densities of gases is expressed in a bigger unit of volume i.e g dm^{-3} instead of g cm^{-3}.

Example: CH4 gas has a density 0.7138 g dm^{-3} at 0^oC. if we express it in g cm^{-3}, it would be 0.0007138 gcm^{-3} which is very small value.

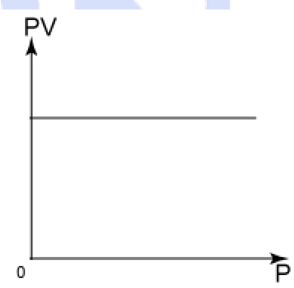
2. Write down the values of atmospheric pressure in four different units.

The SI unit of pressure is **Pascal.**

1 Pa = 1 Nm^{-2}
1 atm = 101325 Nm^{-2}
1 atm = 760 torr
1 atm = 760 mmHg
1 atm = 14.7 psi
1 atm = 1013.25 millibar

Boyle's Law

3. The plot of PV versus P is a straight line at constant temperature and with a fixed number of moles of an ideal gas. Justify.



When we plot a graph between PV on y-axis and pressure P on x-axis, a straight line parallel to pressure axis is obtained for an ideal gas. This straight line indicates that "PV" is a constant quantity at all pressures. At higher constant temperature, the volume increase and value of product PV should increase due to increase of volume at this temperature. This type of straight line will help us to understand the non-ideal behavior of gases.

4. What are isotherms?

Isotherm: (iso = same therm = heat)

The curve obtained at constant temperature is called isotherm.
It is obtained by plotting graph between "V" and "P" at constant temperature

5. State Boyle's law. Give its mathematical expression.

Boyle's law:

The volume of the given mass of gas is inversely proportional to the pressure at constant temperature.

$$V \propto \frac{1}{P} \qquad \text{at constant T}$$

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

$$PV = K$$

It can also be stated as "the product of pressure and volume of given mass of gas is a constant quantity at constant temperature".

Charles's Law

6. Give the quantitative definition of Charles's law?

At constant pressure, the volume of the give mass of gas increases or decreases by 1/273 of its original volume at 0°C, for every 1°C rise or fall in temperature respectively.

$$V_T = V_o\left(1 + \frac{T^oC}{273}\right)$$

7. How absolute zero is explained by drawing graph?

Absolute Zero:

The hypothetical temperature at which the volume of all the gases become zero is called absolute zero.

Value: -273.15 °C or 0 K

Graphical Explanation:

When a graph is plotted between V and T for a gas, a straight line is obtained which intersects the temperature axis at -273 °C which is considered as the lowest temperature. It would be achieved if the substance remains in gaseous state. But all gases liquefy before reaching this temperature.

8. Justify that volume of gas becomes theoretically zero at -273°C.

$$V_T = V_o\left(1 + \frac{T^oC}{273}\right)$$

$$V_T = 546\left(1 - \frac{273}{273}\right)$$

$$V_T = 546\left(1 - \frac{1}{1}\right)$$

$$V_T = 546\left(0\right)$$

$$V_T = 0$$

General Gas Equation

9. Calculate the value of 'R' gas constant in SI units?

P = 101325 Nm^{-2}

V = 0.022414 m^3

T = 273 K

n = 1 mol

Putting these values of R in the following equation

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

$$R = \frac{101325 \times 0.022414}{1 \times 273}$$

$R = 8.314\ Nm^{-2}.\ m^3.\ mol^{-1}.\ K^{-1}$

$R = 8.314\ Nm.mol^{-1}.\ K^{-1}$

$R = 8.314\ J.\ mol^{-1}.\ K^{-1}$ (1 J = Nm)

10. **Derive molecular mass of a gas by general gas equation.**

Calculation of molecular mass of a gas:

The general gas equation is

PV = nRT

Where n = no. of moles

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

now put the value of "n" in general gas equation

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

$PM = \frac{m}{V} RT$

$PM = dRT$ $\quad (d = \frac{m}{V})$

$M = \frac{dRT}{P}$

11. **Prove that $d = \frac{PM}{RT}$**

Calculation of density of a gas:

The general gas equation is

PV = nRT

Where n = no. of moles

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

now put the value of "n" in general gas equation

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

$PM = \frac{m}{V} RT$

$PM = dRT$ $\quad (d = \frac{m}{V})$

$\mathbf{d} = \frac{PM}{RT}$

12. **Convert - 40°C to Fahrenheit scale.**

To convert temperature in degree Celsius into degree Fahrenheit, we use formula:

°F = 9/5 °C + 32

°F = 9/5 (-40) + 32

°F = -40

At - 40°C, temperature in Celsius and Fahrenheit scale becomes equal.

Avogadro's Law

13. **Define Avogadro's aw with two suitable examples?**

Avogadro's Law:

Equal volume of all the gases at same temperature and pressure contains equal numbe of particles.

$$V \propto n$$

For example:

1 mol of H_2 gas = 2 g = 6.02 x 10^{23} = 22.414 dm^3

1 mol of O_2 gas = 32 g = 6.02 x 10^{23} = 22.414 dm^3

1 mol of CH_4 gas = 16 g = 6.02 x 10^{23} = 22.414 dm^3

Dalton's Law of partial pressure

14. Why Dalton's law of partial pressure of gases is only obeyed by those gases which do not have attractive forces among the molecules?

For Dalton's law of partial pressure to hold, there will be no attractive forces among the molecules on the walls of the gases. The pressure of a gas is due to the collisions of the molecules on the walls of the container. In the absence of attractive forces each molecules of gas mixture will hit the walls of the container with the same number of times and with the same force. Thus the partial pressure of a given gas is unaffected by the presence of other gases. In this case, the total pressure is equal to sum of individual pressure of each gas present in the mixture. Hence the law will not hold in the presence of attractive forces among the molecules.

15. Pilots feel uncomfortable breathing at higher attitude. Give reason.

At higher altitude, the partial pressure of oxygen is low. It makes breathing difficult. That's why pilot feel uncomfortable breathing at higher altitude.

16. Why deep sea divers take oxygen mixed with an inert gas like He?

Actually in sea after every 100 feet depth, the diver experiences approximately 3 atm pressure, so normal air cannot be breathed in this depth of sea. So deep sea divers take oxygen mixed with an inert gas i.e Helium (He) so as to adjust the partial pressure of oxygen accordingly to requirement. Helium can be replaced by N_2 because N_2 diffuses into blood at high pressure whereas He has very low solubility in the blood under these conditions.

17. Calculate fraction of total pressure exerted by oxygen when equal masses of CH_4 and O_2 are, mixed in an empty container at 25°C.

Supposed masses of CH_4 and O_2 are

Mass of CH_4 = 32g

Mass of O_2 = 32g

Moles of $CH_4 = \frac{Mass}{Molar\ Mass} = \frac{32}{16}$ = 2 mol

Moles of $O_2 = \frac{Mass}{Molar\ Mass} = \frac{32}{32}$ = 1 mol

Mole fraction of O_2 $\quad X_{O_2} = \frac{1}{1+2} = \frac{1}{3}$

Graham's Law of Diffusion and Effusion

18. What is the difference between Diffusion and Effusion?

Diffusion	Effusion
• The spontaneous intermixing of molecules of one gas with the molecules of other gas is called diffusion. • The spreading and mixing of molecules is due to collisions. • Two or more than two substances are involved in mixing. • Examples: mixing and spreading of perfume molecules with air in a large room.	• The escape of gas molecules one by one from a tiny hole in the wall of container is called effusion. • The spreading of molecules is not due to collision, but due to their tendency to escape one by one. • Only substance is involved. • Example: the escape of hydrogen gas from tiny holes in the walls of rubber balloons.

19. **State Graham's law of diffusion. Write its mathematical form.**

Graham's law of diffusion:

The rate of diffusionor effusion of a gas is inversely proportional to the square root of its density at constant temperature and pressure. Mathematically:

$$\text{Rate of diffusion} \propto \frac{1}{\sqrt{d}} \qquad \text{at constant T \& P}$$

$$\text{Rate of diffusion} = \frac{K}{\sqrt{d}}$$

$$\text{Rate of diffusion} \times \sqrt{d} = K$$

20. **Why lighter gases diffuse through air rapidly than heavier gases?**

At a given temperature, the average kinetic energy of different gas molecules is same. Since their masses are different, so their velocities will also be different. The lighter molecules will have greater velocities and so they will diffuse rapidly.

According to following equation:

$$\frac{r_2}{r_1} = \sqrt{\frac{M_2}{M_1}}$$

Kinetic Molecular Theory

21. **How kinetic energy of molecules of a gas becomes zero at -273°C.**

The temperature -273°C is called absolute zero at which the volume of ideal gas would be zero because at this temperature, the kinetic energy of gases becomes zero due to decrease in motion of gas molecules.

22. **Give four fundamental postulates of kinetic molecular theory of gases.**

i. All gases consist of very small particles called molecules. Gases like He, Ne, Ar have monoatomic molecules.
ii. Gas molecules are in constant random motion.
iii. There are no forces of attraction among the molecules of gas.
iv. The actual volume of gas molecules is negligible as compared to the volume of vessel.

23. **Write two faulty assumptions of kinetic molecular theory of gases.**

i. There are no forces of attraction among the molecules of gas.
ii. The actual volume of gas molecules is negligible as compared to the volume of vessel.

24. **Explain Boyle's law with the help of KMT.**

OR

Explain Boyle's law according to kinetic molecular theory of gases.

According to the Kinetic equation for ideal gas is

$$PV = \frac{1}{3}mN\bar{C}^2 \quad \text{.............(i)}$$

According to kinetic molecular theory of gases, the kinetic energy of molecules is directly proportional to absolute temperature.

$$\frac{1}{2}mN\bar{C}^2 \propto T$$

$$\frac{1}{2}mN\bar{C}^2 = KT \quad \text{................(ii)}$$

Multiplying and divide equation (i) by 2

$$PV = \frac{2}{2}\left(\frac{1}{3}mN\bar{C}^2\right)$$

$$PV = \frac{2}{3}\left(\frac{1}{2}mN\bar{C}^2\right) \quad \text{...............(iii)}$$

Putting equation (ii) in equation (iii)

$$PV = \frac{2}{3}KT$$

If T = constant then **PV = K**

This is Boyle's law.

25. Derive Charles's law by kinetic equation of gases..

Charles's law:

According to the Kinetic equation for ideal gas is

$$PV = \frac{1}{3}mN\bar{C}^2 \quad \text{.............(i)}$$

According to kinetic molecular theory of gases, the kinetic energy of molecules is directly proportional to absolute temperature.

$$\frac{1}{2}mN\bar{C}^2 \propto T$$

$$\frac{1}{2}mN\bar{C}^2 = KT \quad \text{................(ii)}$$

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$$PV = \frac{2}{3}\left(\frac{1}{2}mN\bar{C}^2\right) \quad \text{...............(iii)}$$

Putting equation (ii) in equation (iii)

$$PV = \frac{2}{3}KT$$

$$V = \left(\frac{2K}{3P}\right)T$$

At constant P, $\left(\frac{2K}{3P}\right)T = K''$ (a new constat)

Therefore $V = K''T$ or $\frac{V}{T} = K''$

This is Charles's law.

Liquefaction of Gases

26. Define critical temperature and critical pressure giving one example in each case.

Critical Temperature:

The highest temperature at which a substance can exist as a liquid is called critical temperature. It is denoted by T_c. for example: T_c of water is 647.6 K.

Critical pressure:

The minimum pressure required to liquefy a gas at its critical temperature is called critical pressure. It is denoted by P_c. for example: P_c of water is 217 atm.

27. **What is Joule Thomson effect?**

Joule Thomson effect:

When a highly compressed gas is allowed to expand suddenly into a region of very low pressure, it gets cooled. This is called Joule-Thomson effect.

In Linde's method, gases are liquefied by applying this effect.

Non-ideal Behaviour of Gases

28. **Why water vapours do not behave ideally at 273K?**

Water vapors do not behave ideally at 273K because this temperature is below the critical temperature of water vapors so they have sufficient attractive forces among them so greater is the deviation of water from kinetic molecular theory and gas laws and these are in fact responsible for non-ideal behavior.

29. **Why real gases deviate from ideal behavoiur?**

OR

Gases deviate from ideal behaviour at low temperature and high pressure. Give reasons.

At high pressure, molecules come close to each other while low temperature decreases the kinetic energies. In such conditions, stronger intermolecular forces are produced and gas behaves non-ideally. Gases are more ideal at high temperature (100°C) due to weak intermolecular forces.

30. **SO_2 is comparatively non-ideal at 273 K but behaves ideally at 327K. Explain.**

At the temperature of 273K (0°C), the attractive forces are dominating and make the gas non-ideal. But when the temperature of gas is raised to 327°C (546K) then forces of attractions are weak and gas behaves ideally.

31. **Why real gases show non-ideal behavior at low temperature and high pressure?**

At low temperature, kinetic energy of gas molecules decreases and intermolecular forces increases. At high pressure, molecules come close to each other and intermolecular forces become significant. Due to intermolecular forces, real gases show non-ideal behavior.

32. **What are the causes of deviation of gases from ideality?**

Causes of Deviation:

i. There are no forces of attraction among the molecules of gas.
ii. The actual volume of gas molecules is negligible as compared to the volume of vessel.

33. **Write down SI units of "a" and "b" in Van der Waal's equation.**

Unit of "a"	Unit of "b"
Since $P' = \frac{n^2 a}{V^2}$ $a = \frac{P' V^2}{n^2}$	"b" is excluded or incompressible volume. b = Volume. mol^{-1} **b = dm^3. mol^{-1}** as SI unity of volume is m^3. So **b = m^3 mol^{-1}**

$a = \frac{atm \times (dm^3)^2}{mol^2}$ **a = atm dm^6 mol^{-2}** In **SI** units, $P = Nm^{-2}$ & $V = m^3$ So $a = \frac{Nm^{-2} \times (m^3)^2}{mol^2}$ **a = Nm^4 mol^{-2}**	

Plasma

34. What do you mean by natural plasma and artificial plasma?

Artificial plasma:

Artificial plasma can br created by using electrical charges on a gas as neon signs.

Natural Plasma:

Natural plasma exists only at very high temperature or low temperature vacuum. Natural plasma does not react rapidly.

35. Write down any two applications of plasma.

Plasma has innumerable applications because it

- Shows conductive response to electrical and magnetic field.
- Is efficient source of radiations.

It finds applications in generation of electrical energy and removal of hazardous chemicals from fusion pollution control.

36. What is plasma? Give its application.

PLASMA: Gaseous mixture which consist of ions, electrons and neutral atoms is called plasma. Plasma has innumerable applications because it

- Shows conductive response to electrical and magnetic field.
- Is efficient source of radiations.

It finds applications in generation of electrical energy and removal of hazardous chemicals from fusion pollution control.

37. What is plasma state? How is plasma formed at high temperature?

Plasma:

The gaseous mixture of ions, electrons and neutral atoms is called plasma.

Formation of Plasma:

At high temperature, atoms or molecules loose electrons and develop net positive charge. At this high temperature, ionization of the atoms and molecules happens many times. In this way, a cloud of free electrons and ions is formed. However all the atoms are not necessarily ionized. Some of them may remain neutral.

38. What is plasma? Why it is neutral?

PLASMA: Gaseous mixture which consist of ions, electrons and neutral atoms is called plasma. Plasma has innumerable applications because it

It shows conductive response to electrical and magnetic field.

Plasma is electrically neutral because it is the mixture of positive, negative and neutral charges

LONG QUESTION

1. Prove PV = nRT, Give value of R in SI unit
2. What is an ideal gas? Real gases deviate more from ideal behavior at low temperature and under high pressure. Explain. 4
3. **W**hat is Dalton's law of partial pressure? Also discuss its applications.
4. Derive an expression from general gas equation to calculate the density of a gas?
5. Explain Dalton's law of partial pressure and give its applications in breathing process. **4**
6. State and explain Graham's law of diffusion of gases. **(4)**
7. What are London forces. Explain various factors affecting it. (4)
8. What is Plasma? How is it produced? Give it two applications. (4)
9. Derive different units and values of ideal gas constant (R)
10. Write eight postulates of Kinetic Molecular Theory of Gases.
11. State Graham's law of diffusion and verify it by an experiment.
12. **D**erive Van der Waal's equation for real gases?
13. Give eight postulates of the KMT (Kinetic molecular Theory) **4**
14. How volume and pressure were corrected by Vander Waals? **4**
15. Describe Linde's method for the Liquefaction of gases. **4**
16. Calculate the mass of 1 dm^3 of NH_3 gas at 30°C and 1000 mm Hg pressure, considering that NH_3 is behaving ideally. **4**
17. Working at a vacuum line, a chemist Isolated a gas in a weighing bulb with a volume of 255 Cm^3 at a temperature of 25°C and under a pressure in the bulb of 100 torr, the gas weighed I2.1 mg, What is the molecular mess of this gas ?
18. One mole of methane gas is maintained at 300 K, its volume is 250 cm^3, calculate the pressure exerted by the gas when it is non-ideal.