

## CHAPTER 5

### STATES OF MATTER

1. **Change in state** : It is over all effect of Intermolecular forces, molecular Interactional energy & thermal energy:
2. **Measurable properties of gases** : P,V, T, n, Viscosity, specific heat are some measurable properties.
3. **Gas Laws** : The quantitative relationship b/w any two of the variables (V, n, P,T) when other two are constant.
4. **Boyle's Law** : The pressure of fixed mass of gas varies inversely with the volume at constant T.  $P \propto 1/V$  (n,T const.)  

$$P_1 V_1 = P_2 V_2$$
5. **Charles's Law** : At constant P, the volume of fixed amount of gas varies directly with its absolute temperature.  

$$V \propto T \quad \text{or} \quad \frac{V}{T} = \text{constant}, \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$
6. **Gay lussac's Law** : At constant V, The pressure of fixed amount of gas varies directly with its absolute temperature.  

$$P \propto T \quad \text{or} \quad \frac{P}{T} = \text{const}, \quad \frac{P_1}{T_1} = \frac{P_2}{T_2}$$
7. **Ideal gas equation** : The relationship b/w P, V and T by Gas Laws  $PV = nRT$ .
8. **Avogadro's Law** : At given T and P, the volume of gas varies directly to the amount of gas .  $V \propto n$  ( P, T constant)
9. **Dalton's Law of partial pressure** : The pressure exerted by a mixture of non reacting gases is equal to the sum of their partial pressure at constant (V,T)

$$P(\text{total}) = P_1 + P_2 + P_3 + \dots (T, V, \text{constant})$$

**10. Kinetic Molecular theory :**

- a. Gases consist of large number of identical particles (atoms or molecules) that are so small that the actual volume of the molecules is negligible in comparison to the empty space between them.
- b. There is no force of attraction between the particles of a gas at ordinary temperature and pressure
- c. Particles of a gas are always in constant and random motion
- d. Pressure is exerted by the gas as a result of collision of the particles with the walls of the container
- e. Collisions of gas molecules are perfectly elastic
- f. At any particular time, different particles in the gas have different speeds and hence different kinetic energies
- g. Average kinetic energy of the gas molecules is directly proportional to the absolute temperature

**11. Real Gases :** The gases which deviates from Ideal behavior at higher pressure and low temperature b/c of force of attraction b/w molecules increases .

**12. Compressibility factor (Z) :** It determine extent of deviation

of real gases from Ideal gas behavior :  $Z = \frac{PV}{n.R.T.}$  for ideal

gas  $Z=1$ , for Nonideal gas  $Z < 1$ ,  $Z > 1$

**13. Vander waal's Equation :**  $\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT.$

**14. Critical Temperature : (T<sub>c</sub>)** The temperature above which a gas cannot be liquefied whatever high pressure may be

**15. Critical Pressure :** The minimum pressure required to liquify a gas at its critical temperature.

**16. Critical Volume :** The volume of 1 mole of gas at T<sub>c</sub>, P<sub>c</sub>.

**17. Super cooled liquids :** The liquids which are cooled to a temperature below its freezing point without freezing .

18. Elastic Collision : The collisions in which no loss of K.E. only there is transfer of energy.
19. Vapour pressure : The equilibrium pressure by vapour of liquid in a container at given temperature (T)
20. At higher altitude : The b.p. of water decreases b/c the atmospheric pressure is less than one atmosphere.
21. Surface Tension (V) : It is force acting per unit length perpendicular to the line drawn on the surface : ( $\text{Nm}^{-1}$ ) : It decreases with increases in T, it increases with increase in external pressure, b/c of it falling drops of liquid are spherical, liquid in capillary tube rises.
22. Viscosity ( $\eta$ ) : It is resistance offered to the flow of liquid due to friction b/w layer of fluids .  $F = n.A.\frac{dv}{dn}$
23. Effect of T & P on viscosity : It decreases with increase in T, and increases with increase in P.
24. Low M.P. & B.P. of molecular liquids is due to low magnitude of molecular interaction energy.

### **One mark questions**

1. At what condition surface tension vanishes ?
2. Why Helium is used in balloons in place of hydrogen?
3. At what temperature below which a gas does not obey ideal gas law?
4. At what temperature the volume of a gas is supposed to be zero?
5. What is the molar volume at  $0^\circ\text{C}$  and 1 bar pressure?

6. Name the temperature above which a gas cannot be liquefied by any amount of pressure.
7. What is the effect of increase of temperature on surface tension and viscosity in a liquid?
8. How is the partial pressure of a gas in a mixture is related to the total pressure of the gaseous mixture?
9. Why vegetables are cooked with difficulty at hill station.
10. What is the value of Z (compressibility factor) for an Ideal gas?

### **Answers to One mark questions**

- Ans 1 At critical temperature, meniscus b/w liquid and vapours disappears.
- Ans 2. He is incombustible , though heavier than  $H_2$  .
- Ans 3. Below Boyle Temperature.
- Ans 4. At absolute zero (0 K) temperature.
- Ans 5. It 22400 ml.
- Ans 6. It is critical temperature ( $T_c$ )
- Ans 7. Both decreases with increase in temperature
- Ans 8.  $P_1 = X_1 \times P_{(total)}$
- Ans 9. At hill station the atmospheric pressure is less and so boiling point decreases.
- Ans10. For ideal gas  $Z=1$ .

### **Two Marks Questions**

- Q.1 How do you convert pressure in atmosphere in to SI unit.

- Q.2 What type graph will you get when PV is plotted against P at constant temperature.
- Q.3 What would have happened to the gas if the molecular collisions were not elastic?
- Q.4 At a particular temperature, why vapour pressure of acetone is less than of ether?
- Q.5 Why liquids diffuse slowly as compared to gases?
- Q.6 What would be the SI unit for quantity  $\frac{P.V^2.T^2}{n}$ ?
- Q.7 In terms of Charle's law explain why  $-273^\circ\text{C}$  is the lowest temperature?
- Q.8 For real gases the relation b/w P,V,T is given by vander Waal's equation, write it for n moles?
- Q.9 What correction is applied to obtain pressure of dry gas with the total pressure & aqueous tension?
- Q.10 Name two phenomena that can be explained on the basis of surface tension.

### **Answers to two marks questions**

- Ans 1.  $1\text{ atm} = 101325\text{ Pa or Nm}^{-2}$ ,  $1\text{ bar} = 10^5\text{ Pa}$ .
- Ans 2 .A straight line parallel to pressure axis.
- Ans 3. On every collision there is loss of energy, so molecules would have slowed down & settled down in vessel and pressure reduce to 0.
- Ans 4. b/c molecular force of attraction in acetone is stronger than those present in ether.

Ans 5. In liquids the molecules are less free than in a gas. i. e. intermolecular forces in liquid are greater than in gas.

$$\text{Ans 6. } \frac{P.V^2.T^2}{n} = \frac{(N.m^{-2})(m^3)^2(K)^2}{mal} = N.m^4 k^2 mal^{-1}$$

Ans 7 At  $-273^\circ \text{C}$ , the Volume of gas becomes equal to zero i. e. gas ceases to exist.

Ans 8. Vander waal's equation

$$\left( P + \frac{n^2 a}{v^2} \right) (v - nb) = n.R.T.$$

Ans 9.  $P_{(\text{drygas})} = P_{(\text{Total})} - \text{Aqueous tension}$

Ans 10. Surface tension can explain (i) capillary action. (ii) Spherical shape of small drops of liquid.

### Three Marks Questions

Q.1 Calculate temperature of 4.0 moles of gas occupying  $5\text{dm}^3$  volume at 3.32 bar. ( $R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$ )

$$\text{Ans } PV = nRT, \text{ or } T = \frac{PV}{nR}$$

$$\text{Or } T = \frac{3.32 \text{ bar} \times 5\text{dm}^3}{4.0\text{mol} \times 0.083\text{bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}} = 50.\text{Ans}$$

Q.2 34.05 ml of phosphorus vapours weight 0.0625g at  $543^\circ \text{C}$  and 1 bar pressure what is molar mass of phosphorous?

$$\text{Ans. } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}, \Rightarrow \frac{1 \times 34.05}{(543 + 273)} = \frac{1 \times v_2}{273} \text{ at } 0^\circ \text{C}$$

$$\text{Or } V_2 = 11.35 \text{ ml}$$

Now 11.35 ml of vapours at  $0^\circ \text{C}$  and 1 bar pressure weight 0.0625 gm

Now 22700 ml of vapors at  $0^\circ \text{C}$  and 1 bar pressure weight

$$\frac{0.0625}{11.35} \times 22700$$

Q.3 A mixture of dihydrogen and dinitrogen at 1 bar pressure contains 20% by weight of  $\text{H}_2$ . Calculate partial pressure of  $\text{H}_2$ .

Ans The mixture of  $\text{H}_2$  and  $\text{O}_2$  contain 20%  $\text{H}_2$  means 20 gm  $\text{H}_2$  & 80gm  $\text{O}_2$

$$n_2(\text{H}_2) = \frac{20}{2} = 10 \text{ moles}, n(\text{O}_2) = \frac{80}{32} = 2.5 \text{ contest.}$$

$$P_{(\text{H}_2)} = \frac{n(\text{H}_2)}{n(\text{H}_2) + n(\text{V}_2)} \times P_{(\text{total})} = \frac{10}{10 + 2.5} \times 1 \text{ bar} = 0.8 \text{ bar}$$

Q.4 What will be minimum pressure required compressing  $500 \text{ dm}^3$  of air at 1 bar to  $200 \text{ dm}^3$  at  $30^\circ \text{C}$ ?

Ans.  $P_1 = 1 \text{ bar}$ .  $V_1 = 500 \text{ dm}^3$

$P_2 = ?$   $V_2 = 200 \text{ dm}^3$  & temp. constant  $30^\circ \text{C}$

So by Boyle's law  $P_1 V_1 = P_2 V_2$

$$1 \times 500 = P_2 \times 200 \quad \text{or } P_2 = \frac{500}{200} = 2.5 \text{ bar}$$

Q.5 Calculate the total pressure in mixture of 4g of  $\text{O}_2$  and 2gm. Of  $\text{H}_2$  can fixed to a total volume of 1L at  $0^\circ \text{C}$ . ( $R = 0.0821$ ) Latm.  $\text{Mol}^{-1}$

Ans  $P = P_{\text{O}_2} + P_{\text{H}_2} \times \frac{RT}{V}$

$$= \left( \frac{4}{32} + \frac{2}{2} \right) \times \frac{0.0821 \times 273}{1} = \left( \frac{1}{8} + 1 \right) 22.4 = 25.2 \text{ atm. Ans}$$

Q.6 Account for the following :

- (i) The size of weather balloon becomes longer and larger as it ascend up into higher altitudes.

Ans (i) At higher altitudes atmospheric pressure decreases, but inside the balloon gas exerts pressure and size becomes larger.

Q.8 What do you mean by ideal gas and real gas? Why do real gases deviate from ideal behaviors?

Ans. Ideal gas follows gas laws at all P & T

Real gas donot “ gas laws at all P & T.

Real gas deviate from ideal behaviour due to force of attraction and because of volume of molecules of gases are not negligible.

Q.9 Using the equation of state  $PV=nRT$  Show that at given T, density of gas proportional to gas pressure P.

$$\begin{aligned} \text{Ans } PV &= \underline{n} RT \Rightarrow P = \frac{n}{v} \cdot RT \\ &\Rightarrow P = \frac{m}{M} \cdot \frac{1}{V}, RT = \frac{m}{V} \cdot \frac{RT}{M} \\ &\Rightarrow P = P \cdot \frac{RT}{M} \quad (\text{Where } P = \frac{m}{v}) \\ &\Rightarrow P \propto P \left( \because \frac{RT}{M} = \text{const.} \right) \end{aligned}$$

Q.10 Critical temperature of  $\text{CO}_2$  and  $\text{CH}_4$  gases are  $31.1^\circ\text{C}$  and  $-81.9^\circ\text{C}$  respectively. Which of these has strong intermolecular forces & why?

Ans  $\text{CO}_2$  has strong vander waal's forces of attraction than  $\text{CH}_4$ . b/c of greater polarity and high molecular wt.



### Hots Questions with Answers.

- Q.1 (a) Why aerated water bottles kept under water during summer?  
 (b) Which property of liquid is responsible for spherical shape of drop?  
 (c) Why is moist air lighter than dry air?  
 (d) Define aqueous tension?  
 (e) What is units of a and b which are vander waal's constant?

Ans (a) To reduce temperature so to reduce pressure, other wise bottle may burst.  
 (b) Surface Tension.  
 (c) Moist air has water vapours which lowers vapour density, so it is lighter.  
 (d) It is pressure of water vapours at given T.  
 (e) Unit of a in atm.  $L^2 \text{ mol}^{-2}$ , b is  $L \text{ mol}^{-1}$ .

Q.2 Why does sharpened edge becomes smooth on heating up to melting point?

Ans On heating the glass it melts and take up rounded shape at edges which has minimum surface area. b/c of surface tension.

Q.3 Arrange following in order of increasing density:

$$d = \frac{PM}{RT}, O_2 \text{ at } 25^\circ \text{ C, } 1\text{atm}, O_2 \text{ at } 0^\circ \text{ C, } 2\text{atm}, O_2 \text{ at } 273^\circ \text{ C, } 1\text{atm}.$$

Ans  $d = \frac{PM}{RT}$ , R, M are constant, so d depends upon  $\frac{P}{T}$  so at  $25^\circ \text{C}$ ,

$$1\text{Atm} \frac{P}{T} = \frac{1}{298}, \text{ At } 273^\circ \text{ C, } 1\text{atm} \frac{P}{T} = \frac{1}{546} \text{ Hence increasing order of}$$

density will be:  $O_2 \text{ at } 273^\circ \text{ C, } 1\text{atm} < O_2 \text{ at } 25^\circ \text{ C, } 2\text{atm}.$

Q.4 An  $O_2$  cylinder has 10L  $O_2$  at 200 atm. It patient takes 0.50ml of  $O_2$  at 1 atm in one breath at  $37^\circ \text{C}$ . How many breaths are possible?

Ans 10L at 200 atm = ? L at 1atm  $\Rightarrow P_1 V_1 = P_2 V_2 \Rightarrow 200 \times 10 = 1 \times V_2$  or

$$V_2 = 2000 \text{ L, No of breathes} = \frac{\text{Total Volume}}{\text{Volume for 1 breath}} = \frac{2000 \text{ L}}{0.5 \times 10^{-3} \text{ L}} = 4 \times 10^6$$