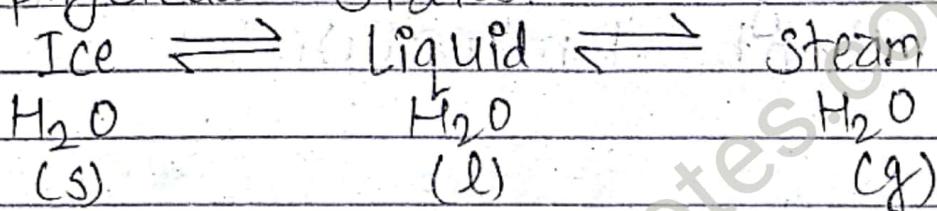


State of Matter

There are three physical states of matter:

- (i) Gaseous State
- (ii) Liquid State
- (iii) Solid State

For e.g. Water has following three physical states:



i) Gaseous State

The state of matter in which it has neither fixed shape nor fixed volume is called gaseous state.

Gas Laws \rightarrow Boyle's Law

\rightarrow Charles' Law

\rightarrow Combined gas Law

\rightarrow Dalton's law of partial pressure

\rightarrow Graham's Law of diffusion

Boyle's Law:

In 1662, Robert Boyle gave a mathematical relationship between volume of a gas & pressure of the gas at constant temperature.

Boyle's law states that "The volume of the given mass of a gas is inversely proportional to pressure at constant temperature."

If P be the pressure of the gas & V be the volume of the gas at given temperature.

Then, According to Boyle's law:

$$V \propto \frac{1}{P} \text{ When temperature remains constant.}$$

Again,

If P_1 & V_1 be the initial pressure and volume of a given mass of a gas & P_2, V_2 are final pressure & volume of same mass of the gas at same temperature.

Applying Boyle's law at initial condition,

$$V_1 \propto \frac{1}{P_1} \text{ at temperature } T.$$

$$\text{or, } V_1 = \frac{K}{P_1}$$

or, $K = P_1 V_1$ --- (i) where K is proportionality constant which value depends upon amount of gas and temperature.

Similarly,

Applying Boyle's law at final Condition
at temperature T .

$$V_2 \propto \frac{1}{P_2}$$

$$\frac{K}{P_2}$$

$$\text{or, } V_2 = \frac{K}{P_2}$$

$$\text{or, } K = P_2 V_2 \text{ --- (ii)}$$

From eqn (i) and (ii), we get,

$$\text{or, } P_1 V_1 = P_2 V_2 = K$$

$\therefore P_1 V_1 = P_2 V_2$ this is the formulae for Boyle's law.

Q. At what condition the product of volume & pressure of a given mass of a gas remain constant?

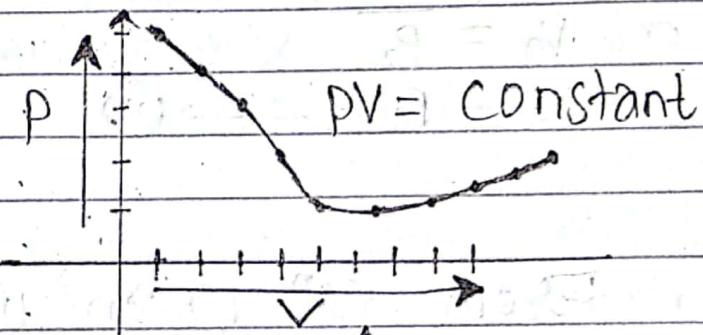
⇒ At Constant temperature, the product of volume and pressure of a given mass of a gas remains constant.

According to Boyle's law,
 $PV = K$ at constant temperature.

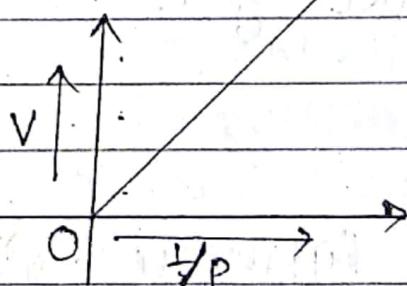
Graphical representation of Boyle's law:

(a) Boyle's law can be verified by plotting graph between pressure & Volume of a given mass of a gas:

→ Curve like hyperbola

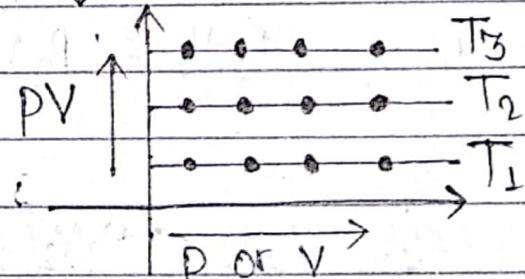


(b)



Straight Line passing through Origin.

(c)



Straight Line parallel to x-axis.

Charles' law:

In 1787, the relationship between volume & temperature of a given mass of a gas at constant pressure was given by Jacques Alexandre Cesar Charles.

This law states that, "The volume of given mass of a gas increases or decreases by $\frac{1}{273} \times t$ of its initial volume at 0°C for every each(\pm) degree rise or fall in temperature at constant pressure."

Let V_0 ml is the volume of a gas at 0°C . Then, according to Charles' law,

On heating it $t^\circ\text{C}$,

$$\begin{aligned}\text{Volume of gas becomes} &= V_0 + \frac{1}{273} \times V_0 \\ &= V_0 \left[1 + \frac{1}{273} \right]\end{aligned}$$

Similarly,

$$\text{Volume of gas at } 2^\circ\text{C} = V_0 \left[1 + \frac{2}{273} \right]$$

$$\text{Volume of gas at } t^\circ\text{C} = \frac{V_0 (273 + t)}{273}$$

If V_1 ml & V_2 ml be the volume of a gas at $t_1^\circ\text{C}$ & $t_2^\circ\text{C}$ respectively.
then, according to charle's law;

$$V_1 = V_0 \left[\frac{273 + t_1}{273} \right] \quad \text{--- (i)}$$

$$\text{and } V_2 = V_0 \left[\frac{273 + t_2}{273} \right] \quad \text{--- (ii)}$$

Dividing (i) by (ii)

$$\frac{V_1}{V_2} = \frac{273 + t_1}{273 + t_2}$$

$\left[\because \frac{V_1}{V_2} = \frac{T_1}{T_2} \right]$ where, $T_1 = 273 + t_1$ which is temperature in Kelvin scale.

This can be written as,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad (\text{at Constant pressure.})$$

This is charle's law formula.

Again,

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

$$\text{or, } V = \text{constant} \times T$$

$$\text{or, } V \propto T$$

charle's law can be stated as, "at Constant pressure the volume of given mass of a gas is directly proportional to absolute temperature."

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Date: / /

Concept of absolute zero temperature:

Let V_0 ml be the volume of a gas at 0°C . According to Charles's law, on cooling the gas.

$$\text{Volume of gas at } -1^\circ\text{C} = \left[V_0 - \frac{1}{273} \times V_0 \right] \text{ ml}$$

$$\begin{aligned}\text{Volume of gas at } -273^\circ\text{C} &= \left[V_0 - \frac{273 \times V_0}{273} \right] \text{ ml} \\ &= 0 \text{ ml}\end{aligned}$$

∴ The hypothetical temperature at which volume of gas becomes zero is called absolute zero temperature. It is -273°C . It is equal to 0 Kelvin. At this temperature all gasses have been converted into liquid or solid state.

Verification of Charles's law:-

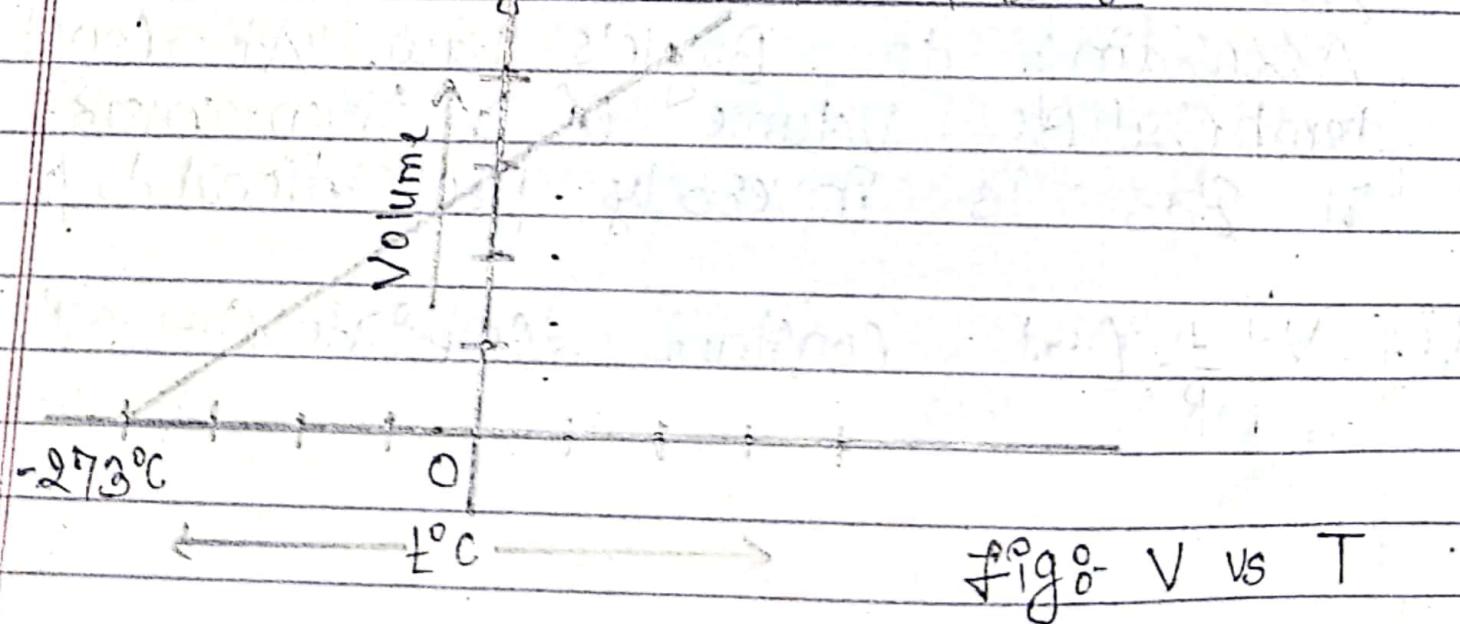


Fig: V vs T

Charles law can be verified by plotting graph between volume occupied by a gas & temperatures at constant pressure. A straight line is obtained which on extrapolation the line meets at -273°C which shows that volume of a gas at -273°C is 0.

Combined gas equation $\left[\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \right]$

A gas equation which is obtained by combining Boyle's law & Charles law is Combined gas equation. It gives the simultaneous effect of temperature & pressure on Volume of a gas. It can be derived as:

Let V_m be the volume of a gas at pressure P & temperature T . According to Boyle's law, 'At constant temperature Volume of a given mass of a gas is inversely proportional to pressure.

$$\text{i.e. } V \propto \frac{1}{P} \text{ (at constant temperature)} \dots \text{---(i)}$$

According to Charles' law, at constant pressure volume of a given mass of a gas is directly proportional to absolute temperature.

i.e. $V \propto T$ (at constant pressure) --- (ii)

Combining (i) and (ii), we get,

$$\frac{V}{T} \propto P \quad (\text{both } T \text{ & } P \text{ varies.})$$

or, $V = \frac{k}{P}$ where k is proportionality constant which value depends on amount of gas taken.

$$\text{or, } PV = kT$$

$$\text{or, } k = \frac{PV}{T} \quad \text{--- (iii)}$$

Equation (iii) is one form of Combined gas equation. If P_1, V_1 & T_1 are initial pressure, volume and temperature of a certain mass of a gas respectively. & P_2, V_2 & T_2 are final. Then,

According to equation of state,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = k \quad \left[\because \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \right]$$

Above eqn is combined gas equation.

Concept of Ideal Gas & real gas

A gas which obey the Boyle's law, Charles law and Combined gas eqn at all temperature and pressure conditions is called ideal gas or perfect gas. There are no ideal gas in nature but the known gases follows gas laws at low pressure high temperature.

A gas which does not obey Boyle's law, Charles law & Combined gas equation in low temperature & high pressure is called real gas. For e.g. H_2, N_2, CO_2

Ideal gas equation [$PV = nRT$]

where, P = pressure of gas

V = volume of gas

n = no. of mole of gas

R = Universal gas constant

T = Temperature of gas

Derivation of ideal gas equation:

According to Boyle's law

$$V \propto \frac{1}{P} \quad \text{--- (i) } [\because T \text{ is constant}]$$

According to Charles law

$$V \propto T \quad \text{--- (ii) } [\because P \text{ is constant}]$$

Similarly,

According to AVOGADRO's law,

$V \propto n$ --- (iii) [$\because T$ & P are kept constant]

Combining these three equation (i), (ii) & (iii). we get,

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

or, $V = \frac{RnT}{P}$ [$\because R$ is proportionality constant (K)
known as Universal gas constant]

$$\therefore PV = nRT$$

This equation is well known equation and
is called ideal gas equation.

Value of R :

The Universal gas constant R may be
defined as:

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

AT INTP : 1 mole gas occupies 22.4 litre.

Given, $n = 1$ mole, $V = 22.4$ litre, $T = 273$ K, $P = 1$ atm.
we know,

$$R = \frac{PV}{nT} = \frac{1 \text{ atm} \times 22.4 \text{ lit.}}{1 \text{ mole} \times 273 \text{ K}}$$

$$\therefore R = 0.0821 \text{ atm. litr.mole}^{-1} \text{ K}^{-1}$$

#

Q.3(B) Two vessel of capacity 1.5 litre and 2 litre contain hydrogen gas and oxygen gas respectively under a pressure of 750 mm and 100 mm. The gases are mixed together in a 5 litre vessel. What will be the final pressure of mixture?

Solution:

For hydrogen gas;

$$\text{Volume of } \text{H}_2 (V_1) = 1.5 \text{ litre}$$

$$\text{pressure of } \text{H}_2 (P_1) = 750 \text{ mm of Hg.}$$

$$\text{Total volume of gas} (V_2) = 5 \text{ litre}$$

$$\text{pressure } (P_2) = ?$$

$$\text{Now } P_1 V_1 = P_2 V_2$$

$$\text{or, } P_2 = \frac{P_1 V_1}{V_2} = \frac{750 \times 1.5}{5} = 225 \text{ mm of Hg.}$$

For Oxygen gas;

$$\text{Volume of } \text{O}_2 (V_1) = 2 \text{ litre.}$$

$$\text{pressure of } \text{O}_2 (P_1) = 100 \text{ mm of Hg.}$$

$$\text{Total volume of gas} (V_2) = 5 \text{ litre}$$

$$\text{pressure } (P_2) = ?$$

$$\text{Now } P_1 V_1 = P_2 V_2$$

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{100 \times 2}{5} = 40 \text{ mm of Hg.}$$

$$\text{or, } P_2 = \frac{P_1 V_1}{V_2} = \frac{100 \times 2}{5} = 40 \text{ mm of Hg.}$$

Again;

$$\text{Total pressure of gaseous mixture: } P_{\text{H}_2} + P_{\text{O}_2}$$

$$= 225 + 40$$

$$= 265 \text{ mm of Hg. } \#$$

Q. 4(A) A fire extinguisher having capacity 3 litres contains 4.4 kg. CO_2 . How much CO_2 gas will it deliver at NTP?

* Solution:

Given; mass of CO_2 (m) = 4.4 kg. = $4.4 \times 1000 = 4400$ gram.

Molecular weight of CO_2 (M) = 44

$V_2 = ?$ (At NTP)

T = 273 K, P = 1 atm, R = 0.0821 litre atm $\text{K}^{-1} \text{mol}^{-1}$

From Ideal Gas equation:

$$PV = nRT$$

$$\text{Or, } 1 \times V = \frac{m}{M} \times 0.0821 \times 273$$

$$\text{Or, } V = \frac{4400 \times 22.4183}{44} = 2241.83 \text{ litres}$$

3 litres remains in vessel.

Hence, It will deliver = $2241.83 - 3$

$$= 2238.33 \text{ litres} \quad \#$$

Q. 4(B) The mass of 525 ml of a gaseous compound at 28°C and 730 mm Hg. pressure was found to be 0.9 g. What will be the volume of 2 g. of the gas at 50°C and 760 mm Hg. pressure?

[Given; R = 0.0821 litre atm $\text{K}^{-1} \text{mol}^{-1}$]

Solution:

PART 1:

$$\text{mass}(m) = 0.9 \text{ g.m.}$$

$$\text{Volume}(V) = 525 \text{ ml} = 0.525 \text{ lit.}$$

$$\text{Temperature}(T) = 273 + 28 = 301 \text{ K}$$

$$\text{pressure of gas (P)} = 780 \text{ mm Hg} = 0.96 \text{ atm}$$

$$R = 0.0821 \text{ atm L K}^{-1} \text{ mol}^{-1}$$

$$\text{molecular mass (M)} = ?$$

$$\text{we know, } PV = nRT$$

$$\text{Or, } PV = \frac{m}{M} RT$$

$$\text{Or, } M = \frac{mRT}{PV} = \frac{0.9 \times 0.0821 \times 301}{0.96 \times 0.525} = 44.12 \text{ g.m.}$$

PART 2:

$$\text{mass}(m) = 2 \text{ gm.}, (T) = 30^\circ\text{C} = 303 \text{ K}, P = 760 \text{ mm Hg} = 1 \text{ atm}$$

$$\text{Molecular mass (M)} = 44.12 \text{ gm.}, R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$V = ?$$

$$\text{We know, } PV = nRT$$

$$\text{Or, } V = \frac{m \times RT}{M \times P} = \frac{2 \times 0.0821 \times 303}{44.12 \times 1} = 1.27 \text{ litre.}$$

Thus, the final volume is 1.27 litre.

Q. 5(A) A flask of 0.3 litre capacity was weighed after it had been evacuated. It was then filled with a gas of unknown molecular mass at 1.0 atm pressure and temperature of 300 K. The increase in mass of the flask was 0.977 g. Calculate the molecular mass of the gas?

* Solution:

Given: Volume (V) = 0.3 litre

Pressure (P) = 1 atm, Temperature (T) = 300 K

Weight of gas (w) = 0.977 gm, R = 0.0821 L atm K⁻¹ mol⁻¹

Molecular mass (M) = ?

Now

According to ideal gas equation;

$$PV = nRT$$

$$\text{or, } PV = \frac{w}{M} RT$$

$$\text{or, } M = \frac{wRT}{PV}$$

$$\text{or, } M = \frac{0.977 \times 0.0821 \times 300}{1 \times 0.3}$$

$$\therefore M = 80.2 \text{ g.m.}$$

B. 6(A) When 2 g. of a gas A is introduced into an evacuated flask kept at 25°C, the pressure is found to be one atmosphere. If 3 g. of another gas B is added to the same flask, the total pressure becomes 1.5 atmosphere at the same temperature. Assuming ideal behaviour of gases, calculate the ratio of molecular masses.

Solution:

For Gas A:

Given: weight of gas (w) = 2 g.m.

temp (T) = 25°C = (25 + 273) K = 298 K.

pressure (P) = 1 atm

volume of two ~~flask~~ flasks is same = 1 lit.

Molecular mass (M) = ?

We know, $PV = nRT$

$$\text{or, } PV = \frac{w}{M} RT$$

$$\text{or, } M = \frac{wRT}{PV} = \frac{2 \times 0.0821 \times 298}{1 \times 1} = 48.93$$

Hence, the molecular mass of gas A = 48.93 = M_A

For Gas B:

$m = 3$ g.m., $T = 25^\circ\text{C} = 298\text{ K.}$, $P = 0.5\text{ atm}$, $R = 0.0821\text{ L atm K}^{-1}\text{ mol}^{-1}$, $V = 1\text{ lit.}$

Now $PV = nRT$

$$\text{or, } PV = \frac{m}{M} RT$$

$$\text{or, } M = \frac{mRT}{PV} = \frac{3 \times 0.0821 \times 298}{0.5 \times 1} = 146.794$$

$$\therefore M_B = 48.93 \quad 48.93 : 146.794 = 1 : 3$$

$$\text{Again, } M_A : M_B = 146.794 : 48.93 = 1 : 3 \#$$

thus, the ratio of molecular masses is 1:3 #

Q.7(A) Two moles of ammonia are enclosed in a five litres flask at 27°C. Calculate the pressure exerted by gas assuming that the gas behaves like an ideal gas.

(Ans: 9.852 atm)

★ Solution: Given,

number of mole (n) = 2,

$$R = 0.0821 \text{ L atm } \text{K}^{-1} \text{ mol}^{-1}$$

$$\text{Temperature (T)} = 27^\circ\text{C} = (273 + 27) \text{ K} = 300 \text{ K}$$

pressure (P) = ?

volume of ammonia (V) = 5 lit.

Now

According to Ideal Gas equation;

$$PV = nRT$$

$$\text{or, } P = \frac{nRT}{V} = \frac{2 \times 0.0821 \times 300}{5} = 9.852 \text{ atm. } \#$$

Q.8(A) 0.50 g.m of a volatile liquid was introduced into a globe of 1000 ml capacity. The globe was heated to 91°C. so that all the liquid vaporized exerted a pressure of 190 mm Hg. (Ans: M = 59.76)

★ Soln: Given;

$$W = 0.50 \text{ g.m}, V = 1000 \text{ ml} = 1 \text{ lit}, T = 91^\circ\text{C} = 364 \text{ K}, P = 190 \text{ mm Hg.}$$

$$= 0.25 \text{ atm}, R = 0.0821 \text{ atm L } \text{K}^{-1} \text{ mol}^{-1} \text{ & } M = ?$$

$$\text{Now } PV = nRT \text{ or, } PV = \frac{W}{M} RT \text{ or, } M = \frac{WRT}{PV}$$

$$\text{or, } M = \frac{0.50 \times 0.0821 \times 364}{0.25 \times 1} = 59.76$$

thus, Molecular mass of given liquid is 59.76 #

Q.9(A) The balloon can hold 975(cc)(ml) of air at 5°C will it burst when it is taken into a home at 25°C ? Assume that the pressure of the gas in the balloon remains constant. (Ans: $V_2 = 1045.14 \text{ ml}$)

Soh:

For initial:

$$\text{Volume } (V_1) = 975 \text{ ml} = 0.975 \text{ ltr.}$$

$$\text{Temp}^{\circ} (T_1) = 5^{\circ}\text{C} = (273 + 5) \text{ K} = 278 \text{ K}$$

For final:

$$\text{Volume } (V_2) = ?$$

$$\text{Temp}^{\circ} (T_2) = 25^{\circ}\text{C} = 298 \text{ K}$$

Now,

According to Charles law,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{or, } V_2 = \frac{V_1 T_2}{T_1}$$

$$0.975 \times 298 = 1.045143855 \text{ ltr.}$$

$$\text{or, } V_2 = \frac{1.045143855}{278}$$

\therefore Balloon will burst; $\therefore V_2 = 1045.14 \text{ ml.}$ #

Q.10(A) Find the number of moles of molecules present in 50 ml of an ideal gas exerting a pressure of 770 mm at 25°C . ($R = 0.0821 \text{ L atm L}^{-1} \text{ mol}^{-1}$)

Soh:

Given; no. of moles (n) = ?, volume (V) = 50 ml = 0.05 ltr.

pressure (P) = 770 mm Hg. = 1.013 atm, Temp[°] (T) = 25°C = 298 K

$$R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

Now

$$PV = nRT$$

on $n = \frac{PV}{RT} = \frac{1.013 \times 0.05}{0.0821 \times 298} = 2.07 \times 10^{-3}$

thus, The number of moles is 2.07×10^{-3} #

II Dalton's law of partial pressure:-

Dalton's law of partial pressure states that, " In a mixture of two or more non-reacting gases, the total pressure of gases is equal to sum of partial pressure of component gas at constant temperature."

mathematically,

$$P_T = P_1 + P_2 + P_3 + \dots \text{ where } P_1, P_2, P_3 \text{ are partial pressure of gas 1, gas 2, gas 3 and so on and } P_T \text{ is total pressure of mixture.}$$

Derivation:

Dalton's law of partial pressure can be derived by using ideal gas equation let n_1, n_2 and n_3 are the no. of moles of component gases of a mixture contained in V volume of vessel and n is the total no. of moles of mixture.

$$\text{then, } n = n_1 + n_2 + n_3 + \dots \quad (i)$$

From ideal gas equation;

A aqueous tension is the pressure exerted by water vapour present in moist gas at only particular temperature. It is denoted by f . Its value depends upon temperature.

GRAHM'S LAW OF DIFFUSION:

It States that "Under Similar Condition of temperature and pressure, the rate of diffusion of gases is inversely proportional to square root of their densities."

mathematically,

$$r \propto \frac{1}{\sqrt{d}} \quad \text{--- (i)}$$

where, r = rate of diffusion of gas
 d = density of gas

DERIVATION:

According to the Graham's law of diffusion

$$r \propto \frac{1}{\sqrt{d}} \quad \text{--- (i)}$$

If r_1 and r_2 be the rates of diffusion of two gases and d_1, d_2 be their corresponding density then, $r_1 \propto \frac{1}{\sqrt{d_1}}$ (At constant T & P)

$$\text{or, } r_1 = \frac{k}{\sqrt{d_1}} \quad \text{--- (ii)}$$

Similarly, $r_2 \propto \frac{1}{\sqrt{d_2}}$

$$\text{or, } r_2 = \frac{k}{\sqrt{d_2}} \quad \text{--- (ii)}$$

Dividing (i) by (ii), we get,

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

Since, molecular weight of a gas is equal to twice of vapour density.

$$M = 2 \times \text{v. d.}$$

$$\text{or, v. d.} = M/2$$

$$d_1 = \frac{M_1}{2} \quad ? \quad \text{--- (iv)}$$

From eqn (iii) and (iv)

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

where M_1 and M_2 are molecular weight of two gases.

Again,

Rate of diffusion means vol^m of gas diffused per unit time

$$\text{i.e. } r = \frac{\text{Volume of a gas (V)}}{\text{time taken (t)}}$$

$$\text{or, } r = \frac{V}{t}$$

$$\text{or, } r_1 = \frac{V_1}{t_1}$$

$$r_2 = \frac{V}{t_2}$$

Putting in eqn (V)

$$\text{Or, } \frac{V_2}{T_1} / \frac{V_1}{T_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\text{Or, } \frac{t_2}{t_1} = \sqrt{\frac{m_2}{m_1}}$$

Time taken for diffusion of two gases of equal to V_{dm} is directly proportional to square root of their densities and molecular weight.

EFFUSION :-

It is difficult to determine the rate of diffusion but it is easy to determine rate of effusion is defined as the phenomena in which a certain V_{dm} of gas is allowed to escape through a small pin hole.

The rate of diffusion is always equal to  rate of effusion.

$$\text{if; } t_1 = t_2 = t$$

$$r = \frac{V}{t}, r_1 = \frac{V_1}{t_1}, r_2 = \frac{V_2}{t_2}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{d_2}{d}} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{r_1}{r_2} = \frac{V_1 t_2}{V_2 t_1} \quad \dots \quad (4)$$

Now,

$$\frac{r_1}{r_2} = \frac{V_1 t_2}{t_1 V_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{m_2}{m_1}}$$

Neumericals

Q.2

Q.1[A] How long will it take 500 ml of hydrogen gas to diffuse through a partition if 150 ml of oxygen diffuse in 50 minutes under similar conditions?

Solution:

For hydrogen gas, $V_{o.f.m} (V_1) = 500 \text{ ml}$, Time (t_1) = ?
molecular mass (m_1) = 2 g.

$$\text{Rate of diffusion of hydrogen} (r_1) = \frac{V_1}{t_1} = \frac{500}{t_1}$$

For Oxygen gas:

$V_{o.f.m} (V_2) = 250 \text{ ml}$

Time (t_2) = 50 minutes

molecular mass (m_2) = 32 g.

$$\text{Rate of diffusion of oxygen} (r_2) = \frac{V_2}{t_2} = \frac{250}{50} = 5$$

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{500}{t_1} = \sqrt{\frac{32}{2}}$$

$$\frac{500}{5 \cdot t_1} = \sqrt{16}$$

$$\frac{100}{t_1} = 4 \Rightarrow t_1 = 25 \text{ minutes}$$

Hence, the time will take by hydrogen gas is 25 minutes.

Q.2(A) A Saturated hydrocarbon C_nH_{2n+2} diffuse through a porous membrane twice as fast as Sulphur dioxide. Determine the molecular formula of the hydrocarbon.

* Solution:

The rate of diffusion of SO_2 , $r_1 = r$

The rate of diffusion of hydrocarbon (r_2) = $2r$

molecular mass of SO_2 (m_1) = $32 + 32 = 64$

molecular mass of hydrocarbon (m_2) = ?

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\text{or}, \frac{r}{2r} = \sqrt{\frac{m_2}{64}}$$

$$\text{or}, (0.5)^2 = \frac{m_2}{64}$$

$$\text{or}, 0.25 = \frac{m_2}{64}$$

$\therefore m_2 = 16$ Hence, the molecular mass of hydrocarbon = 16

Now,

$$C_nH_{2n+2} = 16$$

$$\text{or}, 12n + 2(2n+2) = 16$$

$$\text{or}, 12n + 2n + 2 = 16$$

$$\text{or}, 14n = 14$$

$$\text{or}, n = 1$$

molecular formula of hydrocarbon is $C_1H_{2n+2} = CH_4$
i.e. methane.

Q.2 [B] Hydrogen gas diffuse five times faster than another gas A. Find the molecular wt. of gas A.

★ Solution:

Given: rate of diffusion of gas A (r_1) = r
 " " " " " " " " hydrogen (r_2) = 5r
 molecular wt. of hydrogen (M_2) = 2
 " " " " " " " " gas A (M_1) = ?

We know,

$$\frac{r_1}{r_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\text{or, } \frac{r}{5r} = \sqrt{\frac{2}{m_L}}$$

$$m_1 \frac{1}{25} = \frac{2}{m_1}$$

$$\text{or, } m_1 = 50 \quad \#$$

Hence, molecular wt. of gas A is 50.

Q.2[E] The rate of diffusion of a saturated hydrocarbon (C_nH_{2n+2}) gas is 1.206 times that of SO_2 gas under identical conditions. Find the molecular mass and the value of ' n ' for the gas. (mol. mass of $SO_2 = 64$)

\star son: Given,

The rate of diffusion of SO_2 gas (r_1) = ?

" " " " " hydrocarbon (F_2) = 1.2068

molecular wt. of SO_2 (m_1) = 64

"Hydrocarbon (m_2) = ?

$$\text{Now, } \frac{r_1}{r_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\text{or, } \frac{r}{1.2068} = \sqrt{\frac{m_2}{64}}$$

$$\text{or, } \left(\frac{1}{1.206}\right)^2 = \frac{m_2}{64}$$

$$\text{or, } (0.829187)^2 = m_2/64$$

$$m_1 m_2 = 44$$

Hence, molecular mass of hydrocarbon is 44.00

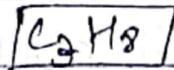
Again, $C_nH_{2n+2} = 44$

$$\text{or, } 12n + 2(2n+2) = 44$$

$$\text{or, } 12n + 2n + 2 = 44$$

$$\text{or, } 14n = 42$$

$$\text{or, } [n = 3]$$



Q.3(A) 0.23 g of a volatile liquid occupies 126.4 cc (ml) at $27^\circ C$ and 760 mm Hg. pressure. calculate the molecular weight of the liquid. How many molecules of the liquid are present in 0.23 g?



Solution:

$$\text{mass of volatile liquid (m)} = 0.23 \text{ g.}$$

$$\text{mol. wt. " " " (M)} = ?$$

$$\text{pressure " " " (P)} = 760 \text{ mm Hg} = 1 \text{ atm}$$

$$\text{Volume " " " (V)} = 126.4 \text{ cc} = \frac{126.4}{1000} = 0.1264 \text{ ltr.}$$

$$\text{Temp " " " (T)} = 27^\circ C = (27 + 273) K = 300 K$$

$$\text{Universal Gas Constant (R)} = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

We know, $PV = nRT$

$$\text{or, } PV = \frac{m}{M} RT$$

$$\text{or, } M = \frac{mRT}{PV} = \frac{0.23 \times 0.0821 \times 300}{1 \times 0.1264} = 44.81 \text{ g.m.}$$

$$1 \text{ mole of volatile liquid} = 44.81 \text{ g.m.}$$

$$\text{" " " " " } = 6.023 \times 10^{23} \text{ molecules}$$

$$44.81 \text{ gram } " " = 6.023 \times 10^{23} \text{ molecules}$$

$$1 \text{ g.m. } " " = 6.023 \times 10^{23} \text{ molecules}$$

$$0.23 \text{ g.m. } " " = \frac{6.023 \times 10^{23} \times 0.23}{44.81} "$$

$$= 3.09 \times 10^{-2} \times 10^{23} "$$

$$= 3.09 \times 10^{21} \text{ molecules}$$

Hence, the no. of volatile molecules is 3.09×10^{21} .

Q. 4(A) An evacuated glass vessel weighs 50 g. When empty.
 I.N.I.M.P. 148 g. When filled with a liquid of density 0.98 g/ml and 50.5 g. When filled with an ideal gas at 260 mm Hg at 27°C. Determine the molecular mass of the gas. How many no. of molecules are present in 12.3 g. in the gas?

Solution:

Given, wt. of empty Vessel = 50 g.m.

" " Vessel + Liquid = 148 g.m.

So, " " Liquid = (148 - 50) = 98 g.m.

Density " " (d) = 0.98 g/ml

$$\rho = \frac{m}{V}; v = \frac{m}{\rho}$$

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So, Volume of Liquid (v) = $\frac{m}{\rho} = \frac{98}{0.98} = 100 \text{ ml}$

Volume of Liquid (v) = Volume of vessel = 100 ml

Again,

Weight of empty vessel = 50 g.

" " Vessel with ideal gas = 50.5 g.

So, " " Ideal gas (w) = (50.5 - 50) g.m. = 0.5 g.m.

Volume " " " " (V) = 100 mL = 0.1 Ltr.

Temp " " " " (T) = 27°C = 300 K

pressure " " " " (P) = 760 mm Hg = 1 atm

$R = 0.0821 \text{ Ltr. atm. } \text{K}^{-1} \text{ mol}^{-1}$

Molecular mass of ideal gas (M) = ?

We know;

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

$$\text{or, } M = \frac{wRT}{PV} = \frac{0.5 \times 0.0821 \times 300}{1 \times 0.1} = 123.15 \text{ g.m.}$$

Hence, molecular mass of gas is 123.15 g.m.

We know that,

1 mole of a gas = 123.15 g.m.

1 " " " " = 6.023×10^{23} molecules

123.15 g.m. gas = 6.023×10^{23} molecules

$$\frac{123.15 \text{ g.m.}}{123.15} = \frac{6.023 \times 10^{23} \times 12.3}{123.15} = 6.015 \times 10^{22} \text{ molecules}$$

Q.5[A] A spherical balloon of 21 cm diameter is to be filled with hydrogen gas at NTP from a cylinder containing gas at 20 atm. and 27°C . If the cylinder can hold 2.66 ltr. of water vapour at NTP. calculate the no. of balloon that can be filled up?

* Solution:

$$\text{Diameter of Sphere (d)} = 21 \text{ cm}$$

$$\text{Radius } " " "(r) = \frac{21}{2} = 10.5 \text{ cm}$$

$$\text{Volume } " " "(V_1) = \frac{4}{3}\pi r^3 = \frac{4}{3} \times \frac{22}{7} \times (10.5)^3 = 4846.59 \text{ cm}^3$$

pressure of Hydrogen (H_2) gas (P_2) = 1 atm.

$$\text{Temp}^\circ \text{ (T}_2\text{)} = 273 \text{ K}$$

For NTP.

$$V_1 = ? , P_2 = 20 \text{ atm}, T_2 = 27^\circ\text{C} = 300 \text{ K},$$

$$\text{We know that, } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\text{or, } \frac{1 \times 4846.59}{273} = \frac{20 \times V_2}{300}$$

$$\therefore V_2 = 266 \text{ cc (ml)}$$

Here, The vol^m of Water vapour that can hold in cylinder = 2.66 ltr. = 2660 cc

The no. of balloon that can be filled by hydrogen gas = $\frac{2660 \text{ cc}}{266 \text{ cc}} = 10$

$$\frac{2660 \text{ cc}}{266 \text{ cc}} = 10$$

Hence, no. of balloon = 10 \pm

Q.6(C) A gas X diffuses five times as rapidly as another gas Y. calculate the ratio of molecular mass of X & Y.

Solution:

For X gas;

$$\text{Diffusion rate}(r_1) = 5r$$

$$\text{molecular mass}(M_1) = M_1$$

For Y gas;

$$\text{Diffusion rate}(r_2) = r$$

$$\text{molecular mass}(M_2) = M_2$$

We know,

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

$$\text{or, } \frac{5r}{r} = \sqrt{\frac{M_2}{M_1}}$$

$$\text{or, } 25 = \frac{M_2}{M_1}$$

$$\text{or, } 25 M_1 = M_2$$

$$\text{or, } \frac{M_1}{M_2} = \frac{1}{25}$$

$$\therefore M_1 : M_2 = 1 : 25 \quad \#$$

Q.7(C) Calculate the volume occupied by 5.0 g. acetylene gas at 50°C and 740 mm Hg. pressure.

Solution:

molar mass of acetylene (C_2H_2) (M) = $(12 \times 2) + (2 \times 1) = 26 \text{ g/mol}$
mass of acetylene (m) = 5 g.m.

$$\text{Temp}^{\circ} (T) = 50^{\circ}\text{C} = 223 \text{ K}$$

$$\text{pressure (p)} = 740 \text{ mm Hg.} = \frac{740}{760} = 0.9737 \text{ atm.}$$

$$\text{Volume (V)} = ?$$

According to ideal gas eqn,

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

$$\text{or, } V = \frac{mRT}{PM} = \frac{5 \times 0.0821 \times 323}{0.9737 \times 26}$$

$$\therefore V = 8.51 \text{ lit.} \#$$

Q.7[B] One mole of a gas Occupies a vol. m. of 1 litre at 27°C. What will be the pressure of the gas?

* Soln:

No. of mole of gas (n) = 1 mol.

Vol. m. of gas (V) = 1 lit.

Temp of gas (T) = 27°C = 300 K

pressure of gas (P) = ?

$$R = 0.0821 \text{ L. atm } \text{K}^{-1} \text{ mol}^{-1}$$

We know, $PV = nRT$

$$\text{or, } P = \frac{nRT}{V} = \frac{1 \times 0.0821 \times 300}{1} = 24.63 \text{ atm}$$

Hence, pressure of gas is 24.63 atm. #

Q.7[C] Calculate the mass of oxygen gas whose Vol. m. is 320 ml at 17°C and 2 atm pressure?

* Soln:

mass of O_2 = ? = (m).

molecular mass of O_2 (M) = 32

Volume of O_2 (V) = 320 ml = 0.320 lit.

pressure of O_2 (P) = 1 atm

$$\text{Temp}^r (T) = 17^\circ\text{C} = (17+273) \text{K} = 290 \text{K}$$

$$R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

We know;

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

$$\text{or, } m = \frac{PVM}{RT} = \frac{2 \times 0.320 \times 32}{0.0821 \times 290} = 0.860 \text{ g.m.}$$

Hence, mass of Oxygen is 0.86 g.

Q.8 [A] A gas occupies 350 ml at 40°C . Calculate the temp^r at which the vol^m of the gas becomes 400 ml. Assume that the pressure remains constant?

Solution:

$$V_1 = 350 \text{ ml}$$

$$V_2 = 400 \text{ ml}$$

$$T_1 = 40^\circ\text{C} = (40+273) \text{K} = 313 \text{K} \quad T_2 = ?$$

Now,

According to the charle's law,

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

$$\text{or, } \frac{350}{313} = \frac{400}{T_2}$$

$$\therefore T_2 = 357.71 \text{ K}$$

Hence, the required temp is 357.71 K.

KINETIC MOLECULAR THEORY OF GASES:-

In order to explain the kinetic behaviour and molecular behaviour of gases, 1738 AD. Bernoulli, Maxwell, Boltzmann & Clausius put forward

57.23

Liquid State

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Solution:

A solution is defined as the perfectly homogeneous mixture of two mixed components. The two components of a solution are called Solute and Solvent.

* Solute: The component of the solution which gets dissolved in another substance is called Solute.

* Solvent: The component of the solution which dissolves the solute is called Solvent.

↳ Types of Solution:

1) Unsaturated Solution:- A solution which can dissolve additional amount of solute at given temperature is called Unsaturated Solution.

For e.g.: Very dilute solution of water & sugar

2) Saturated Solution:- A solution which can not dissolve additional amount of solute at given temperature is called Saturated Solution. In Saturated Solution there is eq. between Solute & Solvent.
For e.g.: Concentrated solution of sugar in water.

3) Supersaturated Solution:- A solution which holds more solute than required to saturate at that temperature is called Supersaturated Sol-

ution. When Saturated Solution prepared at higher temperature is allowed to cool, dissolved Solute is held by Solution Sometime but after sometime it throughout as crystal. Such Solution is known as Supersaturated Solution.

Solubility:

The amount of Solute in gm that can be dissolved in 100 gm Solvent to form Saturated Solution at a particular temperature is known as Solubility of that Substance.

The formula is:

$$\text{Solubility of a substance} = \frac{\text{Wt. of Solute in gm.}}{\text{Wt. of Solvent in gm.}} \times 100$$

It has no unit. It depends upon temperature.

Determination of solubility of a Soluble Salt (like NaCl) in water at lab temperature:

Observation

$$\text{Wt. of Empty Crucible} = W_1 \text{ gm.}$$

$$\text{Wt. of Crucible and Solution} = W_2 \text{ gm.}$$

$$\text{Wt. of Crucible and residue} = W_3 \text{ gm.}$$

Now,

$$\text{Wt. of Solution} = (W_2 - W_1) \text{ gm}$$

$$\text{Wt. of residue} = (W_3 - W_1) \text{ gm}$$

$$\text{Wt. of Solvent (water)} = W_2 - W_1 - W_3 + W_1 = (W_2 - W_3) \text{ gm.}$$

Since, $\frac{\text{wt. of residue in gm}}{\text{wt. of solvent in gm}} \times 100$

Solubility = $\frac{\text{wt. of solvent in gm}}{\text{wt. of solution in gm}}$

$$= \frac{W_2 - W_3}{W_1 - W_3} \times 100$$

★ Solubility Curve:-

A plots drawn between solubility and temperature are called Solubility curve. Generally, Solubility of most substance (e.g. like KCl , KNO_3 , CaSO_4) increases with increase in temperature. But solubility of some substances decreases with increase in temperature (e.g. NaOH , Ca(OH)_2).

L) TYPES OF Solubility Curve

1) Continuous Solubility Curve: The Solubility Curve which shows regular increase or decrease in Solubilities with rise in temperature is called Continuous Solubility Curve. This type of Curve is shown by anhydrous substance like NaCl , NaOH , KBr , KNO_3 , CaCHCOO_2 , etc.

2) Discontinuous Solubility Curve: The Solubility Curve which shows irregular increase and decrease in Solubilities with rise in temperature is called discontinuous Solubility Curve.

This type of curve is shown by hydrated substances like $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ etc.

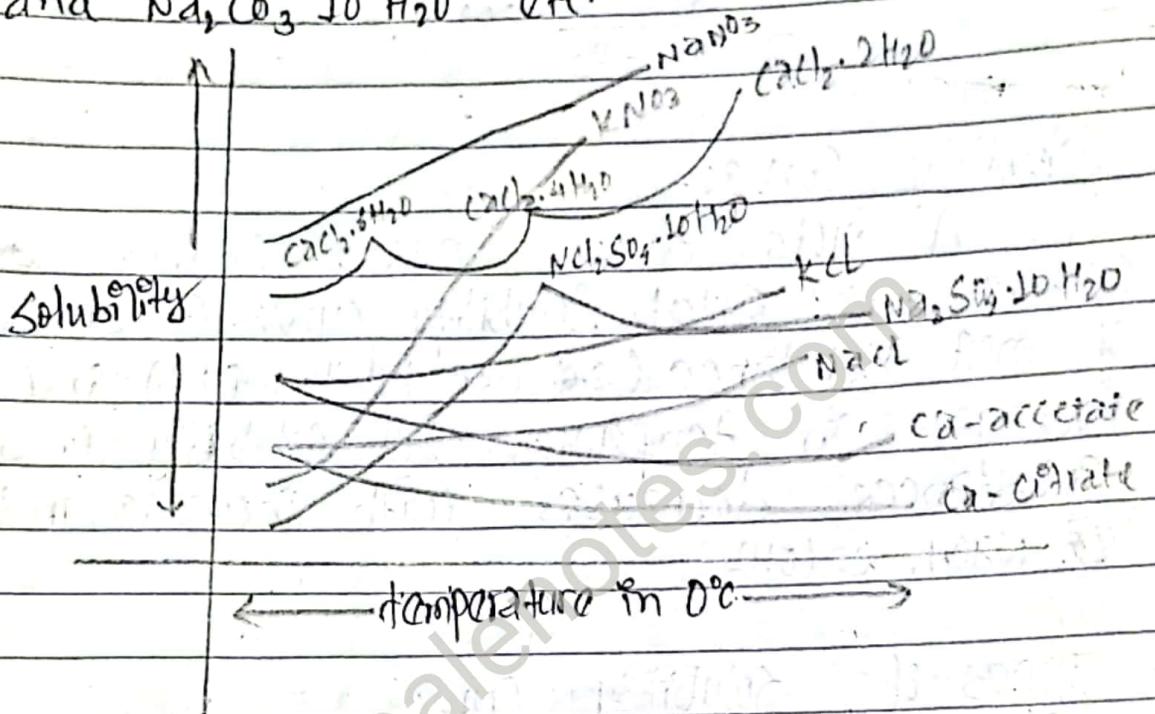


Fig: Solubility Curve

- * Information (application) of Solubility Curve: (Substance)
 - 1) It explains the effects of temp^r on the Solubility of a ^.
 - 2) It indicates the solubility of substance at certain temperature.
 - 3) It informs about the nature of substance either it is anhydrous or hydrated.
 - 4) It helps in comparing the solubilities of different substances.
 - 5) It shows a change in composition of hydrated substance.

properties of Liquids:-

1) Vapour pressure:-

When a liquid is placed in a closed vessel, the evaporating molecules can't escape out and exert pressure on the vessel.

The pressure exerted by the vapour of liquid at the surface of given temperature is known as vapour pressure. The vapour pressure increases with increasing temperature.

Vapour pressure of liquid depends upon following factors:

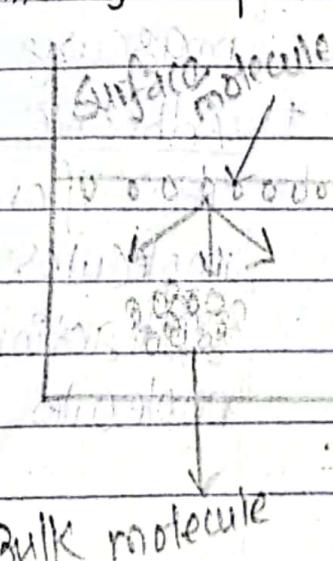
i) Temperature

ii) Nature of Liquid

iii) Impurities present

2) Boiling point : "The temperature at which vapour pressure of a liquid becomes equal to the atmospheric pressure is known as boiling point."

3) Surface tension: Molecules in the bulk of liquid are attracted equally on all sides so that net attractive pull on these molecules is 0. But Surface molecules are attracted from below only. The attractive force acting on surface molecules is called Surface tension.



It is defined as the force per unit length acting at right angle to the surface. Its SI unit is N/m and CGS unit is dynes/cm. Due to Surface tension, surface area of liquid tends to contract to smallest surface area for a given volume of the liquid. For e.g. Sphere has minimum surface area for a given volume of liquid. This explains why drops of liquids are spherical. Surface tension minimises the surface area of a liquid.

Surface area of a liquid is minimised by surface tension due to which soap, detergent and tooth paste are used for cleaning the cloths and tooth paste. Soap, detergents etc decrease the surface tension and show their cleaning action.

→ Cohesive and Adhesive force

Cohesive force:-

↳ The force of attraction between similar type of molecules called cohesive force. Force of attraction between water molecules, glass molecules, molecules of mercury etc is cohesive force.

Adhesive force:-

↳ The force of attraction between different kinds of molecules is called adhesive force. The force of attraction between glass and molecules and water molecules is adhesive force.

Capillary Action:

↳ The rising or falling of liquid from its surface in the capillary tube when capillary tube inserted into the liquid due to different cohesive and adhesive force is called capillary action.

If cohesive force is greater than adhesive force, liquid falls in the capillary tube by forming concave meniscus downward.

For example: The meniscus of mercury is concave downward in the capillary tube.

If adhesive force is greater than cohesive force, liquid rises in the capillary tube from its level by forming convex meniscus.

For example: the meniscus of water is convex downward in capillary tube.

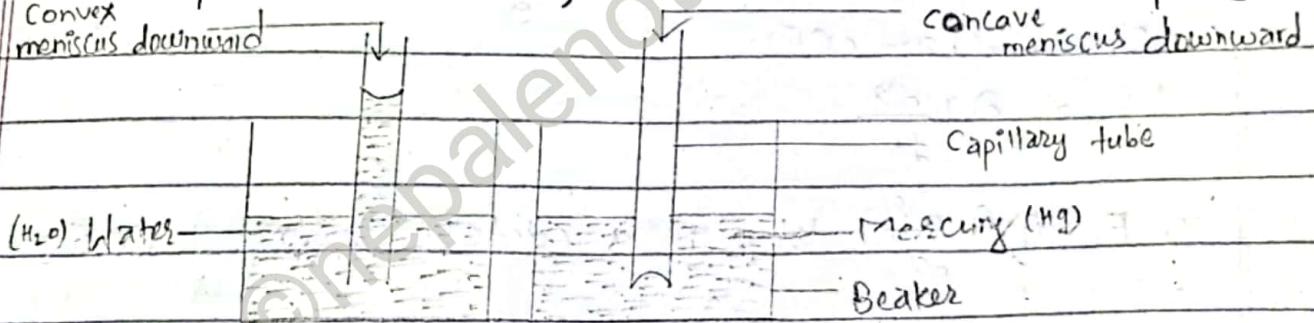


Fig: (Rise of water) and (Fall of mercury) in capillary tube.

SB-1) Falling liquid drops are spherical. Give reason.

↳ Falling liquid drops are spherical due to surface tension. Where surface tension minimise the surface area of a liquid. So, falling liquid drops are spherical. Where sphere has a minimum surface area.

Viscosity:-

↳ Viscosity is defined as the internal resistance to flow of a liquid which one layer offers to another layer trying to pass over it.

A liquid flows by making many layers of molecules and each layer has different velocity.

Viscosity of liquid depends on the force of attraction between the molecular layers and temperature. Higher the molecular force, higher will be the viscosity but increase in temperature decrease the viscosity of liquid because of increase in K.E. of the liquid molecules.

Viscous force is opposing force which is directly proportional to area of contact and velocity gradient.

$$\text{i.e., } F \propto A - \text{eqn(i)} \quad \& \quad F \propto \frac{dv}{dx} - \text{eqn(ii)}$$

combining eqn(i) and eqn(ii)

$$F \propto A \times \frac{dv}{dx}$$

$$\text{or, } F = \eta A \frac{dv}{dx} \quad \text{Where } \eta \text{ is called the coefficient of viscosity.}$$

$$\text{or, } \eta = \left(\frac{F}{A} \right) : \left(\frac{dv}{dx} \right)$$

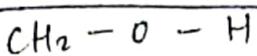
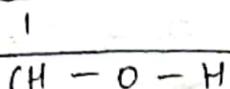
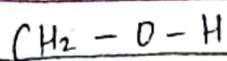
If $\frac{dv}{dx} = 1 \text{ cm/s}$ & $dx = 1 \text{ cm}$, then :

$$\boxed{\eta = \frac{F}{A}}$$

Where η is proportionality constant & said to be coefficient of viscosity. It is defined as the force per unit area required to maintain unit difference in velocity between two layers of liquid separated by unit distance apart. Its unit is 'poise' or $Nm^{-2} \text{ sec}$. [$1 \text{ poise} = 1 \text{ dyne cm}^{-2} \text{ sec}$]

For example:-

Glycerine is more viscous than alcohol & water due to triple hydrogen bonding in glycerine.



sites for the formation of
hydrogen bonding.

fig: Glycerol.

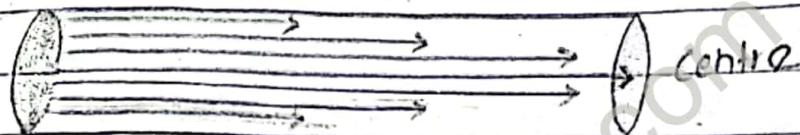


fig: Flow of liquid through a Pipe

Solid State:

Solid state:-

→ The physical state of matter which have fixed shape, fixed volume and fixed mass is called Solid state.

On the basis of physical structure, Solids are of two types:-

- 1) Crystalline Solids
- 2) Amorphous Solids

[1] Crystalline Solids:

→ The solids whose constituents (atom, molecule or ion) are arranged in orderly arrangement in three dimensional pattern are called Crystalline Solids. They are in the form of crystals. They have sharp melting point. For e.g.: NaCl, diamond, graphite, solid CO_2 , etc.

[2] Amorphous Solids:-

→ Those solid substances whose constituents (atom, molecule or ion) are not arranged in orderly in three dimensional pattern are known as amorphous Solids. For e.g.: lime, plastic, glass, etc.

Distinguish between Crystalline & Amorphous Solids:-

Crystalline Solids	Amorphous Solids
1. Those solid substances whose constituent particles are arranged in regular order are called crystalline solids.	1. Those solid substances whose constituent particles are not arranged in regular pattern are called amorphous solids.
2. They have crystals.	2. They are in powdery form.
3. They have sharp melting point.	3. They have no sharp melting point.
4. They are anisotropic.	4. They are isotropic.
5. Example:- ice, dry ice, diamond, blue vitriol, etc.	5. Example:- Lime, anhydrous substances, glass, plastics etc.

Definition of Isotropic & Anisotropic Solids:-

The substances whose physical properties like electrical conductivity, refractive index, thermal conductivity, thermal expansion, are same in all directions are called isotropic substances and phenomenon is called isotropy.

Those substances whose physical properties like thermal conductivity etc. are not identical in all directions are called anisotropic substances and phenomenon is called anisotropy.

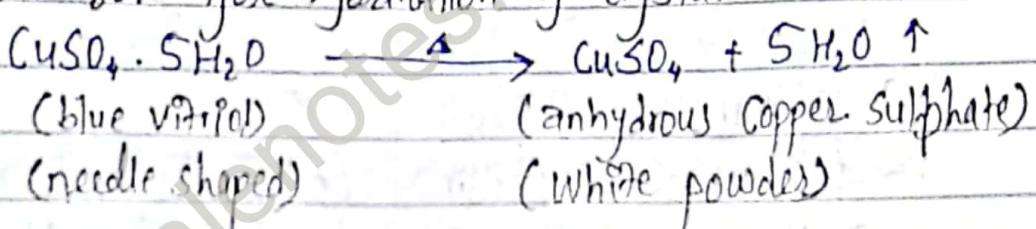
The crystalline solids possess anisotropic nature while amorphous solid possess isotropic nature.

Water of Crystallization:-

→ Every molecule of some hydrated Crystalline Solid Contains a certain number of water molecules as its Constituent. The water associated with crystal as Constituent is called Water of Crystallization.

For e.g.: $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ & $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

The crystalline Solids having water of Crystallization is called hydrated Crystalline Solid. Water of crystallization plays important role for formation of crystal.



Note's

There are some crystalline solids which do not contain water of crystallization, such solids are called unhydrated crystalline solids. For e.g.: - NaCl , AgNO_3 , KCl

Types of Solids:

(1) Hygroscopic Solids:-

→ There are certain solids which absorb moisture from air when exposed to atmosphere and becomes hydrated. Such solids are called hygroscopic solids and phenomenon is called hygroscopy.

Here, the vapour pressure of solid is less than atmospheric pressure. For e.g:- Anhydrous Copper Sulphate, anhydrous

Calcium chloride, etc.

[2] Deliquescent Solids:-

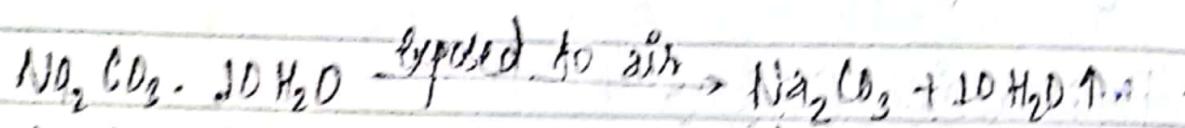
→ Those hygroscopic solids which absorb moisture from air upto such extent that they become solution when exposed to atmosphere are called deliquescent solids. This phenomenon is called deliquescence.

Here, the vapour density pressure of water in the system is very less than pressure of water vapour at atmosphere. For e.g.- NaOH, KOH, MgCl₂, etc.

[3] Efflorescent Solids:-

→ The certain crystalline solids lose their water of crystallization when exposed to atmosphere at ordinary temperature are called efflorescent solids and phenomenon is called efflorescence.

Here, the vapour pressure of water in atmosphere. Thus, they lose water of crystallization. For e.g.- hydrated sodium carbonate.



Washing Soda:

Soda Ash

4) Crystals:-

→ The smallest pieces of a solid which have certain geometrical shape, sharp edges and smooth surfaces are called crystals.

Unit cell:-

↪ Unit cell is a smallest geometric pattern which when repeated again and again in three dimensional space generates whole crystal.

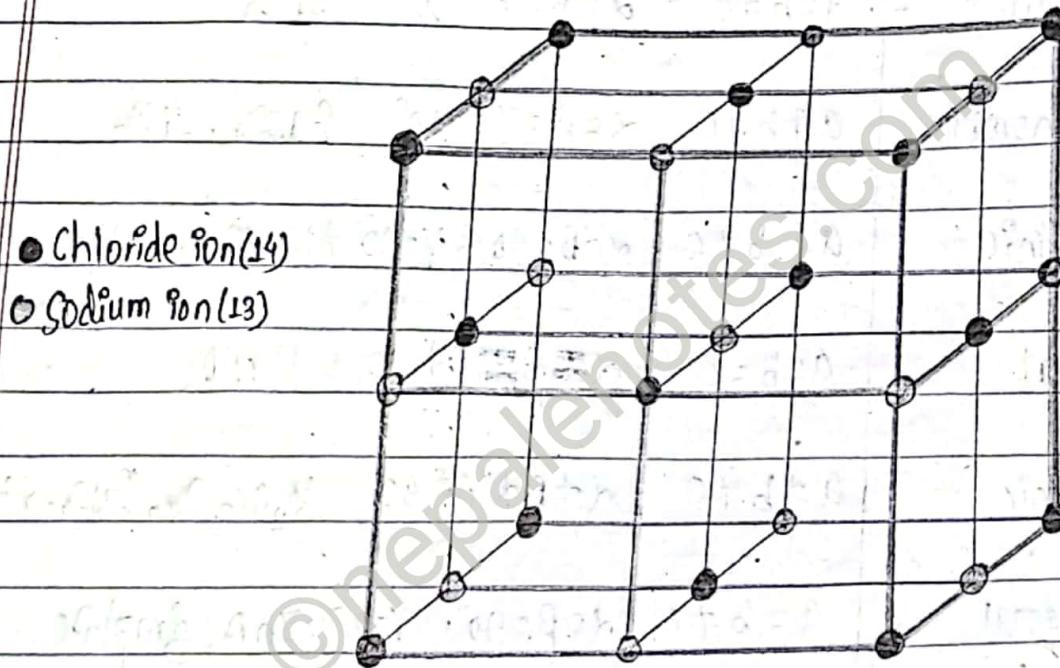


fig: Unit cell of NaCl

Classification of Crystal System:-

↪ The crystal system is ~~in~~ Seven types. 14 types of Lattice are possible in a crystal. The 14 independent arrangement of Lattice points in crystal space are called Bravais Lattices.

The properties of 7 unit cells:-

No.	System	Edge	Angle	example
1.	Cubic	$a=b=c$	$\alpha=\beta=\gamma=90^\circ$	NaCl, KCl, diamond
2.	Tetragonal	$a=b \neq c$	$\alpha=\beta=\gamma=90^\circ$	SnO_2
3.	Orthorhombic	$a \neq b \neq c$	$\alpha=\beta=\gamma=90^\circ$	$\text{BaSO}_4, \text{KNO}_3$
4.	Monoclinic	$a \neq b \neq c$	$\alpha=\beta=90^\circ \& \gamma \neq 90^\circ$	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
5.	Trigonal	$a=b=c$	$\alpha=\beta=\gamma \neq 90^\circ$	NaN_3
6.	Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90^\circ$	$\text{K}_2\text{Cr}_2\text{O}_7, \text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
7.	Hexagonal	$a=b \neq c$	$\alpha=\beta=90^\circ \& \gamma=120^\circ$	$\text{ZnO}, \text{graphite}$

Cubic system:-

↳ Cubic crystals are three types on the basis of unit cell.

(1) Simple Cubic crystal:-



fig:- Simple cubic crystal

It is Cubic Crystal in which structural units lie at the eight corners of the Cube. is Simple Cubic.

[2] Body centred Cubic Crystal:-

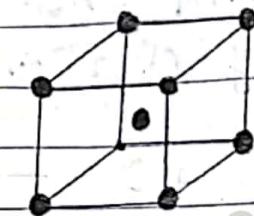


fig:- Body centred Cubic crystal

A unit cell having lattice point at the centre of the body in addition to the lattice point at the corner of cube is called body centred cubic crystal.

[3] Face Centred Cubic Crystal:-

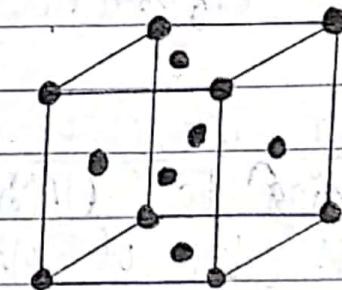


fig:- Face centred Cubic crystal

The Cubic Crystal in which structural units not only lie at the eight corner of the cube but also on the each face (6 faces) of the cube is called face centred cubic Crystal.