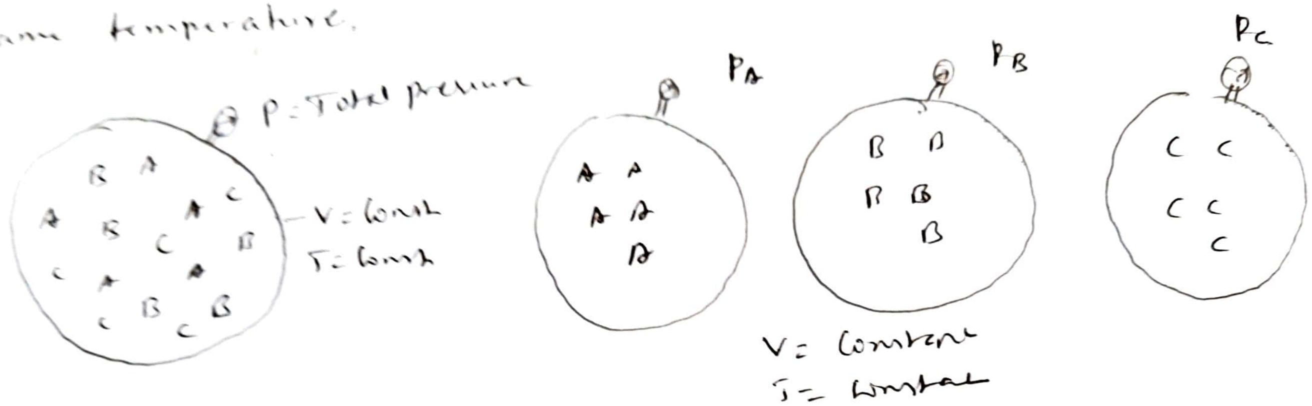
Gaseous mixtures:

Partial pressure:

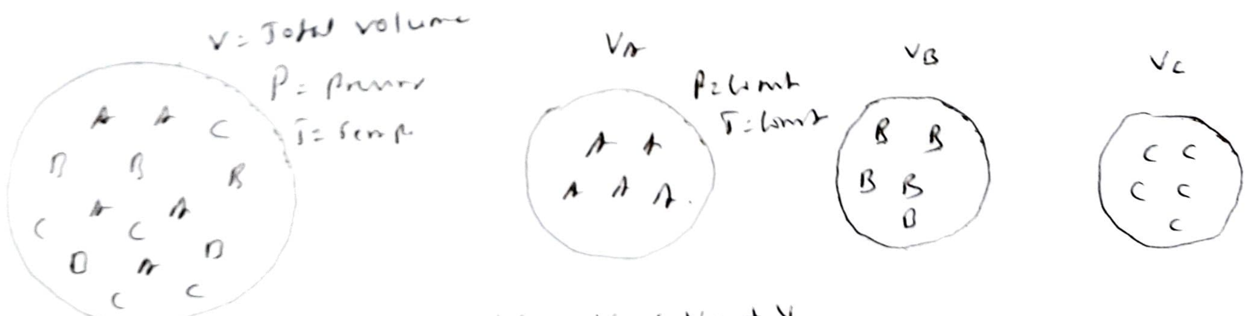
Partial pressure of a component gas in a gas mixture is the pressure that would be exerted by the component gas if it alone occupied the volume of the mixture ~~were present in the same volume and~~ at the same temperature.



$$P = P_A + P_B + P_C$$

Pure component volume

The pure component volume of a component gas in a gas mixture is the volume that would be occupied by that component gas when it alone were present at the same pressure and temperature.



$$V = V_A + V_B + V_C.$$

DALTON'S LAW. In an ideal gas mixture, the total pressure is the sum of the partial pressures exerted by each component

~~Amagat's Law:~~ ~~In an ideal gas mixture,~~ the ~~Total~~ total pressure ~~occupied by a gaseous mixture is equal to the sum of the pure-component volumes~~ is the sum of the partial ~~pressures exerted by~~ pressures exerted by each component

$$P = P_A + P_B + P_C + \cdots \qquad (1)$$

or $$P = \sum P_i$$

AMAGAT'S LAW

Total volume occupied by the gaseous mixture is equal to the sum of the pure-component volumes; that is

$$V = V_A + V_B + V_C + \cdots \qquad (2)$$

or $$V = \sum V_i \, .$$

If V_i is the volume occupied by the component i, if it alone is present at pressure p and temperature T of the mixture

$$V_i = \frac{n_i RT}{P} \qquad (3)$$

when, n_i is the numbers of moles of component i,

From equation (2), it is clear that V_i is proportional to n_i. In other words, the volume % of a component in a gas mixture equals to mole % of it. This is strictly true for ideal gases.

Partial pressure :- The pressure exerted by each component is called partial pressure or pure-component pressure. In other words

$$P_i = \frac{n_i RT}{V} \qquad (4)$$

From eqn (3) and eqn (4), for an ideal gas mixture

$$\text{volume } \% = \text{mole } \% = \text{pressure } \% \qquad (5)$$

Equation (5) is very important equation in stoichiometry.

[In mixture of gases, each gas has a partial pressure which is the hypothetical pressure of that gas if it alone occupied the volume of the mixture at the same temperature]

Average molecular weight

Mathematically $M = \Sigma (M_i \cdot x_i)$ ——— (6)

M_i - molecular weight of the i th component

Gas - liquid mixtures.

At low concentration of gas Raoults law does not hold good. For such non-ideal behaviour, Henry's law is found to be useful. If P_i is the partial pressure of solute gas i,

$$P_i = H_i \cdot x_i \quad \text{———} \quad (7)$$

Where, x_i is the mole fraction of the ith component in the solution and H_i is the Henry's law constant

Eg. (2.17) Calculate the average molecular weight and composition by weight of air. ~~The~~ An average composition of air at sea level by volume is given below.

Composition of Air at Mean Sea Level

Gas	Mole %.
Nitrogen	78.084
Oxygen	20.946
Argon	0.934
Carbon dioxide	0.033
Neon	18×10^{-4}
Helium	5.2×10^{-4}
Krypton	1.1×10^{-4}
Hydrogen	0.5×10^{-4}
Xenon	0.08×10^{-4}

In general, it can be taken that oxygen, nitrogen and argon are present to the extent of 21%, 78% and 1% respectively (on a volume basis)

Basis : 100 Kmol of air.

Gas	Formula	Molecular weight	Kmol	weight Kg	weight %
Oxygen	O_2	31.9988	21	31.9988 × 21 = 671.786	23.19
Nitrogen	N_2	28.0135	78	28.0135 × 78 = 2185.051	75.43
Argon	Ar	39.948	1	39.948 × 1 = 39.948	1.38
		~~100.000~~	100.00	2896.785	100.00

Average molecular weight of air $= \frac{2897}{100} = 28.97$

Example (2.18) Craked gas from a petroleum refinery has the following composition by volume : Methane 45%; Ethane 10%, Ethylene 25%, propane 7%, Propylene 8%, n-Butane 5%.

Find

ⓐ the average molecular weight of the gas mixture

ⓑ the composition by weight

ⓒ specific gravity of the gas mixture

Solution : Basis : 100 Kmol of cracked gas

gas.	Formula	vol%.	mole (Kmol)	Mol. wt.	Weight Kg	weight %.
Methane	CH_4	45%.	45	16	720	27.13
Ethane	C_2H_6	10%.	10	30	300	11.3
Ethylene	C_2H_4	25%.	25	28	700	26.37
Propane	C_3H_8	7%.	7	44	308	11.61
Propylene	C_3H_6	8%.	8	42	336	12.66
n-Butane	C_4H_{10}	5%.	5	58	290	10.93
		100%.	100	~~2654~~	2654	100.00

Average molecular weight of the mixture $= \frac{2654 \text{ Kg}}{100 \text{ Kmol}}$

$= 26.54 \text{ Kg/Kmol}.$

Specific gravity of gas mixture $= \frac{26.54}{28.97} = 0.9161$ Ans