(2.33) A gas mixture has the following composition by volume

Ethylene	30.6 %
Benzene	24.5 %
Oxygen	1.3 %
Methane	15.5 %
Ethane	25.0 %
Nitrogen	3.1 %

Find (a) the average molecular weight of the gas mixture
(b) the composition by weight
(c) the density of the mixture in kg/m3 at NTP.

Basis: 100 Kmol of ~~[illegible]~~ gas mixture.

~~Ethylene(C_2H_2) vol %~~

Gas	formula	M.wt.	vol %	Kmol	weight	wt %
Ethylene	C_2H_2	26	30.6	30.6	795.60 ~~633.60~~	~~17.75~~ 17.25
Benzene	C_6H_6	78	24.5	24.5	1911.00	52.05
Oxygen	O_2	32	1.3	1.3	41.60	1.13
Methane	CH_4	16	15.5	15.5	248.00	6.75
Ethane	C_2H_6	30	25.0	25.0	750.00	20.43
Nitrogen	N_2	28	3.1	3.1	86.80	2.36
				100.0	~~3671.00~~ 3833.00	100.00

30.6 × 26 = 612 / 633.6

78 × 24.5: 390, 312, 156 → 1911.0

1.3 × 32: 26, 39 → 41.6

15.5 × 16 → 248.0

3.1 × 28: 248, 62 → 86.8

$$\text{Avg. mol. wt} = \frac{3671 \text{ kg}}{100 \text{ Kmol}}$$

$$= 36.71 \text{ kg/Kmol}$$

Ideal gas law.

Boyle's law states that for a given mass of an ideal gas, ~~the ratio of the volume to temperature is constant at a given pressure~~ the product of pressure & volume is constant at constant temperature

$$P \times V = \text{Constant}$$

Where P. absolute pressure and V is the volume occupied by the gas.

Charle's law states that for a given mass of an ideal gas, the ratio of the volume to temperature is constant at a given pressure.

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

Where, T is absolute temperature

Combining the above two laws

$$\frac{P \times V}{T} = \text{Constant}$$

$$\frac{P \times V}{T} = R$$

$$PV = RT$$

For 'n' mole of gas

$$PV = nRT$$

$$PV = C_1 \qquad \frac{V}{T} = C_2$$

$$V = \frac{C_1}{P} \qquad V = TC_2$$

$$V = f\left[\frac{T}{P}\right]$$

$$V \propto \frac{1}{P} \qquad V \propto T$$

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

$$PV \propto T$$

$$\frac{PV}{T} = C_3$$

$$\frac{PV}{T} = R.$$

Value of Universal Gas constant (R):

Numerical value of R	Units
8.31451	$m^3 . kPa / k.mol . K$
0.008314	$m^3 , MPa / k.mol . K$
0.08206	$l . atm / mol . K$
0.08206	$m^3 . atm / kmol\ K$
1.987	$kcal / kmol . K$
8.31451	$J / mol . K$

Relation between partial pressure, mole fraction of component gas to total pressure.

Consider the gas consisting of component gases A, B, C etc.

Let V be the total volume of gas mixture and P be the total pressure exerted by mixture

V_A, V_B, V_C are pure component volumes of A, B, C etc respectively

P_A, P_B, P_C etc are partial pressures of component gases A, B, C etc respectively.

Ideal gas law for component 'A' is

$$P_A V = n_A RT$$

$$P_A = \frac{n_A RT}{V} \quad \text{———} \quad (1)$$

Similarly for component B

$$P_B = \frac{n_B RT}{V} \quad \text{———} \quad (2)$$

For component 'C'

$$P_C = \frac{n_C RT}{V} \quad \text{———} \quad (3)$$

Adding Equations (1), (2), (3) etc

$$P_A + P_B + P_C + \dots = (n_A + n_B + n_C + \dots)\frac{RT}{V} \quad \text{———} \quad (4)$$

~~Dalton's law states~~

~~$P = P_A + P_B + P_C + \dots$~~

Divide equ (1) by equ (4)

$$\frac{P_A}{(P_A + P_B + P_C + \dots)} = \frac{n_A}{(n_A + n_B + n_C + \dots)} \quad \text{———} \quad (5)$$

$$\frac{P_A}{P} = \frac{n_A}{n}$$

multiply both sides by 100

$$\frac{P_A}{P} \times 100 = \frac{n_A}{n} \times 100$$

Pressure % of A = mole % of A.

When ideal gas law is applicable it is written for component gas 'A' as.

$$PV_A = n_A RT \quad \text{——— (6)}$$

Similarly for component 'B'

$$PV_B = n_B RT \quad \text{——— (7)}$$

For component 'C'

$$PV_C = n_C RT \quad \text{——— (8)}$$

V_A, V_B, V_C --- etc are pure component volumes

V - total volume of the mixture

Adding Eqns (6), (7) and (8)

$$P(V_A + V_B + V_C + \ldots) = (n_A + n_B + n_C + \ldots) RT \quad \text{——— (9)}$$

Divide Eqn (6) by (9)

$$\frac{V_A}{(V_A + V_B + V_C + \ldots)} = \frac{n_A}{(n_A + n_B + n_C + \ldots)}$$

multiply both sides by 100

$$\frac{V_A}{V} \times 100 = \frac{n_A}{n} \times 100$$

Volume % of A = mole % of A.

∴ Pressure % = mole % = volume %