Dalton's Law of Partial Pressure

Partial Pressure : The pressure exerted by an individual gas in a mixture of non-interacting gases at the same conditions of temperature and volume is called its partial pressure.

Dalton's law of Partial Pressure : The total pressure of a mixture of ideal gases is the sum of the partial pressures exerted by individual gas.

i.e., $P = P_1 + P_2 + ...$

Let us consider a mixture of gases occupying a volume V. Suppose the first gas contains N_1 molecules, each of mass m_1 having mean-square-speed $v^2_{rms_1}$. The second gas contains N_2 molecules each of mass m_2 and mean-square-speed $v^2_{rms_2}$, and so on. Let P_1, P_2,........P_n are the partial pressures of the gases. Each gas fills the whole volume V. According to kinetic theory, we have

$P_1V = \frac{1}{3}m_1N_1v^2_{rms_1}$, $P_2V = \frac{1}{3}m_2N_2v^2_{rms_2}$, and so on.

Adding, we get $(P_1 + P_2 + ...)\ V = \frac{1}{3}(m_1N_1v^2_{rms_1} + m_2N_2v^2_{rms_2} ... + m_nN_nv^2_{rms_n})$ ......(i)

Now, the whole mixture is at the same temperature.

$\therefore \quad \frac{1}{2}m_1v^2_{rms_1} = \frac{1}{2}m_2v^2_{rms_2} ...... = \frac{1}{2}mv^2_{rms}$ (say).

Substituting this result in eq^n. (i) we have

$(P_1 + P_2 + ...)\ V = \frac{1}{3}(N_1 + N_2 + ... + N_n)\ mv^2_{rms}$

The mixture has a total number of molecules $(N_1 + N_2 + ... + N_n)$. Hence the pressure P exerted by the mixture is given by

$$PV = \frac{1}{3}(N_1 + N_2 + ...)\ mv^2_{rms}$$

i.e., $$P = P_1 + P_2\ .... + P_n.$$

This is Dalton's law of partial pressures.