Now, vapour pressure of solution will be proportional to both of them.

i.e., $P_s \propto \frac{n_1}{n_1+n_2}$ and $P_s \propto \frac{n_2}{n_1+n_2}$

As the solution is very dilute. So n_2 is very small. Thus the $\frac{n_2}{n_1+n_2}$ value becomes very small. So that second proportionality can be neglected.

Now, $$P_s \propto \frac{n_1}{n_1+n_2}$$

or, $$P_s = k.\frac{n_1}{n_1+n_2} \quad \text{——— (1)}$$

(where k is constant)

For pure solvent, $n_2 = 0$ and $P_s = P_0$.

From equation (1),

$$P_0 = k \quad \text{——— (2)}$$

From equation (1) and (2), we get

$$P_s = P_0 \frac{n_1}{n_1+n_2}$$

$$\frac{P_s}{P_0} = \frac{n_1}{n_1+n_2} \quad \text{——— (3)}$$

Subtracting both the sides from 1.

$$1 - \frac{P_s}{P_0} = 1 - \frac{n_1}{n_1+n_2}$$

$$\frac{P_o - P_s}{P_o} = \frac{n_2}{n_1 + n_2} \quad \text{——} (4)$$

or, $$\frac{P_o - P_s}{P_o} = X_2 \quad \text{——} (5)$$ This is the Raoult's law.

Application:

If w_2 g of solute dissolve in w_1 g of solvent and the molecular mass of solute and solvent are M_2 and M_1, respectively.

$\therefore$ moles of solute, $n_2 = \frac{w_2}{M_2}$ and

moles of solvent, $n_1 = \frac{w_1}{M_1}$

Put these values in equation (4), we get

$$\frac{P_o - P_s}{P_o} = \frac{w_2/M_2}{w_1/M_1 + w_2/M_2} \quad \text{——} (6)$$

Knowing the value of $\left(\frac{P_o - P_s}{P_o}\right)$, we can calculate the molecular mass of solute (M_2) using equation (6).

Prob. 1: 18.2 g of urea is dissolved in 100g of water at 50°C. The lowering of vapour pressure produced is 5 mm (Hg). Calculate the molecular mass of urea. The vapour pressure of water at 50°C is 92 mm (Hg).

Soln.:

$$\frac{P_o - P_s}{P_o} = \frac{W_2/M_2}{\frac{W_1}{M_1} + \frac{W_2}{M_2}}$$

Given, $P_o - P_s = 5$ mm (Hg)

$P_o = 92$ mm (Hg)

$W_2 = 18.2g$, $M_2 = ?$, $W_1 = 100g$, $M_1 = 18$

$\therefore M_2 = 57.05$ g/mol (Answer)