Colligative Properties

1. What is the vapor pressure of an aqueous solution that has 25.0 g of Na_2CO_3 dissolved in 286.00 g of water at 29.0 °C? The vapor pressure of water at 29.0 °C is 30.0 mmHg.

$P_{soltn.} = P^o \times X_{solvent}$

25.0 g Na_2CO_3 = 0.236 mol 286.00 g H_2O = 15.87 mol

$\chi_{H_2O} = \frac{15.87\ mol}{15.87\ mol + 0.236\ mol} = 0.985$

$P_{soltn.}$ = 30.0 mmHg x 0.985 = **29.6 mmHg**

2. Calculate the freezing point of a solution that is prepared by dissolving 1.35 g of aspirin (acetylsalicylic acid, $C_9H_8O_4$) in 100.00 g of chloroform, $CHCl_3$. The melting point of $CHCl_3$ is -63.5 °C and K_f = 4.70 °C/m.

1.35 g $C_9H_8O_4$ = 0.00750 mol 100.00 g $CHCl_3$ = 0.10000 kg

$m = \frac{0.00750\ mol}{0.10000\ kg} = 0.0750\ m$

$K_f = 4.70° \frac{C}{m} \times 0.0750\ m \times 1 = 0.353°C$

Freezing point = -63.5°C − 0.353 °C = **-63.9 °C**

3. What is the vapor pressure of a solution that contains 8.65 g of urea (CH_4N_2O) in 145.25 g of water at 35.0 °C? The vapor pressure of water at 35.0°C is 42.2 mmHg.

i = 1 145.25 g H_2O = 8.06 mol 8.65 g CH_4N_2O = 0.144 mol

$P_{soltn.} = P^o \times X_{solvent}$

$\chi_{solvent} = \frac{8.06\ mol}{8.06\ mol + 0.144\ mol} = 0.982$

$P_{soltn.}$ = 42.2 mmHg x 0.982 = **41.4 mmHg**

4. A certain sugar is obtained from the degradation of cellulose. A 250.00 mL aqueous solution contains 1.35 g of this sugar. At 28.2 °C, the osmotic pressure is 425.6 mmHg. What is the molar mass of this sugar?

$425.6\ mmHg \times \frac{1\ atm}{760.0\ mmHg} = 0.5600\ atm$ 28.2°C = 301.35 K

$\Pi = MRT$ solve for M $M = \frac{\Pi}{RT} = \frac{0.5600\ atm}{0.0821 \frac{L \cdot atm}{mol \cdot K} \times 301.35\ K} = 0.0226\ M$

0.0226 M x 0.25000 L = 0.00565 mol

$M_m = \frac{1.35\ g}{0.00565\ mol} = \mathbf{238.9\ \frac{g}{mol}} = \mathbf{239\ \frac{g}{mol}}$