Colligative Properties Worksheet

1) **What mass of water is needed to dissolve 34.8 g of copper(II) sulfate in order to prepare a 0.521 m solution?**

2) **The vapor pressure of water at 20° C is 17.5 torr. What is the vapor pressure of water over a solution containing 300. g $C_6H_{12}O_6$ and 455 g of water?**

3) **Calculate the freezing point of a solution made from 32.7 g of propane, C_3H_8, dissolved in 137.0 g of benzene, C_6H_6. The freezing point of benzene is 5.50° C and its K_f is 5.12° C/m.**

4) **Calculate the boiling point of a solution made from 227 g of $MgCl_2$ dissolved in 700. g of water. What is the boiling point of the solution? K_b = 0.512° C/m.**

5) **Calculate the concentration of nitrogen gas in a 1.00 L container exerting a partial pressure of 572 mm Hg at room temperature. Henry's law constant for nitrogen at 25° C is 6.8×10^{-4} mol/L·atm.**

6) **A solution contains 21.6 g of a nonelectrolyte and 175 g of water. The water freezes at -7.18° C and K_f = 1.86° C/m. Is the nonelectrolyte CH_3OH or C_2H_5OH?**

Solutions

1) $m_1 = 34.8\ g\ CuSO_4$

$m = 0.521\ m$

$CuSO_4(aq) \rightarrow Cu^{2+}(aq) + SO_4^{2-}(aq)$

$m = n/kg$

$kg = n/m = (34.8\ \cancel{g\ CuSO_4} \times 1\ mol\ CuSO_4/159.61\ \cancel{g\ CuSO_4})/0.521\ m$

$m_w = 0.418\ kg\ H_2O = 418\ g\ H_2O$

2) $P_A° = 17.5\ torr$ $m_w = 455\ g\ H_2O$

$m_s = 300.\ g\ C_6H_{12}O_6$

$C_6H_{12}O_6(s) \rightarrow C_6H_{12}O_6(aq)$

$P_w = X_w \times P_w°$

$X_w = n_w/(n_w + n_s)$

$n_w = 455\ \cancel{g\ H_2O} \times 1\ mol\ H_2O/18.02\ \cancel{g\ H_2O} = 25.2\ mol\ H_2O$

$n_s = 300.\ \cancel{g\ C_6H_{12}O_6} \times 1\ mol\ C_6H_{12}O_6/180.18\ \cancel{g\ C_6H_{12}O_6} = 1.67\ mol\ C_6H_{12}O_6$

$P_w = 25.2\ \cancel{mol}/(25.2\ \cancel{mol} + 1.67\ \cancel{mol}) \times 17.5\ \cancel{torr} \times 1\ mm\ Hg/1\ \cancel{torr}$

$P_w = 16.4\ mm\ Hg$

3) $m_1 = 32.7\ g\ C_3H_8$ $T_f° = 5.50°\ C$

$m_2 = 137.0\ g\ C_6H_6$ $K_f = 5.12°\ C/m$

$m = n/kg$

$m = (32.7\ \cancel{g\ C_3H_8} \times 1\ mol\ C_3H_8/44.11\ \cancel{g\ C_3H_8})/(137.0\ \cancel{g} \times 1\ kg/10^3\ \cancel{g})$

$m = 5.41\ m$

$\Delta T_f = K_f \times m \times i = 5.12°\ C/\cancel{m} \times 5.41\ \cancel{m} \times 1 = 27.7°\ C$

$\Delta T_f = T_f^{\circ} - T_f$

$27.7°\ C = 5.50°\ C - T_f$

$T_f =$ -22.2° C

4) $m_1 = 227\ g\ MgCl_2$ $K_b = 0.512°\ C/m$

$m_2 = 700.\ g\ H_2O$

$MgCl_2(s) \rightarrow Mg^{2+}(aq) + 2Cl^-(aq)$

$m = n/kg$

$m = 227\ \cancel{g\ MgCl_2} \times 1\ mol\ MgCl_2/95.20\ \cancel{g\ MgCl_2})/(700.\ \cancel{g} \times 1\ kg/10^3\ \cancel{g})$

$m = 3.41\ m$

$\Delta T_b = K_b \times m \times i = 0.512°\ C/\cancel{m} \times 3.41\ \cancel{m} \times 3 = 5.24°\ C$

$\Delta T_b = T_b - T_b^{\circ}$

$5.24°\ C = T_b - 100.00°\ C$

$T_b =$ 105.24° C

5) P_g = 572 mm Hg   V = 1.00 L

$k = 6.8 \times 10^{-4}$ mol/L·atm   T = 25° C

$S_g = kP_g$

$S_g = 6.8 \times 10^{-4}$ mol/L$\cdot\cancel{\text{atm}}$ x 572 $\cancel{\text{mm Hg}}$ x 1 $\cancel{\text{atm}}$/760 $\cancel{\text{mm Hg}}$

S_g = 5.1×10^{-4} M

6) m_u = 21.6 g T_f = -7.18° C

m_w = 175 g K_f = 1.86° C/m

$\Delta T_f = m \times K_f \times i$

$m = \Delta T_f / K_f$

m = 7.18$\cancel{° \text{C}}$/(1.86$\cancel{° \text{C}}$/m) = 3.86 m

m = n/kg

n = m x kg = 3.86 m x 175 $\cancel{\text{g}}$ x 1 kg/10^3 $\cancel{\text{g}}$ = 0.676 mol

n = m/MM

MM = m/n = 21.6 g/0.676 mol = 32.0 g/mol

The electrolyte is CH_3OH.