DC/IB Chem

Name: Answer Key

Be sure to show ALL your work

1. The term "proof" is defined as twice the percent by volume of pure ethanol in solution. Thus, a solution that is 95% (by volume) ethanol is 190 proof. What is the molarity of ethanol in a 92 proof ethanol/water solution? Assume the density of ethanol is 0.79 g/cm^3 and the density of water is 1.0 g/cm^3. ↳ 46% EtOH/vol

C_2H_5OH 46.08 g/mol

$$\frac{46\text{ mL EtOH}}{100\text{ mL EtOH}_{(aq)}}\left|\frac{0.79\text{ g EtOH}}{1\text{ mL}}\right|\frac{1\text{ mol EtOH}}{46.08\text{ g}}\left|\frac{1000\text{ mL}}{1\text{ L}}\right. = 7.886\text{ M} = \boxed{7.9\text{ M EtOH}_{(aq)}}$$

2. What volume of ethylene glycol, a non-electrolyte, must be added to 15.0 L of water to produce an antifreeze solution with a freezing point of -25.0 °C? What is the boiling point of the solution? (The density of ethylene glycol is 1.11 g/cm^3, and the density of water is 1.00 g/cm^3). ↳ 1.00 kg/L $\quad \Delta T_f$ H$_2$O = 1.86 C°/m

OH OH
-C-C-

$C_2H_6O_2$ 62.08 g/mol

$\Delta T_f = i K_f m$

$\Delta T_f = i K_f \frac{\text{mol}}{\text{kg}}$

$$\frac{-25.0\text{ °C}}{}\left|\frac{15.0\text{ L H}_2\text{O}}{}\right|\frac{1.00\text{ kg}}{1\text{ L H}_2\text{O}}\left|\frac{}{1}\right|\frac{\text{mol C}_2\text{H}_6\text{O}_2}{-1.86\text{ °C·kg}}\left|\frac{62.08\text{ g C}_2\text{H}_6\text{O}_2}{1\text{ mol}}\right|\frac{1\text{ cm}^3}{1.11\text{ g}}\left|\frac{1\text{ L}}{1000\text{ cm}^3}\right.$$

$$= 11.3\text{ L C}_2\text{H}_6\text{O}_2$$

$\text{mol} = \frac{\Delta T_f \cdot \text{kg}}{i K_f}$ $\quad \Delta T_b = i K_b m$

$$\frac{1}{}\left|\frac{0.512\text{ C°·kg}}{\text{mol}}\right|\frac{11300\text{ mL}}{1.11\text{ g}}\left|\frac{1\text{ mol}}{62.08\text{ g}}\right|\frac{}{15\text{ kg}} = 6.90$$

$= \boxed{106.90\text{ °C}}$

3. Glycercin, $C_3H_8O_3$, is a nonvolatile liquid. What is the vapor pressure of a solution made by adding 164 g of glycerin to 338 mL of H_2O at 39.8 °C? The vapor pressure of pure water at 39.8 °C is 54.74 torr and its density is 0.992 g/cm^3.

$P_{soln} = X_{solv} \cdot P^\circ_{solv}$

$$\frac{338\text{ mL H}_2\text{O}}{}\left|\frac{0.992\text{ g H}_2\text{O}}{1\text{ mL H}_2\text{O}}\right|\frac{1\text{ mol}}{18.02\text{ g H}_2\text{O}}\left\|\frac{164\text{ g C}_3\text{H}_8\text{O}_3}{}\right|\frac{1\text{ mol}}{92.11\text{ g C}_3\text{H}_8\text{O}_3}\left\|\frac{18.60688\text{ mol H}_2\text{O}}{(18.60688\text{ mol H}_2\text{O} + 1.78048\text{ mol})}\right|\frac{54.74\text{ torr}}{}$$

$$= \boxed{50.0\text{ torr}}$$

18.60688 mol H$_2$O $\qquad$ 1.78 mol $C_3H_8O_3$

4. At a certain temperature, the vapor pressure of pure benzene (C_6H_6) is 0.930 atm. A solution was prepared by dissolving 10.0 g of a non-dissociating, non volatile solute in 78.11 g of benzene at that temperature. The vapor pressure of the solution was found to be 0.900 atm. Assuming the solution behaves ideally, determine the molar mass of the solute.

$P^\circ = 0.930$ atm $\Rightarrow \frac{\text{mol}_{solv}}{(\text{mol}_{solv} + \text{mol}_{solute})} = \frac{P}{P^\circ}$

$P = X_{solv} \cdot P^\circ$

$$\text{mol } X \left\|\frac{0.930\text{ atm}}{}\right|\frac{78.11\text{ g C}_6\text{H}_6}{}\left|\frac{1\text{ mol C}_6\text{H}_6}{78.12\text{ g C}_6\text{H}_6}\right|\frac{}{0.900\text{ atm}} - \left(\frac{78.11\text{ g C}_6\text{H}_6}{}\right|\frac{1\text{ mol}}{78.12\text{ g C}_6\text{H}_6}\Bigg)$$

$P = \frac{\text{mol}_{solv}}{(\text{mol}_{solv} + \text{mol}_{solute})} \cdot P^\circ$ $\quad \text{mol}_u = \frac{P^\circ_v \text{mol}_v}{P_v} - \text{mol}_v$ $\quad \text{mol}_x = 0.0333\text{ mol X}$

$$\text{m.m.} = \frac{10.0\text{ g}}{0.0333\text{ mol}} = 300\frac{\text{g}}{\text{mol}} = 3.00\times10^2\text{ g/mol}$$

5. An aqueous solution containing 0.250 mol of Q, a strong electrolyte, in 5.00 x 10^2 g of water freezes at -2.79 °C. What is the van't Hoff factor for Q? What is the formula of Q if it is 38.68% chlorine by mass and there are twice as many anions as cations in one formula unit of Q?

$\Delta T_f = i K_f m$

$i = \frac{\Delta T_f}{K_f m}$

$$\frac{-2.79\text{ C°}}{}\left|\frac{\text{mol}}{-1.86\text{ C° kg}}\right|\frac{5.00\times10^2\text{ g H}_2\text{O}}{0.250\text{ mol}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right. = 3 \Rightarrow \text{3 ionized particles}$$

$\therefore$ $MCl_2 \Rightarrow$ 3 ionized particles $\quad 1\text{ m} = 2\text{ Cl}^-$

$$\frac{38.68\text{ g Cl}}{}\left|\frac{1\text{ mol Cl}}{35.45\text{ g}}\right. = \frac{1.09\text{ mol Cl}}{2} = 0.5456\text{ mol m}$$

$$\frac{61.32\text{ g m}}{}\left|\frac{}{0.5456\text{ mol m}}\right. = 112.4\frac{\text{g}}{\text{mol}} = \text{Cd} \quad \therefore \boxed{CdCl_2}$$