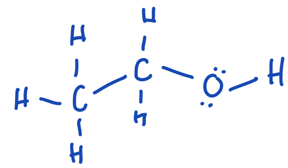
Gen Chem 104
PLI #1
July 8, 2021

Lewis: 
w/ 3D

bond line: 

EtOH = shorthand for ethanol

1. A solution is prepared by mixing 1.00 g ethanol (C_2H_5OH) with 100.0 g of water to give a final volume of 101 mL. Calculate the molarity, mass percent, mole fraction, and molality of ethanol in this solution.

Molarity $\frac{\text{mol EtOH}}{\text{L soln}}$ $\therefore$ $1.00\text{g EtOH} \times \frac{1\text{ mol EtOH}}{46\text{g EtOH}} = \frac{0.0217\text{ mol EtOH}}{0.101\text{ L soln}} = 0.215\text{ M EtOH}$

% mass $\frac{\text{mass EtOH}}{\text{total mass}}$ $\therefore$ $\frac{1.00\text{g EtOH}}{1.01\text{g soln}} \times 100\% = 0.990\%\text{ EtOH}$

mole fraction $\frac{\text{mol EtOH}}{\text{total mol}}$ $\therefore$ $100\text{g } H_2O \times \frac{1\text{ mol}}{18\text{ g}H_2O} = 5.56\text{ mol } H_2O \Rightarrow \frac{0.0217\text{ mol EtOH}}{0.0217 + 5.56\text{ mol}} = 0.00389$

Molality $\frac{\text{mol EtOH}}{\text{kg } H_2O}$ $\therefore$ $\frac{0.0217\text{ mol EtOH}}{0.100\text{ kg } H_2O} = 0.217\text{ m EtOH}$

2. Consider the following solutions:

0.10 m Na_3PO_4 in water $i = 4$
0.20 m $CaBr_2$ in water $i = 3$
0.20 m KCl in water $i = 2$
0.20 m HF in water $i = 1$
↳ weak acid = weak electrolyte

a. Assuming complete dissociation of the soluble salts, please circle the solution(s) that would have the same boiling point as 0.40 m glucose ($C_6H_{12}O_6$, non-electrolyte) in water.

0.10 m Na_3PO_4 and 0.20 m KCl

b. Which solution would have the largest freezing-point depression and why?

$CaBr_2$: $i = 3$ and $m = 0.20$ so effective molality is largest. ΔT is dependent on effective molality

3. How many grams of glucose per liter should be used for an intravenous solution that is isotonic with the 7.65 atm osmotic pressure of blood at body temperature,

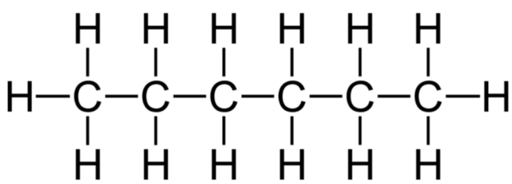
37.0°C?

$\pi = MRT$

$M = \pi / RT \rightarrow (7.65 \text{ atm}) / \left(0.082 \frac{\text{atm} \cdot L}{\text{mol K}}\right)(37 + 273) = 0.301 \text{ mol}/L$

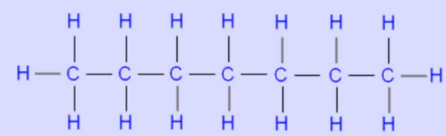
$0.301 \text{ g } \frac{\text{mol glucose}}{1 \text{ L sol'n}} \times \frac{180 \text{ g glucose}}{1 \text{ mol glucose}} = \boxed{54.2 \text{ g glucose}/L}$

4. Two nonpolar organic liquids, hexane (C_6H_{14}), and heptane (C_7H_{16}), are mixed. They are highly miscible at all proportions.



Molecular Structure of Hexane

Heptane (C_7H_{16}) is commonly represented by the structural formula



a. Do you expect the $\Delta H_{solution}$ to be a large positive number, a large negative number, or close to 0? **this one is tricky**

Delta H should be close to 0. Enthalpy has to do with energy involved in the making and breaking of bonds.As we discussed on Thursday in lecture, breaking bonds require energy and making bonds releases energy. in the context of ionic solids dissolving in water, breaking the electrostatic in the lattice requires an input of energy and forming bonds between water and the ions releases energy, which is how we obtain an enthalpy of solution that could be positive or negative.

How can we apply this information to highly non polar liquids?

In order to “dissolve” hexane in heptane (or vice versa), the hexane-hexane and heptane-heptane IMFs must be broken and new hexane-heptane IMFs must be formed. These are our ‘bond breaking’ and ‘bond forming’ values. In looking at these two molecules structures they are very similar! The energy required to break the bonds between the molecules of pure liquids is similar to the energy released on the new IMF formation. Therefore, the enthalpy of solution is close to 0 and not negative. A positive enthalpy would mean low solubility, which we know isn’t the case

b. Given your answer to the previous question, in a solution of hexane and heptane, is the entropy of the system increased, decreased, or close to zero compared to the separate pure liquid?

The entropy of the system increases. We know that mixing these two liquids is highly favorable. Since we know that the enthalpy of the solution is close to 0, which is neither favorable nor unfavorable for solubility, we also know that the entropy change upon mixing must be the factor that is causing solubility to be favorable.

5. A 2.00 g sample of a large biomolecule was dissolved in 15.0 g carbon tetrachloride (CCl_4). The boiling point of this solution was determined to be 77.85°C. Calculate

since we are given the mass of the solute, if moles can then molar mass can be directly calculated.

the molar mass of the biomolecule. For carbon tetrachloride, the boiling point constant, K_{bp}, is 5.03°C•Kg/mol, and the boiling point of pure carbon tetrachloride is 76.50°C. $\leftarrow$ assume $i = 1$

$$\Delta T_{BP} = K_{BP} \cdot m \cdot i \longrightarrow m = \frac{\Delta T_{BP}}{K_{BP} \cdot i} = \frac{77.85\,°C - 76.50\,°C}{(5.03\,°C\ kg/mol)(1)} = 0.268\ \frac{mol}{kg} = 0.268\,m$$

$$0.268\ m = \frac{0.268\ mol\ solute}{1\ kg\ CCl_4} \times 0.015\ kg\ CCl_4 = 0.00403\ mol\ solute$$

$$\text{molar mass} = \frac{2.00\,g}{0.00403\ mol} = \boxed{496.7\ g/mol}$$

$\leftarrow$ this makes sense b/c we're told it's a large biomolecule

6. What mass of ethylene glycol ($C_2H_6O_2$), in grams, must be added to 1.0 kg of water to produce a solution that boils at 105.0°C? The boiling point elevation constant for water, K_{bp}, is 0.512°C/m. We are asked for mass; need to calculate molality & backtrack.

$\Delta T_{BP} = K_{BP} \cdot m \cdot i$ $\quad$ i ethylene glycol $= 1$

$$m = \frac{\Delta T_{BP}}{K_{BP}} = \frac{105\,°C - 100\,°C}{0.512\,°C/m} = 9.766\,m \rightarrow \frac{9.766\ mol\ C_2H_6O_2}{1\ kg\ H_2O} \times 1\ kg\ H_2O = 9.766\ mol\ C_2H_6O_2\ \text{req'd}$$

$$9.766\ mol\ C_2H_6O_2 \times \frac{62.07\,g\ C_2H_6O_2}{1\ mol\ C_2H_6O_2} = \boxed{604.2\ g\ C_2H_6O_2}$$

7. An aqueous solution is 0.907 M lead (II) nitrate. What is the molality of lead (II) nitrate in this solution? The density of the solution is 1.252 g/mL.

$$\frac{0.907\ mol\ Pb(NO_3)_2}{1\ L\ sol'n}$$

$$1\ L\ sol'n \times \frac{10^3\ mL}{1\ L} \times \frac{1.252\,g}{1\ mL} = 1252\,g\ sol'n$$

$$0.907\ mol\ Pb(NO_3)_2 \times \frac{331\,g\ Pb(NO_3)_2}{1\ mol\ Pb(NO_3)_2} = 300.\,g\ Pb(NO_3)_2$$

$$\text{Molality} = \frac{mol\ solute}{kg\ solvent}$$

$$kg\ solvent = (1252\,g\ soln - 300\,g) \times \frac{1\,kg}{10^3\,g} = \underset{\text{solvent}}{0.952\ kg\ H_2O}$$

$$\text{Molality} = \frac{0.907\ mol\ Pb(NO_3)_2}{0.952\ kg\ H_2O} = 0.953\ m\ Pb(NO_3)_2$$

8. Calculate the expected vapor pressure at 25°C for a solution prepared by dissolving 158.0 g common table sugar (molar mass = 342.3 g/mol) in 643.5 cm^3 of water. At 25˚C, the density of water is 0.9971 g/cm^3 and vapor pressure is 23.76 mmHg.

$P_{soln} = X \cdot P°$

moles of sucrose = 0.4616 mol sucrose

moles of H_2O = 35.60 mol H_2O

$X_{H_2O} = 35.60/(35.60 + 0.4616) = 0.9873$

$$P_{soln} = (0.9873\ mol)(23.76\ mmHg) = \boxed{23.46\ mmHg}$$