EXTERNAL FACTORS AFFECTING SOLUBILITY

- There are a few external factors that affect the solubility. (By external, we mean other than the chemical identity of the solute and solvent).

(1) TEMPERATURE

-For gases dissolved in liquids, the solubility DECREASES as the temperature INCREASES

- This is why THERMAL POLLUTION is bad! Hot water holds less oxygen than cooler water.

- For solids dissolved in liquids, solubility USUALLY increases with temperature. This is not true for ALL solid/liquid solutions.

(2) PRESSURE

- For gases dissolved in liquids, solubility INCREASES when the partial pressure of the solute gas over the solution INCREASES.

- Consider soft drinks. They go flat after opening because the pressure of carbon dioxide over the liquid goes down.

- No significant pressure effects for solid/liquid solutions.

Some sample colligative propoerties problems ...

What is the freezing point of a 41% solution of urea in water?

$(NH_2)_2CO$: urea , FW = 60.062 g/mol

$\Delta T_f = K_f \times C_m$

p509

$K_{f,w} = 1.858\ °C/m$

$T_{f,w} = 0.000\ °C$

$C_m = \frac{\text{mol urea}}{\text{kg water}}$

We need to find Cm ... and for that we need moles urea and kilograms water.

41% urea : $\frac{41\text{ g urea}}{100\text{ g solution}}$

We need mass WATER (not mass solution), so subtract out urea!

100g − 41g = 59 g water = 0.059 kg

Since we've assumed a basis of 100g solution, we can calculate the moles urea and then find Cm ...

$$41\text{ g urea} \times \frac{\text{mol urea}}{60.062\text{ g urea}} = 0.682627951\text{ mol urea}$$

$$C_m = \frac{\text{mol urea}}{\text{kg water}} = \frac{0.682627951\text{ mol urea}}{0.059\text{ kg water}} = 11.5699527\ \underline{m}\text{ urea}$$

$\Delta T_f = K_f \times C_m$

p509

$K_{f,w} = 1.858\ ^{o}C/m$

$T_{f,w} = 0.000\ ^{o}C$

$C_m = 11.5699527\ \underline{m}$ urea

Find delta T:

$\Delta T_f = (1.858\ ^{o}C/m)(11.5699527\ m) = 21\ ^{o}C$

Find freezing temperature:

$T_f = 0.000\ ^{o}C - 21 = \boxed{-21\ ^{o}C}$

A compound (containing Mn, C, O) is 28.17% Mn, 30.80% C. A solution of the compound containing 0.125 g in 5.38 g cyclohexane freezes at 5.28 C. What is the molecular formula?

To solve the problem, we need to find the MOLECULAR WEIGHT of the cpmpound, and we also must find the EMPIRICAL FORMULA of the compound (the ratio of Mn:C:O). Let's do molecular weight first.

$\Delta T_f = K_f \times C_m$

p 509: $K_{f,cyc} = 20.0\,^\circ C/m$

$T_{f,cyc} = 6.55\,^\circ C$

$C_m = \dfrac{\text{mol unknown}}{\text{kg cyc}}$; $5.38\text{ g} = 0.00538\text{ kg}$

Find Cm:

$(6.55\,^\circ C - 5.28\,^\circ C) = (20.0\,^\circ C/m)\, C_m$; $C_m = 0.0635\ \underline{m}$ unknown

Find moles unknown:

$0.00538\text{ kg cyc} \times \dfrac{0.0635\text{ mol unknown}}{\text{kg cyc}} = 3.4163 \times 10^{-4}\text{ mol unk}$

So, the molecular weight is:

$\dfrac{0.125\text{ g}}{3.4163 \times 10^{-4}\text{ mol}} = 366\text{ g/mol}$

Molecular weight of unknown.

Now, we need to convert the mass data given to a MOLE ratio:

28.17 % Mn ; 30.80 % C ; 100 − 28.17 − 30.80 = 41.03 % O

Assume 100g compound to determine the formula:

$$Mn: 28.17\,g\,Mn \times \frac{mol\ Mn}{54.94\,g\,Mn} = 0.5127411722\ mol\ Mn \rightarrow 1\ mol\ Mn$$

$$C: 30.80\ \%\ C \times \frac{mol\ C}{12.01\,g\,C} = 2.564529559\ mol\ C \rightarrow 5.002\ mol\ C$$

$$O: 41.03\ \%\ O \times \frac{mol\ O}{16.00\,g\,O} = 2.564375\ mol\ O \rightarrow 5.001\ mol\ O$$

To simplify the mole ratio, divide each part ot the ratio by the smallest part of the ratio ... this gives us the ratio of whole numbers we need for the formula!

$Mn_{0.5127}C_{2.564}O_{2.564}$

↓

MnC_5O_5

Mn : 1 × 54.94
C : 5 × 12.01
O : 5 × 16.00

194.99 g/mol For MnC_5O_5

Compare 195 g/mol to 366 g/mol

195 × 2 = 390 ... closer to 366 than 195 is! (or 195 × 3), so

$Mn_2C_{10}O_{10}$

56 grams of a sample contain 0.51 mole fraction propane and the remainder butane. What are the masses of propane and butane in the sample?

C_3H_8, FW = 44.094 g/mol ; C_4H_{10}, FW = 58.12 g/mol

Know: $X_{C_3H_8} = 0.51$

$X_{C_4H_{10}} = 1 - 0.51 = 0.49$

Want: mass C_3H_8, mass C_4H_{10} in 56 g

How do we get from MOLE FRACTIONS to the masses we need?

$$X_{C_3H_8} = \frac{\text{mol } C_3H_8}{\text{total moles}}$$

Let's assume ... for now ... we have one mole of mixture. (So, ignore the 56 grams for the moment...)

mol C_3H_8 = 0.51 x 1 = 0.51 mol C_3H_8

mol C_4H_{10} = 0.49 x 1 = 0.49 mol C_4H_{10}

$$g\ C_3H_8 = 0.51 \text{ mol } C_3H_8 \times \frac{44.094 \text{ g } C_3H_8}{\text{mol } C_3H_8} = 22.48794 \text{ g } C_3H_8$$

$$g\ C_4H_{10} = 0.49 \text{ mol } C_4H_{10} \times \frac{58.12 \text{ g } C_4H_{10}}{\text{mol } C_4H_{10}} = 28.4788 \text{ g } C_4H_{10}$$

50.96674 g total