CHM 1046 - JOENS WORKSHEET #2 Due date: M,W,F Wednesday, September 7
T,R Thursday, September 8

* While I prefer you turn in a hard copy of the worksheet, I will accept scanned copies sent to my email address, joensj@fiu.edu

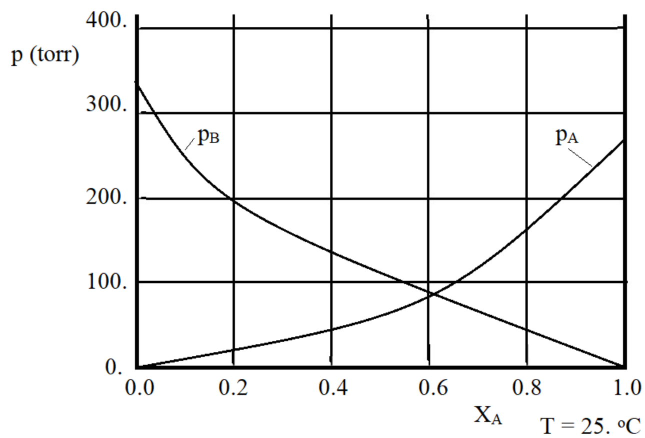
Section: (circle one) M,W,F Tu,Tr

For problems involving calculations you must show your work for credit.

1) Which of the following statements is correct?

a) The solubility of a solid in a liquid usually increases when temperature increases
b) The solubility of a gas in a liquid usually increases when temperature increases
E c) The solubility of a gas in a liquid usually decreases when temperature increases
d) Both a and b
e) Both a and c

2) A diagram showing pressure vs mol fraction A for a solution of two volatile liquids, A and B, is given below. The diagram is for T = 25. °C.



a) Do A and B form an ideal solution (yes / no and a brief explanation)?

No. For an ideal solution the two liquids must obey Raoult's law, which would lead to a linear relationship between pressure and mole fraction. Since we do not see such behavior, the solution is not ideal.

b) What are $p_A°$ and $p_B°$, the vapor pressure of pure A and pure B, at T = 25. °C?

$p_A°$ = _____265 torr_______ $p_B°$ = _____325 torr________

c) What is p_B, the partial pressure of B, when X_B = 0.80?

p_B = _____195 torr_______

For part c, when X_B = 0.80, then X_A = 0.20 Since the solution is not ideal, the answer must be read from the figure. Note that for both part b and c I will not take off for reading error, so if your answers are slightly different from mine don't worry.

3) The normal freezing point and freezing point depression constant for cyclohexane (C_6H_{12}, MW = 84.16 g/mol) are $T_f° = 6.7$ °C and $K_f = 20.8$ kg•°C/mol. How many grams of naphthalene ($C_{10}H_8$, MW = 128.18 g/mol) must be added to 1000.0 g of cyclohexane to form a solution with a melting point $T_f = 0.0$ °C?

We want $T_f = 0.0$ °C, and so $\Delta T_f = T_f° - T_f = 6.7$ °C – 0.0 °C = 6.7 °C

The nonvolatile solute is naphthalene (N).

Since $\Delta T_f = K_f\, m_N$, then $m_N = \dfrac{\Delta T_f}{K_f} = \dfrac{6.7\ °C}{20.8\ kg•°C/mol} = 0.322$ mol/kg

Since the mass of solvent (cyclohexane) is 1000.0 g = 1.0000 kg, the moles of naphthalene is

moles N = $\dfrac{0.322\ mol}{kg}$ (1.0000 kg) = 0.322 mol N

And so the number of grams of naphthalene is

grams N = 0.322 moles N $\dfrac{128.18\ g}{mol}$ = 41.3 g naphthalene

4) A solution is formed by dissolving 4.7 mg of a pure protein in water. The protein is nonvolatile and nonionizing. The final volume of the solution is V = 1.00 mL. The osmotic pressure of the solution relative to pure water, measured at T = 37. °C, is $\Pi = 8.1$ torr. Based on this information, find the molecular weight of the protein.

The molecular weight of the protein is MW = $\dfrac{\text{grams protein}}{\text{moles protein}}$

The grams of protein is 4.7 mg $\dfrac{1\ g}{1000\ mg}$ = 4.7×10^{-3} g

To find the moles of protein (P) we need to work with the osmotic pressure.

Since $\Pi = M_P RT$, where T =37. °C = 310. K

then $M_P = \dfrac{\Pi}{RT} = \dfrac{(8.1\ torr)\ (1atm/760torr)}{(0.08206\ L•atm/mol•K)\ (310.\ K)} = 4.19 \times 10^{-4}$ mol/L

We have 1.00 mL = 1.00×10^{-3} L of solution, and so

moles protein = $\dfrac{4.19 \times 10^{-4}\ mol}{L}$ (1.00×10^{-3} L) = 4.19×10^{-7} mol protein

So the molecular weight of the protein is MW = $\dfrac{4.7 \times 10^{-3}\ g}{4.19 \times 10^{-7}\ mol}$ = 11200 g/mol

It turns out that unless you can determine the sequence of amino acids in a protein there are no great methods for finding the molecular weight of a protein. This method will work, but only for relatively low molecular weight proteins, and only if you can obtain a large amount of pure protein (4.7 mg may not sound like a lot, but for most proteins it is).