

Quiz 7
CHEM 323
Fall 2008

Name: _____

1. (8 Points) The addition of 100.0 g of an unknown compound to 750.0 g of CCl_4 ($K_f = 30.0 \text{ K}\cdot\text{kg}\cdot\text{mole}^{-1}$, MW 153.82 g/mole) lowered the freezing point of the solvent by 10.5 K. Calculate the molar mass of the unknown compound.

Rearrange $\Delta T = K_f b$ to $b = \frac{\Delta T}{K_f}$. Substitute and solve for b , giving

$$b = \frac{\Delta T}{K_f} = \frac{10.5 \text{ K}}{30.0 \text{ K}\cdot\text{kg}\cdot\text{mole}^{-1}} = 0.350_0 \text{ m. We can set up the following equation}$$

$$\frac{100.0 \text{ g} \left(\frac{1 \text{ mole}}{x \text{ g}} \right)}{0.7500 \text{ kg}} = 0.350_0 \text{ mole}\cdot\text{kg}^{-1} \text{ (from the definition of molality) and solve for } x$$

(the molar mass of the unknown compound) giving 381. g/mole as the molar mass.

2. (10 Points) For anthracene (MW 178.23 g/mole), $\Delta_{fus}H$ is 28.8 kJ/mole and its melting point is 217.0 °C. Calculate its solubility (in grams) in benzene (MW 78.11 g/mole) at 25.0 °C.

Start with $\ln \chi_{anth} = \left(\frac{\Delta_{fus}H}{R} \right) \left(\frac{1}{T^*} - \frac{1}{T} \right)$ and substitute to find χ_{anth} (the mole fraction of anthracene).

$$\ln \chi_{anth} = \left(\frac{\Delta_{fus}H}{R} \right) \left(\frac{1}{T^*} - \frac{1}{T} \right) = \left(\frac{28.8 \times 10^3 \text{ J}\cdot\text{mole}^{-1}}{8.31447 \text{ J}\cdot\text{K}^{-1}\cdot\text{mole}^{-1}} \right) \left(\frac{1}{490.1_5} - \frac{1}{298.1_5} \text{ K}^{-1} \right)$$

$$\ln \chi_{anth} = (3.46_3 \times 10^3) (0.002040_1 - 0.003354_0) = (3.46_3 \times 10^3) (-0.001313_9) = -4.55_0$$

$$\chi_{anth} = e^{-4.55_0} = 0.010_5$$

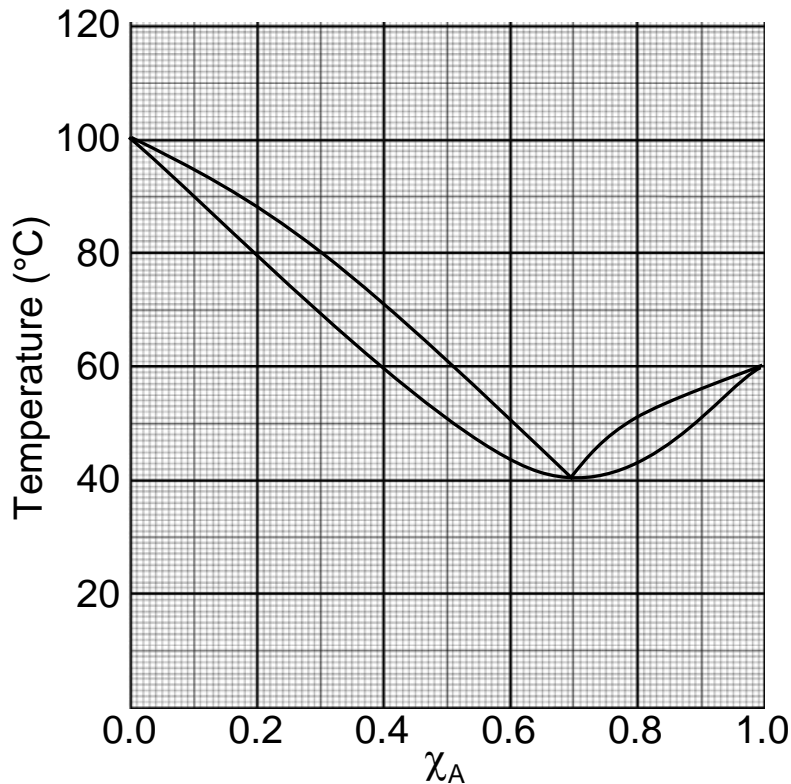
If we assume that the solution is dilute (as it would appear to be based on the calculated mole fraction), then we can simplify the mole fraction as follows and then convert to grams of anthracene per kg of benzene (or any other unit we want).

$$\chi_{anth} = \frac{\text{mole}_{anth}}{\text{mole}_{anth} + \text{mole}_{benzene}} \approx \frac{\text{mole}_{anth}}{\text{mole}_{benzene}}$$

$$\left(\frac{0.010_5 \text{ mole anthracene}}{1 \text{ mole benzene}} \right) \left(\frac{1 \text{ mole benzene}}{78.11 \text{ g benzene}} \right) \left(\frac{1000 \text{ g}}{1 \text{ kg}} \right) \left(\frac{178.23 \text{ g anthracene}}{1 \text{ mole anthracene}} \right) = 24. \text{ g}$$

Thus, we would predict the solubility of anthracene to be 24. g in 1 kg of benzene.

3. (9 Points) The liquid-vapor phase diagram for a homogeneous binary system consisting of the two compounds A and Q is shown below.



- The boiling point of Q is **100 °C**
- The azeotrope's composition is $\chi_A = \mathbf{0.7}$
- The azeotrope boils at **40 °C**
- At what temperature does a solution with $\chi_A = 0.2$ start to boil? **79 °C**
- Distilling a solution with $\chi_A = 0.2$ on a distillation apparatus with one theoretical plate would yield a distillate with $\chi_A = \mathbf{0.31}$
- Distilling a solution with $\chi_A = 0.2$ on a distillation apparatus with several thousand theoretical plates would yield a distillate with $\chi_A = \mathbf{0.7}$
- What is the boiling point range of a solution with $\chi_A = 0.2$? **79 – 88 °C**
- Is A or Q more volatile? **A is more volatile** (*it has the lower boiling point*)