UNIVERSITY OF MANITOBA
DEPARTMENT OF CHEMISTRY

Chemistry 2290, Winter 2012, G. Schreckenbach

PROBLEM SET 4, March 16, 2012

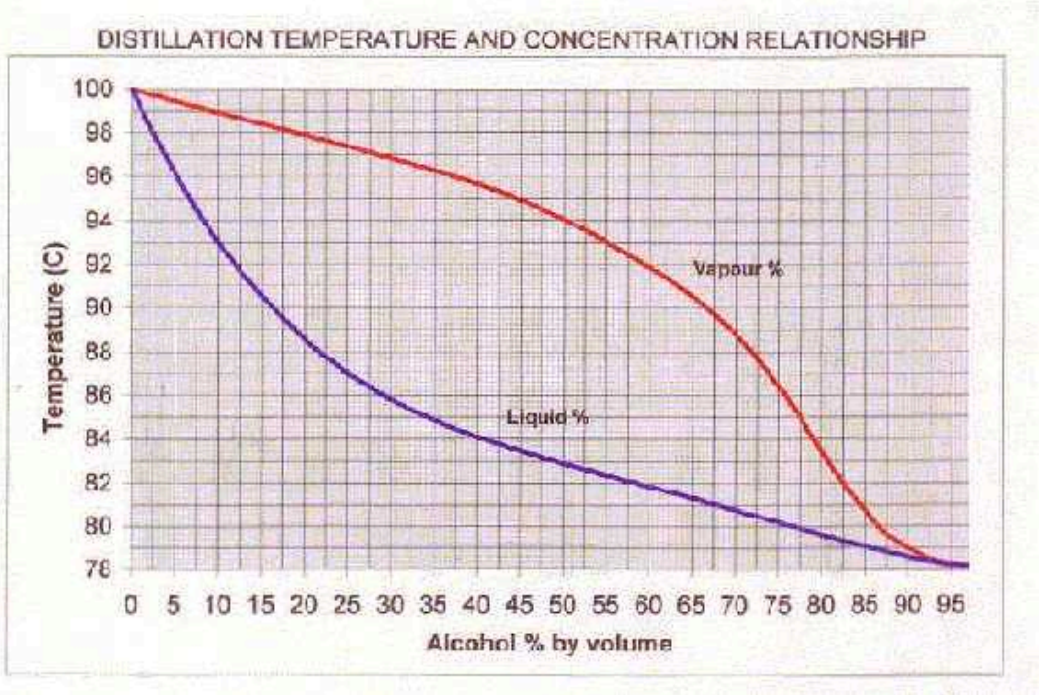
Due date: The solved problem set is due on Friday, March 23, 2012, at the time of the lecture.
Questions to be marked: A preselected set of four out of the five questions will be marked. (*As usual, I will make the selection.*)

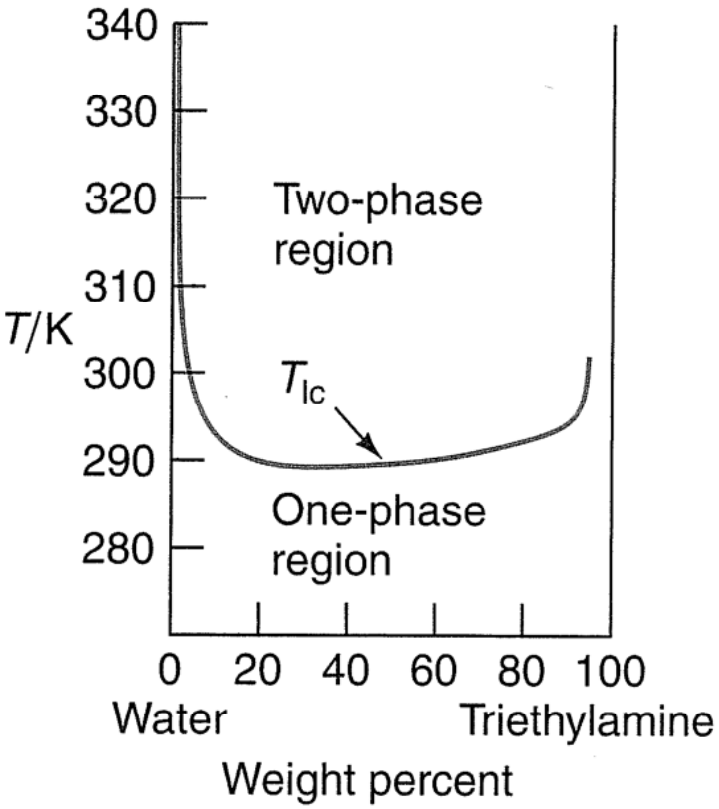
1. Benzene and toluene form solutions that are nearly ideal (i.e. an ideal solution can be assumed.) At 300K, the vapor pressures of the pure liquids are p^0(benzene) = 9.657kPa and p^0(toluene) = 3.572kPa, respectively. Given this data, compute the vapor pressure of a solution containing x_t = 0.750 mol fraction of toluene. What is the mole fraction of toluene in the vapor over this liquid? [Comment: This is effectively question LM43 as posted.]

2. Find the melting point of ice at 200.0 atm. Use the following numerical values:
For 1.00g of ice, ΔH_{fus} = 79.9 cal.
ρ(ice) = 0.917 g cm^{-3} (at 0.0°C)
ρ(water) = 1.000 g cm^{-3} (at 0.0°C)

3. Using the following water-ethanol (alcohol) phase diagram, answer the following question: (Source of figure: *http://www.physics.rutgers.edu/ugrad/351/; accessed 03/2005.*)

Starting with a 5.0% ethanol by volume solution (a typical value for beer or cider), what is the minimum number of steps required in a fractional distillation to reach a solution that contains at least 90.0% (by volume) of ethanol? *(Note the azeotrope concentration of 95.6% alcohol: This is the limit that can be reached by distillation of a less-alcohol-rich mixture.)*





4. (a) From the phase diagram to the left (water-triethylamine), determine the ratio of the masses of the phases present at 295K, for a mixture containing 30.0 wt % triethylamine. **(b)** What are the respective compositions of the phases?
(Figure copied from Laidler, Meiser, Sanctuary, Physical Chemistry, 4th edition.)

5. Calculate the boiling point of water at 98.7kPa *(a typical barometric pressure at 275m altitude)*? *You may need some or all of the following information:* At standard conditions (373.15K; 1.00 atm), the heat of vaporization is 2258Jg^{-1} (that's Joule per gram); the molar volume of liquid water is 18.78 cm^3 mol^{-1}, and the molar volume of water vapor is 30.199 dm^3 mol^{-1}. The molar mass of water is 18.015 g mol^{-1}.

Comment: This question has been taken from the 2011 midterm 2.