CHE 205 -- Fall 2005
STUDY GUIDE FOR TEST 3

The test will be open book/closed notes and workbook and will cover through Section 8.4d excluding Section 7.7.

- **Everything on the previous study guides**
- **"Test Yourself" questions from Sections 6.4–8.4d.**
- **Explanations**. Be able to briefly and clearly explain each of the following in your own words:
  - Raoult's law and Henry's law for multicomponent multiphase systems—what they are and when they are most applicable. Ideal solution behavior. Bubble point and dew point of a multicomponent mixture at a specified pressure. The vapor pressure of a liquid mixture. Evaporation and boiling, and how they differ. The boiling point of a liquid mixture.
  - Solubility of a solid in a liquid. Saturated solutions, supersaturation, and crystallization. Vapor pressure lowering, freezing point depression, and boiling point elevation. (The phase diagram should appear in your explanation.)
  - The three forms of energy a system can possess and what they depend on. The two forms of energy transfer, when they are positive, and when they are negative. Adiabatic systems. The first law of thermodynamics for a closed system and when terms in it can be neglected.
  - Flow work, shaft work, specific internal energy, and specific enthalpy. Definitions and formulas for ΔH and ΔU for closed and open systems. The first law of thermodynamics for an open system, how it was derived from the closed system form, and when terms in it can be neglected.
  - Why the value 3673 kJ/kg shown in Table B.7 for water at 600^{o}C and 20 bars isn't the true enthalpy of steam at the given condition. What it really is. What all the other quantities tabulated in Tables B.5—B.7 mean. What "150-pound steam" means.
  - Why food cooks more rapidly in a pressure cooker. (Refer to the phase diagram for water.) Why soda fizzes when you take the bottle cap off, and why it fizzes more if the soda is warm. (Refer to Henry's law.) What's going on during the three stages of heating a pot of water on a stove (small bubbles, no bubbles, large bubbles). Why when steam comes out of a teakettle there is a clear space just outside the spout and then a white mist. Why you feel warm when you step into a shower and cold when you step out, even if the room temperature is the same. Why mist sometimes forms above the surface of a pond or an ice skating rink. (The term dew point should be used.) How antifreeze in an automobile cooling system works in both summer and winter, and why highways and driveways are salted when it snows.
  - State property. Process path. Why you can choose any convenient path from one state to another to evaluate the associated internal energy or enthalpy change. What makes a path convenient.
  - C_p and C_v—how they are defined (give mathematical and graphical definitions), how they are related, and how to use them. Latent heats of phase change.
  - Psychrometric chart. Dry bulb and wet bulb temperatures, absolute humidity, humid volume, enthalpy at saturation, enthalpy deviation. Given any two of the variables shown on the chart, how to calculate the others, including dew point.
- **Equilibrium calculations for ideal solutions**. For a mixture of two condensable species and possibly a third noncondensable species, apply the Gibbs Phase Rule to determine how many intensive variables (pressure, temperature, liquid and vapor component mole fractions), must be specified to determine all others. Then, given the necessary number of variable values, use Raoult's law or Henry's law (whichever is most appropriate) to determine the remaining variables.

- **Behavior of a binary (two-component) system that obeys Raoult's law at all compositions**. Given the composition of the system (mole fractions of each component) and formulas or tables of the pure-component vapor pressures as functions of temperature:
    - If T and P are both given, determine whether the mixture is a liquid, a vapor, or some of each. If the latter, determine the fraction of the total mixture in each phase and the phase compositions.
    - If the mixture is a liquid and it is heated at constant P in a closed vessel, determine the bubble point temperature and the composition of the first bubble, and the temperature at which the last droplet vaporizes and the composition of the droplet. If the mixture is a vapor and is cooled at constant P, determine the dew point temperature and composition of the first droplet, and the temperature at which the last bubble condenses and its composition. Do the same calculations for changing the pressure at constant T.
    - Outline how to do each of the preceding calculations using (i) E-Z Solve, (ii) Excel with Goal Seek, (iii) a Txy or Pxy diagram.
    - Describe what will happen if the mixture is liquid and is heated in an *open* container. Discuss both evaporation and boiling, when each one occurs, what happens to the liquid composition over time, and the composition of the vapor produced for any specified liquid composition.
- **Material balances on binary two-phase (vapor mixture-liquid mixture) systems with the outlet streams in equilibrium**. Draw and label the flow chart.* Determine whether Raoult's law or Henry's law should be applied to each species, and justify your choice. Do the DOF analysis, then write the equations, then (*maybe*) do the calculations.
- **Energy balances on closed and open systems involving only water or other species for which tabulated internal energies or enthalpies are available**. Given the process description, be able to write the appropriate form of the first law of thermodynamics, drop terms that may be neglected (and state why they may be neglected), calculate all but one of the remaining terms from process information, and calculate the final term from the energy balance.
- **Estimation of heat capacities and latent heats**. Estimate the heat capacity (C_p) of a solid or liquid using Kopp's rule. Estimate a heat of fusion or a heat of vaporization using any of the correlations given in Section 8.4b. Given a value or formula for C_p, calculate the corresponding value or formula for C_v and vice versa. Given a heat of fusion or a heat of vaporization, calculate the corresponding internal energy of fusion or vaporization.
- **Determination of internal energy and enthalpy changes for a single species undergoing a change in state**. Given a species that makes a transition from one specified state (phase, T, P) to another, calculate the associated internal energy or enthalpy change using appropriate data in the text (i.e., using the most accurate available data or correlation for the given task). The data you use may include the steam tables, specific enthalpies from Tables B.8 and B.9, heat capacities from Table B.2 or (if necessary) from Kopp's rule, and latent heats from Table B.1 or (if necessary) Section 8.4b.
- **Material and energy balances on nonreactive processes**. Given any process that does not involve heats of mixing or chemical reactions:
    - Draw and label a flowchart, including in the labeling the states of all species in the inlet and outlet streams and any nonzero heat or work terms, and do the DOF analysis.
    - Choose suitable reference states for each species, set up an inlet-outlet enthalpy table (open system) or internal energy table (closed system), fill in amounts and flow rates from the flow chart, and label all unknown specific enthalpies or specific internal energies.
    - Write the equations you would use to calculated all requested quantities. If an equation includes a physical property (e.g. a heat capacity, latent heat, melting or boiling point, vapor pressure,...), state where in the text you would obtain the required value or formula. *Do no calculations in this part*.
    - Perform some of the calculations (*maybe*).

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* Show both vapor and liquid product streams, unlike what some of you did on Problem 3 of Test 2.