**CHE 205 -- CHEMICAL PROCESS PRINCIPLES**

# STUDY GUIDE FOR TEST 2

The test will be open book/closed notes and workbook and will cover through Section 6.3. *You are strongly advised to annotate your textbook with tabs, highlight key equations, and add to the "Selected Tables and Figures" list on the inside front cover*.

- **Everything on the previous study guide.**
- **"Test Yourself" questions and questions about homework problems**.
- **Explanations**. Be able to briefly and clearly explain each of the following in your own words:
  - Recycle (and its purpose). Purge (and its purpose).
  - Fractional conversion of a limiting reactant. Percentage excess of a reactant. Theoretical air and percent excess air in a combustion reactor. Dry basis composition of a mixture containing water. Extent of reaction, yield, and selectivity.
  - The statement "Assume volume additivity" for a liquid mixture.
  - The statement "Assume ideal gas behavior." You should also be able to state two ways to determine whether this assumption is a good one.
  - STP. SCMH. Why "350 $m^3$(STP)/h of nitrogen at 25$^oC$ and 3.5 atm" looks like a contradiction but is not one.
  - Partial pressure of a gas mixture component. Percentage by volume (% v/v) of a gas mixture component, e.g. 20% v/v CO. How to calculate the mole fraction of a component of a gas mixture given either of the first two quantities and the total pressure.
  - The law of corresponding states. The compressibility factor ($Z$). Pseudocritical temperature and pressure. Kay's rule.
  - A phase diagram. Boiling and melting points and how they depend on pressure. The difference between a gas and a vapor. Normal boiling point and normal melting point. Triple point. Critical temperature and pressure. Where in F&R you can look up normal boiling points, normal melting points, critical temperatures and critical pressures.
  - Vapor pressure and how it depends on temperature. Two ways to determine from data in F&R the vapor pressure(for a given $T$) or the boiling point (for a given $P$) of certain species, and a third way if the species is water. How you can tell which of two liquids is more volatile, and what that means.
  - The Gibbs phase rule--what it is and what information it gives you.

- Saturated vapor, superheated vapor, dew point, degrees of superheat, relative saturation, and relative humidity. How to calculate the mole fraction of a vapor in a gas mixture given any of the last four quantities along with temperature, total pressure, and an equation or data for vapor pressure.
- Why it takes longer to make a hard-boiled egg at a ski resort than at the beach. Whether it should take longer to boil an egg on a stormy day than on a sunny day, and why.(The terms "atmospheric pressure" and "boiling point" should appear in the explanations.)

- **Multiple unit processes, recycle, bypass, and purge**. Given a process description, choose a convenient basis of calculation, draw and *completely* label the flow chart, identify the systems on which balances could be written, do the DOF analysis for each system, write the equations you would use to calculate specified process variables, and (maybe) perform the calculations. *State all assumptions you make.*
- **Balances on reactive systems**. Given a description of a reactive process, assume a basis and draw and completely label the flow chart, do the DOF analysis (basing it on molecular balances, atomic balances, or extents of reaction as requested), write the equations you would use to solve for unknown process variables using either atomic balances or extents of reaction, and (maybe) perform the calculations. *State all assumptions you make.*
- **Combustion**. Given information about a fuel composition, assume a basis of calculation and calculate the feed rate of air from a given percent excess or vice versa (given the percent excess air, calculate the air feed rate). Given additional information about the conversion of fuel and/or the wet-basis or dry-basis composition of the exhaust gas, draw and completely label the flow chart, do the DOF analysis, write the equations you would use to solve for unknown process variables, and (maybe) perform the calculations. *State all assumptions you make.*
- **Ideal gas calculations**. Given any three of the variables *P*, *V*, *T*, and *n* (or any two of *P*, $\hat{V}$ and *n*) for a gas, calculate the remaining variable directly from the ideal gas equation of state or using conversion from standard conditions. Quickly determine whether the error you will make by assuming ideal gas behavior is less than 1%. Do the DOF analysis and solve material balance problems for process systems in which one or more of the streams are ideal gases and volumes are either given or requested. (*Warning: If you label volume fractions or try to do a volume balance you will lose major points!*)
- **Real gas calculations**. Given any three of the variables *P*, *V*, *T*, and *n* for a gas, outline how you would calculate the fourth variable using the SRK equation of state or the compressibility factor equation of state and the compressibility

charts. Do the latter calculation for a single species or for a mixture using Kay's rule.

- **Phase behavior**. Given a phase diagram for a species, state what happens when a specified path is followed (like Path ABCDE on Figure 6.1-1). The words "boiling point," "melting point," "sublimation point," and "vapor pressure" should appear when appropriate. Calculate volumes after every step of the path.
- **Vapor pressure determination**. Given a temperature of a pure species, look up or calculate the vapor pressure from data in F&R. Given a pressure, look up or calculate the boiling point. Do the latter the easy way if the pressure happens to be 1 atm.
- **Behavior of a gas mixture containing a single condensable species**. Suppose you have a gas mixture containing a single condensable species, A(v), for which the vapor pressure, $p_A^*(T)$, is given or can be calculated or looked up.
  - Given any three of the quantities $T$, $P$, $y_A$ (mole fraction), $p_A$ (partial pressure), $T_{dp}$ (dew point), *DS* (degrees of superheat), and *RS* (relative saturation) or *RH* (relative humidity) for the gas mixture, calculate all of the others. (Some combinations may not work, like specifying $T$, $T_{dp}$, and *DS*, since you can calculate any one from the other two).
  - Given that the mixture is in equilibrium with the liquid of the condensable species, calculate all of those variables from given values of any two of the variables $T$, $P$, and $y_A$. Explain why any of the calculated values could be in error, assuming that you did not make any mistakes. (In other words, what have you assumed?)
- **Material balances on two-phase (vapor mixture-pure liquid) systems with the outlet streams in equilibrium**. Suppose the liquid species is A and you are given saturation information ($T_{dp}$, *RH*, *DS*, etc.) for the gas inlet stream. Draw and label the flow chart, do the DOF analysis, write the equations, then (maybe) do the calculations. *State all assumptions you make.*