CHE 205 --- Chemical Process Principles **Fall 2005**

TEST #3. Open book–closed notes. Put your name, section (1–Bullard, 2–Felder), and "Test #3" on the outside of your blue book. Any work on the back of a page will not be considered scratch work and will not be graded. *Begin each numbered problem on a new page, show all your work, and box your final answers*.

1. (10 pts) The following are *short* answer questions. You should not spend more than two minutes answering each one.

(a) (3) An outside steam pipe in an industrial plant in which superheated steam flows has sprung a leak. Just outside the leak there is a clear space, and a short distance away a white plume forms. What is in the plume, what is in the clear space, and why is there a clear space?

(b) (2) Two beach picnics are going on—one by the ocean and one by a fresh-water lake. At each picnic, someone fills a pot from the nearby body of water, boils the water, and puts an egg in. At which picnic will the egg become hard boiled first, and why?

(c) (5) Table B.6 lists $\hat{H}$ for saturated steam at 10.0 bar as 2776.2 kJ/kg.

(i) (2) Sketch a phase diagram for water and show where the steam is located, labeling the values of both *T* and *P*.

(ii) (3) Exactly what does the given value represent? (Remember, it is not the true enthalpy of the steam, which can never be known.) Identify the conditions (phase, *T*, *P*) of any state you refer to.

2. (15) You wish to calculate the heat of vaporization of water at 0°C, $(\Delta\hat{H}_v)_{H_2O}(0^oC)(kJ/mol)$.

(a) (5) Calculate it using the steam tables. (Pay attention to units.)

(b) (10) Write an expression for it in terms of physical property data tabulated in Tables B.1, B.2, ***and B.8***, neglecting the effect of pressure on enthalpy at $P \le 1$ atm. Clearly show the process path you construct and the enthalpy changes corresponding to each step on it, indicating which table you will retrieve each physical property from. Substitute heat capacity formulas where they occur, but don't carry out integrations and don't do any arithmetic.

3. (10) 100.0 mol of liquid *n*-decane ($C_{10}H_{22}$) at 20°C and 1 atm is to be heated at constant pressure to its normal boiling point and vaporized.

(a) (2) Estimate the heat capacity of liquid *n*-decane in [kJ/(mol-°C)]. (Note that you won't find it in Table B.2.)

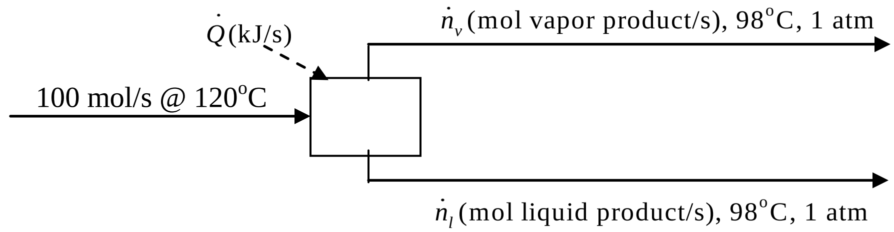
(b) (2) Estimate the heat of vaporization of *n*-decane in (kJ/mol). (Note that you won't find it in Table B.1 and that *n*-decane is a nonpolar liquid).

(c) (6) Estimate the heat (kJ) required, noting that for this constant pressure process the energy balance reduces to $Q = \Delta H$.

OVER

4. (65) A vapor mixture containing 40.0 mole% benzene (B) and the balance toluene (T) at 120°C is fed at a rate of 100 mol/s to a partial condenser. Vapor and liquid product streams emerge in equilibrium at 98°C and 1 atm. ***Do not use the Txy diagram except for Part (e).***

(a) (15) Fill in and completely label a flow chart of the process – *write directly on the test paper below.* Then do the degree-of-freedom analysis and prove that you have enough information to solve for all unknown stream flow rates and compositions and the required rate of heat transfer. Begin your flow chart with the following sketch (which you should reproduce in your test booklet).



(b) (15) Fill out the inlet-outlet enthalpy table for this process, using the reference states indicated below. *Write directly on the test paper below – do not recopy into the blue book.*

References: B(v, 98°C, 1 atm), T(v, 98°C, 1 atm)

Species	$\dot{n}_{in}$	$\hat{H}_{in}$	$\dot{n}_{out}$	$\hat{H}_{out}$
B(l)				
T(l)				
B(v)				
T(v)				

Mark out cells you don't need, insert expressions for flow rates from the flow chart, enter zeroes for specific enthalpies where you can, and label the remaining unknown enthalpies as $\hat{H}_a$, $\hat{H}_b$, etc.

(c) (20) Identify (number and label) and write the equations you would solve to calculate all unknown stream flow rates and compositions and the required rate of heat transfer, using only physical property data (vapor pressures, normal boiling and melting points, heat capacities and latent heats, etc.) found in Appendix B of your text. Include the full expression for the unknown specific enthalpies of Part (b) in your list of equations. If you have integrals show the limits, and when a physical property appears in an equation, make clear what it is for [e.g., $(C_p)_{B(v)}$] and state the table you would look it up in. *Do not do any arithmetic or algebra or carry out any integrations.*

(d) (5) State all of the assumptions built into your equations in Part (c).

(e) (10) Use the Txy diagram on p. 262 to estimate (i) the maximum outlet temperature of the condenser that would be needed to get any liquid product at all, and the mole fraction of benzene in the condensate, and (ii) the minimum outlet temperature at which any vapor product would remain, and the mole fraction of benzene in that vapor.

HONOR PLEDGE: "I have neither given nor received unauthorized aid on this test."

____

Student Signature