SAMPLE

PRELIMINARY QUESTIONS

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THERMODYNAMICS

1. How do you determine equilibrium constants at varying temperatures from thermodynamic tables.

2. Given two metal bodies (same mass and heat capacities), one at T1 and the other at T2 how would you find their final temperature, if there is no transfer to any other bodies, or to the surroundings (assume reversibility). What is the maximum heat obtainable from this system.

3. What is the minimum possible work required to separate air into N2 and O2.

4. You have an open tank of liquid N2 and you are measuring the constant rate of evaporation. Then a storm blows overhead and the rate of N2 evaporation doubles. Find the pressure drop caused by the storm that would have this effect.

5. We are interested in changing refrigerants in order to improve the environmental safety pf our units. What do we need to know about the new refrigerant (assuming that nothing is known about it except that it is safe to use)? How can we measure these properties? Is there some way to check to see if these data are thermodynamically consistent?

6. What steps are required to make liquid hydrogen from hydrogen gas? (requires use of Joule-Thomson coefficients).

7. Discuss the origins and justification of corresponding-states theory.

8. Write the Gibbs-Duhem equation. Discuss its significance and usage.

KINETICS

1. I have a friend who has this reaction (A + B = C) he wants to use for profit. What are important kinetic (and thermodynamic) considerations? A very broad question where one ended up talking qualitatively about both collision and transition state theory and reactor design.

2. Compare/Contrast batch/PFR/CSTR/packed bed/fluidized bed reactors in terms of cost, advantages, disadvantages, etc.

3. Consider a series reaction A→B→C with rate constants k1 and k2 respectively. How do the concentrations of each species change with time in a batch reactor? What do they depend on? What happens to the profile of B as the ratio of k1 to k2 is increased/decreased? Why

(physical explanation)?

4. Write equations for a reactor in which mass transfer is rate-limiting.

5. Discuss parameters that characterizes the mass-transfer resistances vs. the kinetic resistance.

TRANSPORT

1. A broad heat, mass and momentum transfer question. Started off with a solid sphere of Napthalene falling through air. Turned into a liquid drop falling through air. The drop is a classic wet-bulb problem; the sphere was just application (and knowledge of) drag coefficient, heat and mass transfer coefficients.

2. You want to run water from a mountain lake to the valley below and collect the work at the bottom by using a turbine. If you have the height of the mountain, how would you determine if this was feasible (also economically).

3. You have two pressurized tanks with components A & B in both. The partial pressure of A in tank 1 is greater than the partial pressure of A in tank 2, and vice versa. The total pressure in each tank is constant and equal. Assuming the tanks are kept at the given concentrations, solve for the concentration profiles in the tube joining the tanks. Then, solve for the unsteady state concentartion of A in tank two assuming that the concentration is not held constant but the the tank is well mixed

4. How do gas and liquid diffusivities vary with T & P. How does gas diffusivity vary with P at very low P in our system above?

5. We are interested in developing a correlation for mass transfer in packed beds. Consider a tube packed with Naphthalene balls. Derive such a correlation. How would you present your data? What happens if the tube is too long? Is this a problem? Why?

6. Consider heat transfer through a pipe wall held at constant temperature. Derive an expression for the temperature of the fluid as a function of the tube length. Where could you predict the heat-transfer coefficient? What is a log-mean temperature difference? Is is correct to use LMTD? What is a velocity-average temperature and when could it be used?

7. You draw molten glass into a cool gas (eg. air) in the shape of a rod (assume the rod has constant radius). What are the equations describing temperature in this system.

8. For film flow down an inclined plane find the layer thickness, given the volumetric flowrate. Use a macroscopic balance including the effects of friction.

9. Discuss the pressure drop vs. flowrate characteristics in turbulent flow.

DESIGN

1. Make solid CO2 (dry ice).

2. Make food-grade phosphoric acid.

3. Given two pressurized tanks in series, connected by a recycle. You know the flowrates and initial temperature and pressures. Show how the pressure in each tank varies with time, if the recycle is ruptured. Can any maxima/minima be predicted?

4. Discuss the preparation of zinc for use in manufacturing zinc electrodes. Where does the zinc come from, how is it refined, what do you with the waste products?