

A Sample of Prelim Questions from 1994

Thermodynamics and Kinetics

1. • Give two statements of the Second Law of Thermodynamics. Prove that heat flows from a hot block to a cold one. (Maboudian)
2. • What is the relationship between P and V during the adiabatic compression of an ideal gas? (Maboudian)
3. • For the series reaction $A \rightarrow B \rightarrow C$ where k_1 and k_2 are the two rate constants, draw the concentrations of each reactant as a function of time for each reactant for $k_1 \gg k_2$ and for $k_1 \ll k_2$. What type of reactor will maximize the production of B? (Clark)
4. • If one had a CSTR of unknown volume, how could the volume be determined if you could control the inlet concentration and you knew the flowrate? (Soane)
5. • How would you describe "residence time distribution" to a high school student? How might you demonstrate it? (Reimer)
6. • Starting from the assumption of equilibrium, discuss how one relates the vapor phase composition to the liquid phase composition in a binary solution. What are the assumptions necessary to derive Raoult's Law?
7. • Derive the Langmuir-Henschelwood rate expression. (Chakraborty)
8. • How long will it take a kettle of water to boil given a constant heat addition Q - do not make assumptions? (Reimer)
9. • Analyze the concentration profile across a catalyst particle if the reaction is diffusion limited. (Soane)
10. • How does a refrigerator work? Give operating diagrams. Where is the bulk of the entropy produced? What are the equations for entropy production a compressor? (Newman)
11. • Suppose a species A is absorbed from a gas into a liquid. What does the concentration profile look like at the interface? What if there is a reaction in the liquid phase? (Radke)
12. • What is steam distillation? (Soane)
13. • What is the Thiele Modulus? (Clark)
14. • Derive the rate expression for the following surface reaction:

$$A_{(g)} + * \rightleftharpoons A^*$$

$$A^* + B_{(g)} \rightarrow C^*$$

$$C^* \rightleftharpoons C_{(g)} + * \quad (\text{Neumann})$$
15. • What is transition state theory? (Neumann)
16. • How does one design a reversible heat exchanger? (Newman)
17. • For the non-elementary, liquid phase reaction $A + B \rightleftharpoons C$, what experiments would you run, and how would you analyze the data to determine the rate expression for the reaction? (Clark)

Transport

1. • Derive the DE for the height of liquid in a tank w.r.t. time when the tank is connected to a long straight pipe with a valve on it. (Blanch)
2. • What is the shear stress profile for a Newtonian fluid flowing in a pipe? How about a non-Newtonian fluid? What is the temperature profile taking into account viscous heating? (Denn)
3. • How do you think Dow Chemical "scientifically engineered" their new Ziplock bags with "freshness vents" in order to keep just the right amount of moisture in the bag to keep your vegetables fresher longer?

- Describe diffusion of salt from a pickle to a solution of lower salt concentration. (Denn and Muller)
- Describe the temperature profile for a pipe with hot fluid flowing in it located in a room much cooler than the fluid. What are the mechanisms of heat transfer involved inside and outside the pipe? What are the mathematical expressions for these processes? What is the Brinkmann #? What is the Grashoff #?
- Why does the point of boundary layer separation move back behind a sphere at Re # approx. 200,000?
- Describe the melting of an ice ball rising in a hot liquid. Include mass transfer, heat transfer, and flow around a sphere. How would these nonlinear equations be solved numerically? (Radke)
- Why is the stress tensor symmetric? (Goren)
- Derive an equation for the concentration profile in a plug flow reactor where the reaction is wall catalyzed. (Graves)
- Wind blows past a small metal ball which hangs from a string. Determine the angle that the string makes with respect to the vertical. Draw the drag coefficient vs. Re #. Discuss it qualitatively. (Blanch and Radke)

Process Design

- How do you make ethylene glycol? (Vorhis)
- Draw a diagram to make vinyl chloride. Where does the energy come from? What do you do with the HCl?
- What do you do with waste H_2S ? Can you make it into H_2SO_4 ? Describe the process units, recycle, and separations? (Lynn and many others)
- Where is nickel obtained from? Explain the purification process (balanced equations)? What do you do with the waste? (Cairns)
- How would you control the temperature of a bath tub? Discuss the advantages and disadvantages of P, PI, and PID type controllers. What if we could only measure the inlet flow rate and the tub temperature? (Keasling)
- Outline a process to make liquid and solid CO_2 . How would a pure source of CO_2 be obtained? (Cairns)
- Design a process to produce zinc. (Cairns)
- How is phosphoric acid made? (Cairns)
- What is your research about?