Additional Questions

You are in the lab on Saturday and need H_2 for an experiment. Come up with as many ways as possible for making H_2 from materials you might find in your lab.

You have a block of metal at temperature T1 and a heat sink at T2. Calculate the maximum amount of work that can be extracted from this system.

Describe how temperature affects the rate and equilibrium conversion of a chemical reaction.

Describe the transition to fully developed flow for flow between two paralell plates. Calculate the distance from the entrance to where flow is fully developed.

Discuss unimolecular reaction theory.

Consider a CSTR with a feed preheater and an exothermic reaction.
What does the X vs. T curve look like?
Where does this curve come from?

What is T for a free expansion of a Van Der Waals gas?

What is the VanDerWaals equation of state?
What is the significance of the different parameters?

What is the Virial equation of state?
What do each of the coefficients in the Virial equation model?

Consider an incandescent light bulb. What is the dominant factor responsible for the visible light output?
What could one do to increase the light:heat output ratio?

Discuss boudary layers. When and why do they exist? What are the relative magnitudes of momentum and concentration boundary layers? What eqation(s) relates the magnitudes of the various kinds of boundary layers?

Consider a magnetic hard disk drive. In normal operation, it spins at high rpm an the magnetic head does not come in contact with the disk. In time, however, instabilities cause the head to wander and it eventually hits the disk. When this happens the disk crashes. What might be done to prevent a crash?

Consider a centrifugal pump.with a shutoff valve on its output stream. What happens to power consumption of the pump if the valve is closed? Why do we not put valves on the inlet side of centrifugal pumps?

Consider a positive displacement pump with a shutoff valve on its outlet stream. What happens if the valve is closed?

Balance the reaction of $Ga(CH3)3$ and $AsH3$ to make GaAs. For a PFR, what is the reactor design equation in terms of conversion for this system? (assume kinetics are first order in each of the reactants)

Sketch a plot of the drag coefficient for a sphere vs Re from
Re <<1 to RE >>1(i.e. from creeping flow to turbulent flow).

Why does a golf ball have dimples?

What is the difference between form drag and skin friction?

For the catalysis of CO to form CO_2 given the elementary irreversible reaction:

$$CO + 1/2\ O_2 \Rightarrow CO_2$$
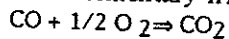
devise a Langmuir-Henchelwood mechanism for this reaction.
If the rate expression is observed to be:

$$r = k[CO][O_2]^{1/2}$$

what is a reasonable mechanism for the reaction?
How does the 1/2 order in O_2 arise?
What is the steady state approximation?
When does it apply?

What is the activation energy?
Give a physical interpretation of the activation energy.

What is a reaction rate constant?
How does a reaction rate constant vary with temperature?

What is the frequency factor?
What physical significance does it have?

How do you get the rate constant from plug flow experimental data for a first order reaction?

For a series reaction, what variables influence the amount of intermediate formed?
How would you maximize the production of intermediate in a CSTR, in a PFR, or in a batch reactor?

For an exothermic, first order reaction, plot the extent of reaction and the reaction rate as a function of temperature.

When can the steady-state approximation be used?

What is the chemical potential?

Experimentally, how would you determine ΔH_f, ΔG_f, and ΔS_f?

How does a refrigerator work?
Sketch T-S, P-V, and P-H diagrams.

How does the rate constant vary with temperature?

Derive design equations for mass and energy for CSTR, PFR, and Batch reactors.

Define space time, space velocity, and mean residence time.

What are the Clapeyron and Clasius-Clapeyron equations?

How would you calculate the adiabatic flame temperature.

Which type of reactor is best for a series reaction? a parallel or an autocatalytic?

Give the three laws of thermodynamics.

Diagram the Carnot cycle, the Otto cycle, the Diesel cycle, and the Rankine cycle.

Derive a Langmuir-Hinshelwood kinetic expression for a solid catalyzed reaction; eg., A + B $\Rightarrow$ R.

Prove that ΔG is $\leq$ zero for any process.

Prove that S tends toward a maximum.

What is the Gibbs mixture rule?

Derive the Gibbs-Duhem equation.

Find the enthalpy change for this system;

What is a Joule-Thompson liquification process?

What is the slope of lnKeq vs 1/T curve for an exothermic and for an endothermic reaction?

Why is entropy zero at 0 Kelvin?

How would you calculate the heat capacities of two gases (eg H_2 and CH_3NCO)?

Prove that ΔS = zero for equilibrium and that S tends toward a maximum.

What is the melting point of Boron?

What is a Mollier diagram?

What is the Langmuir isotherm?
Where does it come from?

Consider laminar flow in a pipe.
a. Write out the momentum equation appropriate for this geometry. Drop all terms that are identically zero.
b. reduce the equation to a non-dimensional form. Use L for characteristic length and V for characteristic velocity.
c. One should notice that Re does not appear in the non-dimensonal form. Why then is Re so important in determining if flow in a pipe is laminar or turbulent?

Discuss the mass transport associated with a gas stream flowing over a pan of volitile liquid.

You wish to employ fins to enhance heat exchange between a liquid and a gas phase in a heat exchanger. Where should you put the fins (gas or liquid side) and why?

Draw the temperature profile associated with a hot liquid flowing through a cold pipe.

Highly viscous fluid causes viscous heating near a wall. Draw the steady state temperature profile associated with this flow.

Draw the steady state temperature profile associated with hot fluid flowing through a cold pipe where viscous heating is present.

Estimate the number of pipe diameters required to achieve fully developed flow in a pipe.

Derive the Van't Hoff osmotic pressure relationship.
$$\pi V = nRT$$
Why is this relationship so similar to the ideal gas law?

Say you were asked to design an automobile that would run on NH_3 but the EPA will not let you burn NH_3 due o NO_x formation so you decide to run the automobile on H_2. Design a flow sheet for this process and discuss some of the problems.

What is a fluidized bed reactor?
What are its advantages and disadvantages?

Given a CSTR at temperature T with no reaction, what would happen if the temperature of the inlet were suddenly increased?
What if instead of a CSTR you had a stream of air flowing past a thermocouple?
What property of the thermocouple governs the rate at which it shows the temperature change?

What do activity and fugacity mean in words?
How could you calculate fugacity theoretically?

How do you make ammonia?
(the whole story)

What is a standard state?
Why do we need a standard state for G and H?
Do we need a standard state for S?
Is H° a function of P, T and standard state?

How does an ice skate work?

Increasing the heat to the boiler of a steamboat caused the boat to slow down. Why?

Consider two pressurized vessels connected in series with recycle. If the recycle is cut off, how will the pressure in each vessel vary with time?

What is the lowest temperature water can be cooled to in a cooling tower?

Given the pressure drop, L and D for a pipe, how would you find the velocity?

What is the reflux ratio and a pinch point?

Diagram an HCL or SO2 absorber.

How do you make pure N2 from air with out cryogenic techniques?

Discuss how to establish a scheme to separate a multi-component system of liquids.

What methods could be used to purify a stream of a polar organic substance from trace nonpolar impurities?
Which would you choose and why?

Why is distillation done at high pressure?

Develop a process for separating NH3 from an NH3-air gas stream at low pressure (P << 1atm).
Because of the low pressure one cannot afford to have any pressure drops in the process.

How would you separate air into pure O_2 and N_2?

How would you separate two organic compounds with similar melting points and boiling points?