

ECHE 460 20 Questions

Centrifugal Pumps

1. Sketch a typical pump curve including units, and then explain how this curve would change if two identical pumps are operating in series and in parallel.
2. Sketch a typical pump curve and then overlay a typical system curve on this pump curve and explain what this means in terms of the operating conditions.
3. Sketch a typical pump curve and a typical system curve, and then explain how the system curve would change if more valves, fittings, tees etc. have been added to compensate for a design change. What if anything does this suggest for the operation of the pump?
4. Define cavitation and describe any effects this might cause. What can be done to the pump or system to minimize the chance that cavitation will occur. How can you tell cavitation is indeed occurring?
5. What is Net Positive Suction Head (NPSH)? Compare and contrast NPSH available versus that required. How does a change in temperature or pressure affect the NPSH available?
6. How does a centrifugal pump change electrical energy into pressure energy or head?
7. Describe how to convert the units of pressure in, for example, psi differential into units of feet of water column or head.
8. How are the values of C_v and K related for the 1" glove valve, V-5? Are there units associated with these constants? Explain.
9. Describe and explain the physical meaning behind each term in the Bernoulli's mechanical energy balance?
10. Describe each of the types of valves being used on the pump test stand?
11. How do you determine a system curve for this experiment?
12. How do you experimentally determine a system operating point for this system? Then, explain where this point should lie on a measured pump curve and a calculated system curve.
13. What are the following terms: Reynolds number, friction factor and Roughness factor?
14. What can you find on a Moody Chart? How is it used?
15. List the different efficiencies measured on this system? What are they a ratio of? Which one cannot be measured with this system?
16. Besides centrifugal pumps, name two other types of pumps and give examples of what kinds of fluids and or materials they are capable of pumping.
17. What is a swing check valve? What is the purpose of the swing check valve on the suction line of pump #2?
18. How do the suction and discharge pressure gauges on the pump experiment work?
19. Name the key internal components of a centrifugal pump and describe their function.
20. Using a typical pump curve identify and explain what is meant by the "shut off head" of a pump and the "run out" of a pump.

Heat Conduction in Solids

1. Explain how a thermocouple works in the measurement of temperature. What kind of thermocouple is used in the experiment?
2. Describe cold junction compensation and why it is important to the use of thermocouples.
3. Explain Fourier's law of heat conduction.
4. Explain Newton's law of cooling with respect to heat convection.
5. Explain the differences between conduction, convection and radiation heat transfer.
6. Define the thermal conductivity of a solid and its units in the cgs system.
7. Define the heat capacity of a solid and its units in the cgs system.
8. Define the thermal boundary layer that may form around a solid.
9. What is a heat transfer coefficient, how is it used in chemical engineering analyses, and how is it determined in this experiment? Be very specific.
10. What does a typical heat transfer coefficient depend on in terms of system and material properties.
11. How would this experiment change if oil was used instead of water as the heat transfer medium?
12. How would this experiment change if there was no forced circulation, i.e., no circulation in the water bath?
13. Explain the difference between steady-state and unsteady-state or transient heat transfer.
14. Under what conditions is it appropriate to ignore end effects in the mathematical modeling of a cylinder?
15. Name the two different geometries and seven different materials used in this experiment. Compare and contrast the unsteady-state heat conduction properties associated with the same material but for the two different geometries and with the same geometry but for the different types of materials.
16. Explain the lumped capacitance method, its assumptions, when it is applicable, and what it can be used for in this experiment.
17. Explain the spatial gradient method, its assumptions, when it is applicable, and what it can be used for in this experiment.
18. Define the Biot number and explain how it is used in this experiment.
19. Define the Fourier number and explain how it is used in this experiment.
20. Define thermal diffusivity and explain its similarity to mass and momentum transfer phenomena.

Voltammetry

1. What is a background scan and why is it performed?
2. What does the term *Electrode Sensitivity* mean, as it pertains to this potentiostat?
3. What is a SCE reference electrode and why is it used? Name the active materials of the working and counter electrodes?
4. Describe the reactions (if any) that are taking place at the anode in this experiment.
5. Describe the reactions (if any) that are taking place at the cathode in this experiment.
6. Name the three electrochemical methods that are used to determine the diffusion coefficient of an ion in solution. Which one of these techniques yields the most reliable result? Why?
7. For the Cyclic Voltammetry (CV) experiment, sketch a typical cyclic voltammogram that exhibits a reversible reaction and explain what is going on physically and chemically as the current changes.
8. For a cyclic voltammogram, state two relationships of reversibility?
9. For the Rotating Disk Electrode (RDE) experiment, sketch a typical current versus voltage curve and explain what is going on physically and chemically.
10. For the chronoamperometry (CA) experiment, sketch typical current and voltage versus time curves and explain what is going on physically and chemically.
11. The Cottrell (CA) equation has two unknowns: the bulk concentration and diffusion coefficient. Explain how the experiment is carried out according to this model to find the diffusion coefficient for a known bulk concentration and vice versa.
12. The Randles-Sevcik (CV) equation has two unknowns: the bulk concentration and diffusion coefficient. Explain how the experiment is carried out according to this model to find the diffusion coefficient for a known bulk concentration and vice versa.
13. The Levich (RDE) equation has two unknowns: the bulk concentration and diffusion coefficient. Explain how the experiment is carried out according to this model to find the diffusion coefficient for a known bulk concentration and vice versa.
14. During an RDE experiment, at the lowest sweep rate the formal potential E_o for the ferricyanate/ferrocyanide redox couple was determined. Why is the lowest sweep rate used for this determination and how does the formal potential compare to a standard hydrogen electrode?
15. For an RDE experiment, explain what happens in the diffusion layer immediately adjacent to the electrode surface that causes a faster rotational rate to give rise to a higher peak current.
16. For a CV experiment, explain what happens in the diffusion layer immediately adjacent to the electrode surface that causes faster sweep rates to give higher peak currents.
17. During the RDE experiment you reach a "limiting current". Define this condition.
18. The initial and final potentials for the CA experiment are chosen so that they bracket the formal potential for the analyte. Why?
19. In each of these experiments, why are 100 ml of 1.0 M KCl added to the solution?
20. The CV potential sweep voltage ranged from +800 mv to -100 mv, and that for the RDE ranged from +500 mv to -100 mv Why were these ranges used? What would happen if the potential sweep voltage ranged from +3000 mv to -1000 mv in either case? What would the corresponding responses look like?

Plate and Frame Filtration

1. Describe in general how a plate and frame filter system works.
2. Explain what happens to the pressure during a constant filtrate flow rate experiment.
3. Explain what happens to the filtrate flow rate during a constant pressure experiment.
4. Explain what happens to the pressure and the filtrate flow rate during an experiment when neither is controlled and all the discharge from the pump is sent through the filter press.
5. Sketch three mass of filtrate collected versus time curves for three different constant flow rate experiments and explain.
6. Sketch three pressure versus time curves for three different constant flow rate experiments and explain.
7. Sketch three mass of filtrate collected versus time curves for three different constant pressure experiments and explain.
8. Sketch three pressure versus time curves at three different constant pressure experiments and explain.
9. Explain how to measure the concentration of CaCO_3 in the water slurry in mol/cm^3 .
10. Describe the two resistances that are important in the design and operation of a plate and frame filter press.
11. Should either of these resistances be a function of how the filtration experiment was carried out, i.e., whether it was carried out at a constant flow rate or at a constant pressure? Explain.
12. Describe what is meant by an incompressible or a compressible filter cake.
13. What specific set of experiments are used to determine whether the filter cake is compressible or not? Explain.
14. If a filter cake is compressible, how does it affect the performance of the filter press?
15. Sketch how the porosity of a filter cake may vary with pressure for both compressible and incompressible filter cakes.
16. In many physical situations a flux is proportional to a driving force and inversely proportional to a resistance. Explain this situation in terms of the plate and frame filtration experiment.
17. Sketch the centrifugal pump curve associated with this experiment and explain how this curve can be used to predict the performance of the filter press. What information also needs to be known about the filter press?
18. What specific set of experiments are used to quantify and validate the mathematical model developed of the plate and frame filtration system? Explain.
19. State all the system parameters that are needed in the mathematical model to carry out a parametric study with the plate and frame filtration system.
20. Is it possible to use this model to scale-up a plate and frame filtration system for an industrial application?

Rheology

1. Explain the difference between a Newtonian and a Non-Newtonian fluid.
2. Non-Newtonian fluids may be broadly classified into three types of fluids. Compare and contrast the rheological properties of these three different types of fluids.
3. Describe the following: time-independent flow, time-dependent flow, and viscoelastic flow.
4. Explain the different types of time-independent flows.
5. Define thixotropic and rheopectic fluids and give two common examples of each.
6. “Silly Putty” is an example of a material that exhibits both solid and liquid like properties depending of the rate of shear. Classify the rheological behavior of this type of material and explain how this dual mode behavior occurs from a molecular point of view.
7. Define apparent viscosity and viscosity, and explain the difference.
8. Describe “Newton’s law of viscosity” in terms of shear stress and shear rate relations.
9. Give a detailed molecular picture of the meaning of the viscosity of a liquid.
10. Sketch typical apparent viscosity versus shear rate curves for Newtonian, shear thinning and shear thickening fluids. Discuss any differences.
11. Sketch typical shear stress versus shear rate curves for Newtonian, shear thinning and shear thickening fluids. Discuss any differences.
12. Explain the “no slip” wall boundary condition, and give three examples of fluids that exhibit wall-slip.
13. Explain the physics behind the cone and plate viscometer and how it is used to determine the apparent viscosity of a fluid.
14. Explain in detail how the cone and plate viscometer was calibrated.
15. Name three other types of viscometers besides the cone and plate set-up. Explain how they work, and then explain the advantages and disadvantages of each for different types of fluids.
16. Explain the difference between kinematic and dynamic viscosity and provide CGS units for each. What type of viscometer directly provides kinematic viscosity?
17. Name the three models studied in this experiment, and then compare and contrast their applicability to different Newtonian and a Non-Newtonian fluids.
18. An energy (E) can be obtained from the temperature (T) dependence of the viscosity (μ) of a Newtonian fluid using a typical Arrhenius type expression. What is the physically meaning behind this energy? For a mixed fluid such as water-glycerol, how does the magnitude of this energy in kJ/mol compare to other energies associated with, for example, physical adsorption of small molecules in porous solids, phase change enthalpies, or chemical reaction energies?
19. Provide a physical, i.e., molecular, explanation as to why the viscosity of liquid decreases with increasing temperature, whereas the viscosity of a gas increases with increasing temperature.
20. The Ellis model is a unique three parameter model because it is simply the sum of the Newtonian (one parameter) and power law (two parameter) models. Show how to convert the Ellis model in the handout into a form that looks like a combination of the other two models.

Vapor-Liquid Equilibria

1. In thermodynamic and physical terms, describe what is meant by the vapor-liquid equilibria of a binary system.
2. Is the VLE of a binary system a function of pressure? Explain.
3. Sketch typical x-y diagrams for ideal, non-ideal, and azeotropic binary VLE systems.
4. Sketch typical T-x-y diagrams for ideal, non-ideal, and azeotropic binary VLE systems.
5. Sketch typical H-x-y diagrams for ideal, non-ideal, and azeotropic binary VLE systems.
6. Is it possible to determine the H-x-y diagram for the ethanol-water binary system from the data measured during this experiment? Explain.
7. Explain how the Othmer still is used to measure VLE.
8. Explain the physical principle behind the densitometer. In other words, how does it measure the density of a gas or a liquid. Be very specific and technical.
9. Explain how to convert the density of a binary solution into mole fractions.
10. Explain how to calculate a liquid phase activity coefficient from the experimental VLE data.
11. Explain why the gas phase fugacity coefficient can be neglected in these VLE experiments.
12. Explain the Poynting correction and why it does not apply to this VLE experiment.
13. Explain the physical basis (if any) behind the Wilson activity coefficient model.
14. Explain the physical basis (if any) behind the Van Laar activity coefficient model.
15. Explain the physical basis (if any) behind the Margules activity coefficient model.
16. Of the three activity coefficient models, which one should provide the best representation of non-ideal VLE. Explain.
17. Explain what is meant by the thermodynamic consistency of experimental data.
18. Explain how to apply the thermodynamic consistency concept to the VLE data measured during this experiment. Be specific and state any assumptions involved in this analysis.
19. Explain what would happen if a soluble amount of a salt, like NaCl, was added to the ethanol-water binary system.
20. Explain what would happen if an organic, like benzene, was added to the ethanol-water binary system.

Adsorption and Diffusion

1. Explain how a gas chromatograph works when using a thermoconductivity detector (TCD).
2. Describe the structure of the 5A zeolite and why it works so well as a physical adsorbent.
3. What role does helium serve in this experiment? In particular, does helium become adsorbed along with ethane in the 5A zeolite structure? Does it even enter the 5A zeolite structure? Explain.
4. Name the three mass transfer resistances that are important to the adsorption and diffusion of ethane in 5A zeolite.
5. Describe film diffusion, macropore diffusion, micropore (or crystal) diffusion, and their relevance to this experiment.
6. Define the Henry's law constant for the physical adsorption of a gaseous species in microporous zeolite or adsorbent.
7. Define the heat of adsorption or energy of adsorption for the physical adsorption of a gaseous species in microporous zeolite or adsorbent.
8. Provide a range of physical adsorption energies in kJ/mol, and compare this range to other energies associated with, for example, chemisorption or chemical reaction.
9. Define the activation energy for diffusion for the physical adsorption of a gaseous species in microporous zeolite or adsorbent.
10. Explain the implications (if any) if the heat of adsorption is less than, equal to or greater than the activation energy for diffusion.
11. Describe the basis behind and the information that can be obtained from the first moment analysis of a chromatographic peak.
12. Describe the basis behind and the information that can be obtained from the second moment analysis of a chromatographic peak.
13. Define the three different porosities associated with the packed bed of zeolite particles (i.e., the bed, the particle and the total porosities).
14. Define the two different velocities associated with the packed bed of zeolite particles (i.e., the superficial and the interstitial velocities).
15. Define the three different densities associated with the packed bed of zeolite particles (i.e., the absolute or skeletal, the particle and the packed bed or column densities).
16. Describe gas phase dispersion as it pertains to this packed bed experiment. How is it measured in this experiment? Explain its importance relative to the other three mass transfer resistances.
17. Describe why the experiments need to be carried out at more than two and preferably four different interstitial velocities (use mathematical reasoning related to the analysis).
18. Explain why the retention time (t_r) of a peak decreases with increasing temperature and interstitial velocity.
19. Explain why and how the peak area changes with increasing temperature and interstitial velocity.
20. How would the equilibrium capacity, heat of adsorption, micropore diffusion coefficient and activation energy for diffusion change if methane was used instead of ethane, and then if propane was used instead of ethane. What if nitrogen was used with ethane instead of helium?