

ChE 231 - Spring 2009 - Closed Book Question List

Chapter 1

- 1 Compare and contrast the typical physical properties of metals, ceramics, and polymers. (Generalization is expected; there will be specific exceptions to any statement you make.)
- 2 Briefly describe the different dimensional scales that are used to characterize the structure of a material.
- 3 Describe some common trade-offs in material properties.

Chapter 2

- 4 Explain the difference between a compound and a molecule.
- 5 Describe how and explain why atomic radius and electronegativity change with position in the periodic table.
- 6 Describe the different kinds of primary atomic bonds and how each type of primary atomic bond acts to fill the valence electron shells of individual atoms.
- 7 How can you tell what kind of primary atomic bonding is present by noting where the involved elements are located on the periodic table?
- 8 Describe how the electronegativity difference affects the ionic/covalent character of a bond.
- 9 Describe secondary atomic bonds including their cause and factors affecting their strength..
- 10 Explain why some covalently-bonded molecules have low boiling points and others have high boiling points.
- 11 Explain why covalent bonds are strong yet covalently-bonded polymers are weak.

Chapter 3

- 12 Compare the BCC, FCC, and HCP crystal structures. Consider the arrangement of atoms, coordination number, and packing density.
- 13 Explain is the structural difference between FCC and HCP structures.
- 14 Describe the factors which determine the crystal structure of crystalline ceramic materials.
- 15 Describe the difference in structure between crystalline and amorphous materials. Which way do metals, ceramics, and polymers generally behave?
- 16 Explain the relationship between the atomic structure and mechanical properties of the 2-dimensional (sheet) and 3-dimensional SiO_2 and carbon compounds.
- 17 How are grain boundaries of a metal caused by the solidification process? How will changes in the solidification process affect the grain size?
- 18 Explain how and why glass composition is varied. You don't have to remember specific formulations.

Chapter 4

- 19 Explain why it is important to know both the number-average and weight-average molecular weights of a polymer.
- 20 Describe the different ways that the configuration and structure of polymer molecules can vary. Consider the effects of monomer type, monomer functionality, branching and crosslinking, and the sequencing of monomer units in copolymers.
- 21 Explain the way that polymers are classified with respect to their response to elevated temperature. Relate the answer to the polymer structure and mer functionality.
- 22 Describe the crystalline structure of polymers and the factors which can affect the extent of crystallinity.

Chapter 5

- 23 Describe the different kinds of point defects that exist in solids. Include the specific differences that exist in ceramic crystal structures.
- 24 Define the term solution. Describe the two kinds of solid solutions and the kinds of atoms that are involved in each.
- 25 Describe edge and screw dislocations. Include the appearance of the dislocation and the orientation of the distortion relative to the dislocation.

Chapter 6

- 26 Describe the difference between kinetics and thermodynamics and explain the diffusion process in these terms.
- 27 Describe vacancy and interstitial diffusion. Include the types of elements involved, and their typical relative rates.
- 28 Explain the concepts of steady-state and nonsteady-state diffusion.

Chapter 7

- 29 Tell what you know about the different kinds of stress affecting solid parts and the ways to define and measure stress and strain.
- 30 Define elastic deformation and the terms used to characterize it.
- 31 How is the onset of plastic deformation defined and observed on a stress-strain diagram
- 32 Explain the difference between strength and toughness and how they are measured on a stress-strain diagram. When is strength important and when is toughness important?
- 33 Describe two different energy measurements that can be made using a stress-strain diagram.
- 34 Explain the significance of a decrease in engineering stress as strain increases.
- 35 Explain the influence of porosity on the mechanical properties of ceramics. Consider variability and stress concentration.
- 36 Describe three different typical stress-strain behaviors of polymers and relate this to temperature, crystallinity, and crosslinking.
- 37 Describe the possibilities for the strain response of a polymer subjected to a constant stress for a finite period of time, after which the stress is removed.
- 38 Describe the relationship between relaxation modulus and temperature and the effect of crystallinity and molecular weight.
- 39 Explain the difference between hardness and strength. Consider both the behavior that each term characterizes and the measurement technique.

Chapter 8

- 40 Describe the slip process and the importance of dislocations to slip. Include a description of how dislocations interact with each other during slip.
- 41 Why is slip easier in FCC than in either HCP or BCC crystal structures?
- 42 Explain why slip planes change direction when they cross grain boundaries.
- 43 Explain how and why a metal solution can have better mechanical properties than either pure metal.
- 44 Describe the process of strain hardening and how and why it changes a metal's properties.
- 45 Describe what happens to the grain structure of a cold-worked metal as it is held at an elevated temperature.
- 46 Explain how and why the typical mechanical properties of ceramics and metals differ. Consider plastic deformation.
- 47 Explain the mechanisms of plastic deformation for crystalline and non-crystalline ceramics.
- 48 Briefly describe the factors that affect the mechanical strength of semicrystalline polymers.
- 49 Explain the mechanical behavior of elastomers in terms of atomic-scale structures and processes.

Chapter 9

- 50 Describe and explain the relationship between temperature, toughness, and brittle vs. ductile failure modes in metals. Need to connect ideas of slip, ductility, and toughness.
- 51 Describe fatigue and some of the things that can be done to minimize it.
- 52 Define the term “fatigue limit” and explain why is it important?
- 53 Describe creep, compare it to slip, and describe the method and basis for predicting creep behavior in a short-duration test.

Chapter 10

- 54 Describe the changes in the equilibrium structure (atomic and microscopic scale) of a liquid mixture of nickel and copper as it's cooled and solidified. Other binary isomorphous systems could be substituted. The phase diagram will be provided..
- 55 Describe the possibilities for the solid atomic structure present when two dissimilar metals are mixed. Consider binary eutectic diagrams only.
- 56 Describe what happens (in terms of atomic and microscopic scale structure) to a liquid mixture of 20 wt% Ag in Cu as it is cooled to below 779 C. The phase diagram will be provided. Other materials and compositions could be substituted.
- 57 Describe what happens in an invariant reaction other than the eutectic reaction.
- 58 What do horizontal and vertical straight lines indicate on a two-component phase diagram?
- 59 Describe the origin and equilibrium microstructure of hypereutectoid and hypoeutectoid steel.

Chapter 11

- 60 Explain the shape of the isothermal phase transformation diagram for plain-carbon steel. Include both nucleation and diffusion concepts in your answer.
- 61 Describe the microstructure and cooling process followed to form the various two-phase mixtures which can be formed by cooling austenite.
- 62 Describe the mechanism by which martensite is formed. .
- 63 Compare the cooling programs needed to produce pearlite, bainite, and martensite.
- 64 Explain how alloy steels can be used to make larger parts made of martensite.
- 65 Explain how and why the strength of steel varies with carbon content and microstructure.
- 66 Compare constant cooling transformations and isothermal transformations. Consider both the ease and practical significance of the experiments.
- 67 Compare the strength and toughness of martensite, tempered martensite and bainite. Explain the reason for this. Consider the location of the carbon and the shape of any cementite particles.
- 68 Describe the process of precipitation hardening and explain why the hardness goes through a maximum value as aging time increases.
- 69 Describe the concept of the glass transition, and how it relates to the structure of polymers.
- 70 Describe the factors that affect the melt temperature and glass transition temperature of polymers.

Chapter 20

- 73 What are the three factors over which the engineer has control and which affect the final cost of a product? Which of these has this course been most concerned with?
- 74 (refers to Question 73) Thinking about the other two factors, give some examples where a particular material might be ideal for a given application, but it's not used. Why isn't it used?

Rubric for closed-book answers in CHE 231.

There are four main elements to a good answer. Weighting of the items is given below.

- 1 (4 points) All of the key technical elements (usually two to four items) of the required answer are identified. Usually some of the elements are given in the question.
- 2 (6 points) The technical elements which are present are correctly described along with their causal or sequential relationships to each other. The answer suggests that the student has a solid understanding of the material. Appropriate scientific or engineering terminology is used throughout. Pronouns are not used unless the noun they reference is clear. Colloquial or slang terms or phrases are not present.
- 3 (2 points) All of the text is grammatically correct and appears as sentences. Paragraphs, if needed, are effectively used to organize material. The first minor error, such as a missing article or incorrect capitalization are excused. Spelling, as long as it is reasonable, doesn't count.
- 4 (3 points) Overall, the answer is a well-structured, clear, concise statement. The answer doesn't ramble, the order of information is logical, all of the information present is either a part of an introduction to the answer or the answer to the question itself. Extraneous information, which does not address the question, is not present. Information is not repeated unnecessarily. This is the most subjective section.