INDIAN INSTITUTE OF TECHNOLOGY

Mid Term Examination

Autumn Semester, 2009 Sub. No. MT-30001 Sub. Name : Materials Engineering

Full Marks : 60 Time : 2 h

Instructions:

- Attempt **Question 1.** and **ANY THREE (3)** from the rest four (4) questions.
- Show your working and reasoning carefully for credit. Draw schematic diagrams wherever necessary.
- Points for each question are written below.
- Closed books, closed notes, closed laptop and cell phones. A calculator is allowed only.

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1. (A) Choose the correct alternative(s): 5

(i) Intermetallic compounds can be recognized on binary phase diagrams by:
(a) horizontal lines at the transformation temperature.
(b) a large solubility of element "A" in element "B".
(c) the presence of a peritectoid reaction.
(d) vertical lines at the stochiometric composition.

(ii) Coring occurs in systems with:
(a) non-equilibrium cooling from liquid to solid.
(b) changes in the solid composition as a function of temperature.
(c) all of the above.
(d) none of the above.

(iii) Nucleation of a solid phase from a liquid phase:
(a) requires some amount of undercooling.
(b) requires a minimum nucleus size.
(c) requires overcoming an energy barrier.
(d) all of the above.

(iv) Which of the following is a proper sequence?
(a) elastic limit, proportional limit, yielding, failure
(b) proportional limit, elastic limit, yielding, failure
(c) proportional limit, yielding, elastic limit, failure
(d) elastic limit, proportional limit, failure, yielding

(v) A semiconductor material has
(a) high band gap energy (b) low band gap energy
(c) zero band gap energy (d) overlapping band

(B) State whether the following statements are true or false: 5

(i) As the temperature decreases below the equilibrium transformation temperature, the energy barrier to nucleation gets larger.
(ii) Pearlite is a mixture of phases, not a single phase.
(iii) The maximum number of phases in equilibrium together in a binary alloy is three.
(iv) In general, the larger the coefficient of thermal expansion, the larger the melting temperature.
(v) Metallic bonds are stronger than ionic bonds.

(C) Arrange the following properties of metals, ceramics and polymers in ascending order: 5

Melting Temperature _____ _____ _____

Bonding Energy _____ _____ _____

Elastic Modulus _____ _____ _____

Coefficient of Thermal Expansion _____ _____ _____

Optical Transparency _____ _____ _____

2. (a) Why covalently bonded materials are generally less dense than ionically or metallically bonded ones?
   (b) What are the three phase reactions observed in Fe-Fe_3C phase diagram? Write the reactions.
   (c) Write down the expression for Gibbs phase rule for condensed phases (for solids and liquids). How does an interstitial solid solution differ from interstitial compound? Briefly state the various factors suggested by Hume-Rothery rule.
   (d) Distinguish between any two: (i) Unit cell and Lattice; (ii) Crystalline and Amorphous materials; (iii) Grain-boundary and Phase boundary.

2+3+6+4

3. (a) What is a phase? Is it different from solid solution? –Justify your answer.
   (b) For the perovskite ceramic crystal structure $BaTiO_3$, sketch the atomic configurations on the planes (111) and (110). Be sure to label the atoms.
   (c) A Cu-Ni (1:1) alloy is heated to 1300°C. The solid solution at this temperature has 58% Ni. Find the liquid composition at 1300°C if the ratio of solid to liquid is 0.5. Find the degrees of freedom in the point of 50% Cu at that temperature.
   (d) "Eutectic composition usually does not show coring whereas a solid solution may show coring". Explain why.
   (e) What is an 'anti-site'? Name a linear defect and a planar defect.

3+4+3+2+3

4. (a) What is recrystallization? Is it different from recovery? - Explain. How do you distinguish between hot and cold working?
   (b) Find the Miller indices of the line of intersection of $(1\ \bar{1}\ 0)$ plane and closed packed plane of FCC crystal.
   (c) Compute the number of atoms/m^3 in pure Al. Density of Al = 2.71 g/cm^3; A(Al) = 26.98; Z(Al) = 13; Crystal Structure = FCC
   (d) Determine the magnitude of tensile stress that is applied along the $[1\ \bar{1}\ 0]$ axis of a silver crystal to cause slip on the $(1\ \bar{1}\ \bar{1})[0\ \bar{1}\ 1]$ system. The critical resolved shear stress is 6 MPa.
   (e) "Amorphous materials often are transparent to visible light compared to their crystalline part however the electrical conductivity of the former is less". – Explain.

4+2+3+3 +3

5. (a) Why most of the semiconductor materials are opaque under optical light?
   (b) Draw a typical microstructure of a casting and indicate the different zones.
   (c) Why ferroelectric ceramics are dipolar?
   (d) Is electrical resistance is geometry dependent? Support your answer.
   (e) Show schematically how the magnetic moments will be aligned under the influence of a magnetic field in case of dia-, para-, ferro- and ferri-magnetic materials.
   (f) Distinguish between the phosphorescence and fluorescence. What is the working principle of an optical fiber?

2+2+2+2+4+3