INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Date: FN/AN, Time: 2 Hrs., Full Marks: 60,
Deptt.: Metallurgical & Materials Engineering, Mid Autumn Semester, 2011
Sub. No. MT 30001 **Sub. Name: MATERIALS ENGINEERING**
3rd Year B. Tech. Students of ME and MF No. of Students: 151

Instructions: Answer ALL the questions. Total number of questions: 6. Time your answers according to the marks allotted.
Where necessary, use schematic diagrams to illustrate your answer. Total number of pages: 3.

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1. Q1 Total: 10

(a) Classify the following materials in different types of Engineering Materials: Plywood, Concrete, Rubber, Cement, Fe_3O_4, Clay, Titanium alloys, SiC. 4

(b) What may be the reason behind the following: "While metallic materials are usually good conductor of heat and electricity, ceramic materials are usually insulators for both."? 2

(c) Aluminum oxide may be transparent, translucent, or opaque depending on the material structure. Which of the following may be transparent and which one may be opaque: a) Single crystal b) Polycrystal: Low porosity c) Polycrystal: high porosity. 2

(d) Which of the following cases material will normally have a higher coefficient of thermal expansion: 1) Material with higher bonding energy 2) Material with lower bonding energy? 1

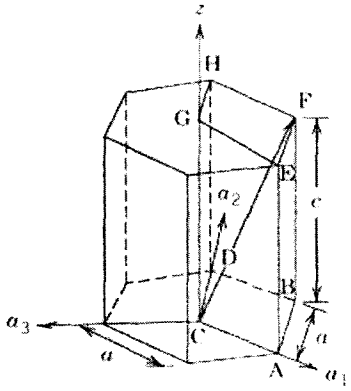
(e) What type of bonding do you find in HF? 1

2. Q2 Total: 12

(a) Which of the following is not a Bravais lattice?

a) Body-centered Orthorhombic, b) Base-centered Monoclinic
c) Face-centered Tetragonal d) Base-centered Orthorhombic 1

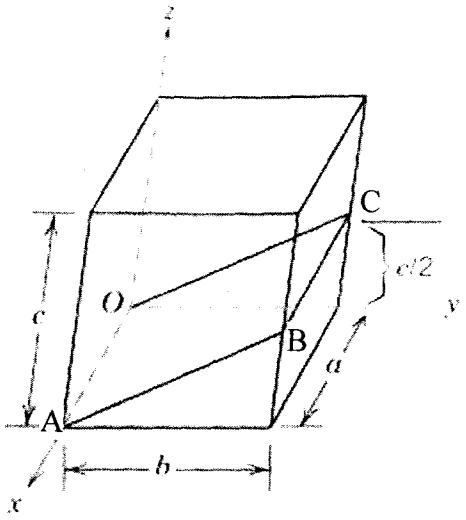
(b) In four index system what is the Miller Indices of the crystallographic direction of CE in the following figure?



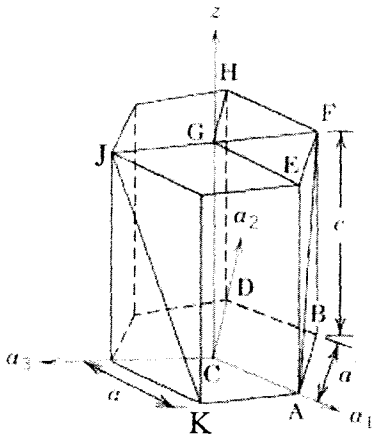
2

(c) Which of the crystal structure among BCC and FCC has bigger size octahedral site? Show your work mathematically. 1+4

(d) What are the Miller indices of the planes (plane OABC in fig. (a) and plane KAFJ in fig. (b)) shown in the figures? 4



(a)



(b)

3. Q3 Total: 8

(a) Give example for each of the following in a crystalline solid: a) Point defect b) Area/ planar defect. 2

(b) What is the relation between equilibrium number fraction of vacancy and temperature? Can there be a crystal with no vacant site at zero degree celcius? 2+1

(c) What is the Frenkel defect in ceramic crystal structure? 2

(d) Which microscope is generally used to image dislocations? 1

4. Q4 Total: 15

(a) What are the usual slip systems of FCC and HCP crystals? What are the numbers of slip systems in each of these cases? Which one of these crystals would be more ductile? 2+2+1

(b) Consider a single crystal tensile specimen with critical resolved shear stress of 3000 psi. The specimen is pulled with a tensile stress. The angles that the tensile stress direction makes with the normal to the most favourably oriented slip plane and that with the slip direction in that plane are 60 degree and 35 degree respectively.

   a. Will the crystal yield under the applied tensile stress of 6500 psi? Explain mathematically. 1+2

   b. What is the minimum tensile stress in the same tensile stress direction that would cause starting of plastic deformation in the single crystal? 3

(c) If you are given a block of single crystal of a pure metal, how will you increase its strength? 2

(d) What are the characteristic differences between recovery and recrystallization? 2

5. Q6 Total: 10

(a) Nickel (Ni) and Copper (Cu) form isomorphous phase diagram. Melting point of pure Ni is 1452 deg C and that of pure Cu is 1083 deg C. Draw a schematic phase diagram indicating the different phase regions. 3

(b) Which of the following is not true about a binary eutectic system? 1

a. Pure metals have higher melting points than any alloy
b. Eutectic reaction occurs at a particular temperature
c. One solid phase and one liquid phase react to form one solid phase on cooling at eutectic temperature
d. Alloy of eutectic composition shows the lowest melting point

(c) A binary system shows eutectic reaction with following phase compositions at the eutectic temperature. Alpha phase: 18 mole %, Liquid: 58 mole %, Beta phase: 98 mole %. For an alloy composition of 38 mole %,

a. What phases are present just above the eutectic temperature? What are the relative amounts of these phases (assuming the phase compositions are almost same as that at eutectic temperature)? 1+2
b. What is the degree of freedom below the Eutectic temperature? Apply Gibbs Phase rule (indicating each term) to answer. 1+2

6. Q7 Total: 5

(a) Plot the variation in activation energy barrier with degree of undercooling for both homogeneous and heterogecneous nucleation in the same schematic diagram. 2
(b) Why for pure metal, solidification happens at a particular constant temperature? 2
(c) With increase in the wetting angle for the solid on mold, will the undercooling required for heterogeneous nucleation increase or decrease? 1