INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Sub. Name: MATERIALS ENGINEERING (Sub. No. MT 30001)

MID Autumn Semester, 2012 Time: 2 Hrs. Full Marks: 30
3rd Year B. Tech. Students of ME, MF, QE and QM No. of Students: 176
Dept.: Met. & Mater. Engg.

Instructions: Answer ALL the questions. Total number of questions: 4. 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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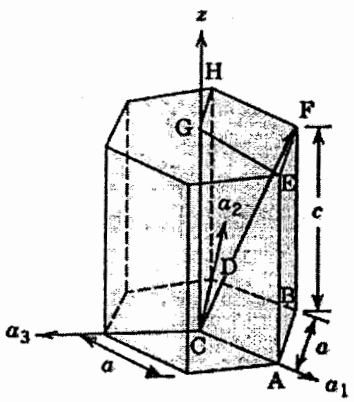
1. Q1 Total: 8

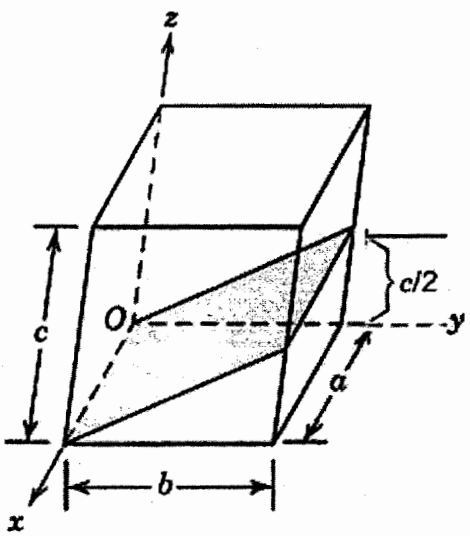
(a) Which of the following is not a Bravais lattice? 1

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

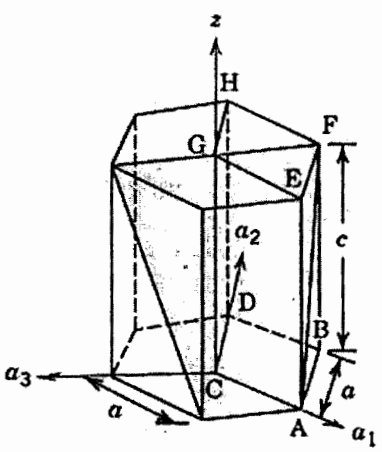
(b) In four index system what is the crystallographic direction of CF in the following figure? 1



(c) What are the Miller indices of the planes shown in the figures? 2



(a)



(d) Give examples for each of the following in a crystalline solid: a) Point defect b) Area/ planar defect. 1

(e) 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? 1+1

(f) What are the Frenkel and Schottkey defects in ceramic crystal structure? 1

2. Q2 Total: 8

(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? For which of the common metallic crystal structures, the twinning deformation mode is the most probable? 1+1+0.5+0.5

(b) Under an applied shear stress, in which directions a screw and an edge dislocation will move: parallel or, perpendicular or at an angle to the direction of applied stress? 0.5+0.5

(c) A single crystal of aluminum is oriented for a tensile test such that its slip plane normal makes an angle of 28.1^0 with the tensile axis. Three possible slip directions make angles of 62.4^0, 72.0^0, and 81.1^0 with the same tensile axis.
(i) Which of these three slip directions is most favored? 1
(ii) If plastic deformation begins at a tensile stress of 1.95 MPa (280 psi), determine the critical resolved shear stress for aluminum. 1

(d) If you are given a block of single crystal of a pure metal, how will you increase its strength? 1

(e) What are the characteristic differences between recovery and recrystallization? What is the driving force for grain growth? 0.5+0.5

3. Q3 Total: 8

(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. 1

(b) Which of the following statement is true about "Recrystallization": 1
   a. Driving force for it is "Reduction in surface energy"
   b. Recrystallization temperature is not a function of amount of prior deformation
   c. Driving force for it is "Reduction in volume free energy"
   d. Recrystallization is associated with increasing the total "grain boundary energy"

(c) For a 99.65 wt% Fe–0.35 wt% C alloy at a temperature just below the eutectoid, determine the following:
(a) The fractions of total ferrite (alpha) and cementite phases. 2
(b) The fractions of the proeutectoid ferrite (alpha) and pearlite. 2
(c) The fraction of eutectoid ferrite (alpha). 1
(d) The degrees of freedom 1

At the eutectoid temperature, the phase compositions are: ferrite (alpha): 0.022 wt%, austenite: 0.76 wt% (eutectoid composition), cementite: 6.7 wt%.
Pearlite is the eutectoid product (an aggregate of eutectoid ferrite (alpha) and cementite).

Q4 Total: 6

4.

(a) Derive the critical nucleus size for homogeneous nucleation during solidification of a pure metal. 2

(b) Plot the nucleation rate vs. Temperature for homogeneous nucleation during solidification. 2

(c) Plot the variation in activation energy barrier with degree of undercooling for both homogeneous and heterogeneous nucleation in the same schematic diagram. 1

(d) Why for pure metal, solidification happens at a particular constant temperature? 1