INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Subject Name: MATERIALS ENGINEERING (Sub. No. MT30001)

MID Autumn Semester, 2016   Time: 2 Hrs.   Full Marks: 30
3rd Year UG Students of ME, MF, and 2nd year UG students of QE and QM
No. of Students: 171
Dept.: Metallurgical and Materials Engineering

Instructions: Answer ALL the questions. Total number of questions: 5. Total number of pages: 2. Where necessary, use schematic diagrams to illustrate your answer.

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1.   Q1 Total: 6
(a) How do melting temperature and coefficient of thermal expansion vary with bonding energy?   2

(b) Explain why hydrogen fluoride (HF) has a higher boiling temperature than hydrogen chloride (HCl) (19.4 vs. −85°C), even though HF has a lower molecular weight.   1

(c) What type of bonding would be expected for each of the following materials: solid xenon, bronze, CsCl and rubber?   2

(d) What is the ratio of the linear density of the closest packed direction to that of the [001] direction in a BCC crystal?   1

2.   Q2 Total: 6
(a) What are the Miller Bavais indices of the normal directions to the following crystallographic planes:$(2\bar{1}\bar{1}0)$ and $(10\bar{1}0)$?   2

(b) The number of vacancies in a metal increases by a factor of ten when the temperature is increased from 800K to 1000K. Calculate the energy for vacancy formation assuming that the density of the metal remains the same over this temperature range. Boltzmann's constant is 8.62×10^{-5} eV.K^{-1}. Proper unit needs to be mentioned.   2

(c) What is the ratio of the interplanar spacings of the planes denoted by the first two peaks of a XRD profile of a FCC crystal? What is the ratio of the same for a BCC crystal?   2

3.   Q3 Total: 6
A single crystal of tungsten (BCC) is oriented for a tensile test such that tensile stress is applied along the [001] direction.
(a) On which family of planes should slip most likely occur? Of the planes in this family, list which will feel a resolved shear stress. Which will not? Will any of the planes that do feel stress be more favoured than the others?   0.5+1+1+0.5

(b) Choose one of the planes that experiences stress from part (a). If the critical resolved stress for this slip system of tungsten is 9.5 MPa, calculate the tensile stress needed to initiate slip along this plane in a close-packed direction.   3

4.   Q4 Total: 6
(a) For a material that obeys Hall-Petch strengthening, it is found that grain size contribution to yield strength is 45 MPa. If the grain diameter is increased by four times, corresponding strength is found to be 35 MPa. What would be the corresponding strength when grain diameter is reduced by 25% of the initial value?
                                                                            3
(b) In which of the following metals deformation by slip is easier: Ni and Ti. Explain.
                                                                            0+1
(c) What is the difference between slip and climb?   1

(d) In a precipitation hardened alloy where the main deformation mechanism is dislocation bypass of the precipitates by formation of Orwan loops, then how much will be increase / decrease in strength if the precipitates are coarsened to make the inter-precipitate distance doubled?   1

5.   Q5 Total: 6
(a) In a plain carbon steel, equilibrium compositions of α ferrite, austenite and cementite phases are 0.022, 0.77 and 6.67 wt.% C respectively. If for a specific alloy 20% proeutectoid ferrite is observed, what is the alloy composition?   2

(b) In a binary phase diagram drawn at 1 atm. pressure, what is the degree of freedom on the solvous line? Show your calculation.   1

(c) Which of the following materials is used in the turbine section and which one is used in the compressor section of a jet engine: Ti alloy and Ni based superalloy?   1

(d) Draw and explain the shape of the curve for nucleation rate vs. temperature for solidification of a pure metal. Indicate the melting point in the axis.   2

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