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Final Assessment Test – April 2019

Course: MEE1005 - Materials Engineering and Technology
Class NBR(s): 2072 / 2154 / 2275
Time: Three Hours

Slot: B1+TB1
Max. Marks: 100

Answer ALL Questions
(10 X 10 = 100 Marks)

1. a) Calculate the radius of an iridium atom, given that Ir has an FCC crystal structure, a density of 22.4 g/cm^3, and an atomic weight of 192.2 g/mol. [5]

   b) Calculate the fraction of atom sites that are vacant for lead at its melting temperature of 327 °C (600K). Assume energy for vacancy formation of 0.55 eV/atom. [5]

2. For some transformation having kinetics that obeys the Avrami equation, the parameter n is known to have a value of 1.7. If, after 100 s, the reaction is 50% complete, how long (total time) will it take the transformation to go to 99% completion?

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

4. Draw the continuous cooling transformation diagram for a 1.13 wt% C iron-carbon alloy. Make a copy of this figure and then sketch and label continuous cooling curves to yield the following microstructures:
   (a) Fine pearlite and proeutectoid cementite
   (b) Martensite
   (c) Martensite and proeutectoid cementite
   (d) Coarse pearlite and proeutectoid cementite
   (e) Martensite, fine pearlite and proeutectoid cementite.

5. For alloys of two hypothetical metals A and B, there exist an α, A-rich phase and a β, B-rich phase. From the mass fractions of both phases for two different alloys provided in the table below, (which are at the same temperature), determine the composition of the phase boundary (or solubility limit) for both α and β phases at this temperature.

Alloy Composition	*Fraction α Phase*	*Fraction β Phase*
60 wt% A–40 wt% B	*0.57*	*0.43*
30 wt% A–70 wt% B	*0.14*	*0.86*

6. Consider 1.0 kg of austenite containing 1.15 wt% C, cooled to below 727° C (1341° F).

(i) What is the proeutectoid phase?

(ii) How many kilograms each of total ferrite and cementite will form?

(iii) How many kilograms each of pearlite and the proeutectoid phase will form?

(iv) Schematically sketch and label the resulting microstructure.

7. a) Briefly explain why, upon solidification, an alloy of eutectic composition forms a microstructure Consisting of alternating layers of the two solid phases. [5]

b) Given here are the solidus and liquidus temperatures for the germanium-silicon system. Construct the phase diagram for this system and label each region. (If provided, please use the graph sheet to plot this) [5]

Composition (wt% Si)	Solidus Temperature (°C)	Liquidus Temperature (°C)
0	938	938
10	1005	1147
20	1065	1226
30	1123	1278
40	1178	1315
50	1232	1346
60	1282	1367
70	1326	1385
80	1359	1397
90	1390	1408
100	1414	1414

8. For a bronze alloy, the stress at which plastic deformation begins is 275 MPa (40,000 psi), and the modulus of elasticity is 115 GPa (16.7×10^6 psi).

(a) What is the maximum load that may be applied to a specimen with a cross-sectional area of 325 mm^2(0.5 $in.^2$) without plastic deformation?

(b) If the original specimen length is 115 mm (4.5 in.), what is the maximum length to which it may be stretched without causing plastic deformation?

9. a) Cite one reason why ceramic materials are, in general, harder yet more brittle than metals. [5]

b) Is it possible for two screw dislocations of opposite sign to annihilate each other? Explain your answer with proper justification. [5]

10. An undeformed specimen of some alloy has an average grain diameter of 0.040 mm. You are asked to reduce its average grain diameter to 0.010 mm. Is this possible? If so, explain the procedures you would use and name the processes involved. If it is not possible, explain why?

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