THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION 2006/2007

MEX 4233/MED 2204 – MATERIALS ENGINEERING - PART B

DATE : 17th MARCH 2007
TIME : 1015 HRS. – 1230 HRS.
DURATION : 2 HOURS AND 15 MINUTES

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS.

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1. (a) Write an expression for Fick's second law of Diffusion in solids and define each term of the expression.

(b) The surface of a steel gear made of 1016 steel (0.16 wt% C) is to be gas carburized at 927^{0}C. Calculate the time necessary to increase the carbon content to 0.25 wt% at 0.75mm below the surface of the gear. Assume the carbon content of the surface to be 1.20 wt%.

D = 1.28x10^{-8} m^2/sec at 927^{0}C.

Z	Erf Z
1.00	0.843
1.10	0.880
1.20	0.910
1.30	0.934
1.40	0.952
1.50	0.966

2. (a) Draw a typical creep curve for a metal under constant load and at a relatively high temperature. Briefly explain all three stages of creep.

(b) Tests at 450^{0}C on a steel shows that the strain rate is $d\varepsilon/dt = 8x10^{-10}hr^{-1}$ at a stress of 21 MPa and $d\varepsilon/dt = 4x10^{-9}$ at 30 MPa.
Assuming that the secondary creep rate can be represented by the relationship $d\varepsilon/dt = B\,\sigma^n$, calculate constants B and 'n' for the steel.

(c) A steel component made with this steel is subjected to a constant tensile stress of 40 MPa at 450^{0}C.
Calculate the strain rate at 40 MPa and 450^{0}C.

3. (a) List the mechanisms available for strengthening of materials.

(b) What is the difference between second phase strengthening and solute strengthening?

What is the similarity between the two?

(c) Using the Hall-Petch equation, explain how grain size affects the strength of a material.

4. (a) Describe how the liquidus and solidus of a binary phase diagram can be determined experimentally.

(b) The solidus and liquidus temperature for two pure metals A & B in a Binary system are given below.

Composition (Wt% A)	Solidus temperature(C^o)	Liquidus temperature (C^o)
0	900	900
10	1000	1150
20	1050	1200
30	1100	1250
40	1150	1300
50	1200	1350
60	1250	1350
70	1300	1400
80	1350	1400
90	1350	1400
100	1425	1425

(i) Construct the thermal equilibrium phase diagram for this system and label all phase fields in the diagram. (Use a graph paper)

(ii) Briefly describe the solidification of an alloy containing 20wt% A when cooled from 1300°C under equilibrium conditions. Use your diagram in section (i) above to answer this question.

(iii) Using the lever rule, determine the composition of the liquid and the solid present in equilibrium at 1100°C in an alloy containing 20% of A.

5. (a) Explain briefly with suitable sketches, the types of imperfections found in materials.

(b) (i) Write an expression to calculate the equilibrium number of vacancies for a given quantity of a material.

(ii) Assuming the constant in the expression in section (i) is equal to unity (C=1), calculate the number of vacancies per cubic meter in iron at 850^0C. The energy for vacancy formation is 1.08 eV/atom. The density and atomic weight for Fe are 7.65 g/cm^3 and 55.85 g/mole respectively and $N_0 = 6.02 \times 10^{23}$atoms, $K_B = 8.617 \times 10^5$ eV/K^0.

6. (a) Derive an equation for the Elastic Modulus (E_c) of a lamellar continuous fiber-metal matrix composite for Isostrain condition.

(b) A newly developed metal-matrix composite is made for the National Aerospace plane with a matrix of the intermetallic compound titanium aluminide (Ti_3Al) and continuous silicon carbide (SiC) fibers. A unidirectional composite is made with the SiC continuous fibers all in one direction.

If the modulus of the composite is 229 GPa and assuming isostrain conditions, what must be the volume percent of SiC fibers in the composite?

E (SiC) = 400 GPa and E(Ti_3Al) = 145 GPa.

7. (a) What are the basic steps in processing of ceramic products by agglomeration of particles?

(b) What type of ingredients is added to ceramic particles in preparing ceramic raw materials for processing?

(c) What is cast iron?
Compare and contrast gray cast iron and nodular cast iron.

8. (a) Derive a formula to calculate the theoretical density (ρ) of a material using its atomic weight (M), crystal structure defined by the number of atoms per unit cell (n), lattice parameter(a) and Avogadro's number (N_0).

(b) Copper has an FCC crystal structure and an atomic radius of 0.1278 nm. Assuming the atoms to be hard spheres which touch along the face diagonals of the FCC unit cell, calculate a theoretical value for the density of copper in g/cm^3. The atomic mass of copper is 63.5 g/mole.

(c) Calculate the theoretical volume change accompanying a polymorphic transformation in a pure metal from the FCC to BCC crystal structure. Assume the hard sphere atomic model and that there is no change in atomic volume before and after the transformation.

9. Discuss and analyze the significance of any two of the following from an engineering point of view.

(i) Effect of carbon content on TTT curves
(ii) Atomic bonds present in materials.
(iii) Ductile failure of materials
(iv) Types of polymers