The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4233 Materials Engineering**
Academic Year	:	2013/14
Date	:	**16th AUGUST 2014**
Time	:	**0930 HRS. – 1230 HRS.**
Duration	:	3 hours

ANSWER 5 PARTS FROM SECTION A & FIVE QUESTIONS FROM SECTION B.

SECTION A

Select any **Five** Parts

1 (a) Draw the following crystallographic plane and the direction in a cubic unit cell.
(i) (3 $\bar{2}$ 0) (ii) [3 $\bar{2}$ 0] **4 marks**

(b) List 5 important Mechanical properties of materials and name the test that can be used to measure each of the properties. **4 marks**

(c) Copper has a Face Centered Cubic (FCC) structure and an atomic radius 0.128 nm. Calculate the linear density of copper atoms in the [110] direction. **4 marks**

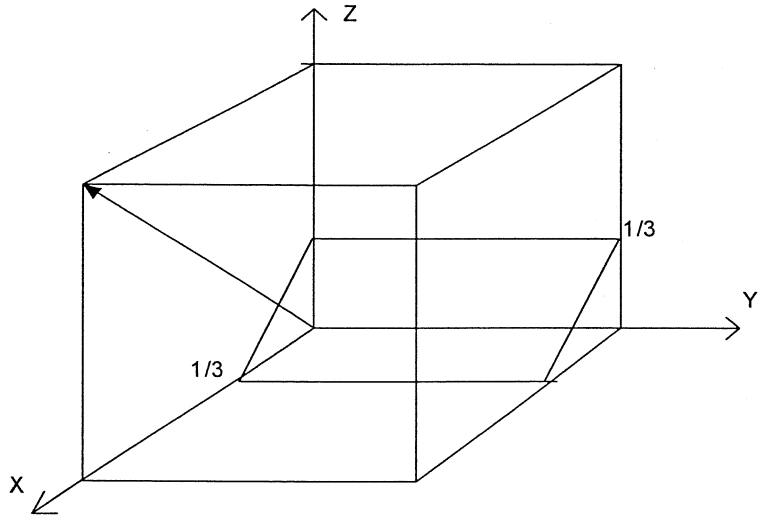
(d) Explain briefly work hardening or strain hardening phenomenon. **4 marks**

(e) Differentiate Engineering stress-strain from True stress-strain. **4 marks**

(f) List the basic steps involved in the processing of ceramic products by the agglomeration of particles. **4 marks**

(g) State the difference between Grain boundary strengthening and solute strengthening. **4 marks**

(h) Identify the Miller indices of the plane and the direction given in the figure below.



4 marks

SECTION B

1 (a) List the types of Primary bonds and Secondary bonds present in materials. Explain them briefly with the aid of diagrams. **4 marks**

(b) State Hund's rule on pairing of electrons in atoms giving an example. **4 marks**

(c) Write the electronic configuration of Cr^{2+} and Fe^{3+} elements. Atomic numbers of Cr and Fe are 24 and 26 respectively. **4 marks**

(d) (i) Calculate the mass in grams of one atom of Aluminium. Atomic mass of Aluminium is 26.98 g/mol. Avogadro's number is 6.02×10^{23} atoms.
(ii) How many Aluminium atoms are in 1 g of Aluminium? **4 marks**

2 (a) Define the terms "Space lattice", "Unit cell" and "Atomic Packing Factor". **6 marks**

(b) Derive a formula to calculate the theoretical density (σ) of a material using atomic weight (M), number of atoms per unit cell (n), lattice parameter (a) and Avogadro's number (N_0). **4 marks**

(c) Given below are the atomic weight, density and lattice parameter for three hypothetical alloys. For each determine whether its crystal structure is FCC, BCC or Simple cubic. Justify your answer. Avogadro's number is 6.02×10^{23} atom/mol.

Alloy	Atomic weight (g/mol)	Density (g/cm^3)	Lattice parameter (nm)
A	43.1	6.40	0.122
B	184.4	12.30	0.146
C	91.6	9.60	0.137

6 marks

3 (a) State Fick's first and second laws of diffusion. **4 marks**

(b) The wear resistance of a steel gear can be improved by hardening its surface. Briefly explain surface hardening heat treatment process. **4 marks**

(c) The initial carbon content of the steel is 0.30 wt%, whereas the surface concentration is to be maintained at 1.00 wt%. For this treatment to be effective, a carbon content of 0.70 wt% must be established at a position 0.80 mm below the surface. Calculate the time taken for this heat treatment in terms of temperature.
Activation energy Q_d = 148,000 J/mol and diffusion coefficient $D_0 = 2.3 \times 10^{-5}$ m^2/s. Gas constant R = 8.31 J/mol.K
Error function values are given in the table below.

Z	erf (Z)
0.40	0.4284
0.45	0.4755
0.50	0.5205
0.55	0.5633

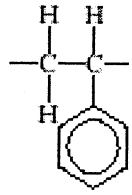
8 marks

4 (a) Differentiate Thermoplastics from Thermosetting plastics. Give **two** examples and applications for each of them. **6 marks**

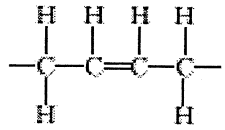
(b) What are homo-polymers and co-polymers? **4 marks**

(c) The number-average molecular weight of a poly styrene-butadiene alternating copolymer is 200,000 g/mol and the number average degree of polymerization is 3000. Determine the average number of Styrene and Butadiene mer units per molecule. Mer units of Styrene and Butadiene are given below. Atomic weight of C and H are 12.01 and 1.01 respectively. **6 marks**

Styrene



Butadiene



5 (a) Write down the conditions under which two elements are soluble in each other in all proportions. **4 marks**

(b)

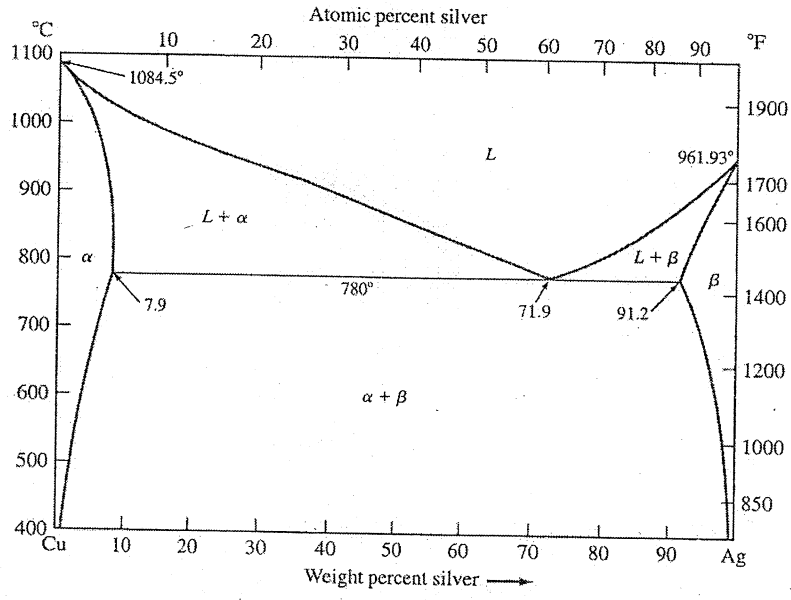


Fig. 5

Shown in Figure 5 above is the Binary Eutectic Copper-Silver phase diagram. Consider an alloy containing 30 wt% Ag and 70 wt% Cu, and answer the following.

(i) Make phase analyses when cooling from 1100^0C to 400^0C. **4 marks**

(ii) Calculate the amount of liquid and α phase present at 900^0C. **4 marks**

(iii) Sketch the microstructure at 900^0C using circular microscopic field. **4 marks**

6 (a) Derive an equation for Elastic modulus of a lamellar continuous fiber and matrix composite for isostrain condition.
Hence show that for longitudinal loading, the ratio of load carried by the fiber (F_f) to that carried by the matrix (F_m) is $\left\{ \frac{E_f V_f}{E_m V_m} \right\}$
Where E_f and E_m are Elastic moduli of fiber and matrix respectively.
V_f and V_m are volume fractions of fiber and matrix respectively **8 marks**

(b) A continuous and aligned carbon fiber reinforced composite consists of 30 vol% of carbon fibers having a modulus of elasticity 228GPa and 70 vol% of a polyester resin that , when hardened, displays a modulus of 3.4 GPa.

(i) Compute the modulus of elasticity of this composite in the longitudinal direction. **4 marks**

(ii) If the cross-sectional area of the composite is 200 mm^2 and a stress of 60MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases. **4 marks**

7 (a) What is Ductile-Brittle transition temperature? **4 marks**

(b) Following is tabulated data that were gathered from a series of Charpy impact tests on a commercial low -carbon steel alloy.

Temperature (C^0)	Impact Energy (J)
50	76
40	76
30	71
20	58
10	38
0	23
-10	14
-20	9
-30	5
-40	1.5

(i) Plot the data as impact energy versus temperature. **4 marks**

(ii) Determine a ductile-brittle transition temperature as that temperature corresponding to the average of the maximum and minimum impact energies. **4 marks**

(iii) Determine the ductile-brittle transition temperature as that temperature at which the impact energy is 20 J. **4 marks**

8 Discuss and analyze the significance of any **three** of the following from an Engineering point of view.

(a) Time-Temperature-Transformation curves

(b) Ductile failure of materials

(c) Invariant reactions in Iron-Carbon phase diagrams

(d) Vulcanization process of natural rubber

(e) Types of point imperfections

16 marks

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