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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX4533 / MEX4233 Materials Engineering**
Academic Year	: 2017/18
Date	: 23rd January 2019
Time	: 0930-1230hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. Answer for each question should commence from a new page.
3. This is a Closed Book Test (CBT).
4. Answers should be in clear hand writing.
5. Do not use Red colour pen.

THIS QUESTION PAPER HAS TWO SECTIONS, SECTION A AND B. ANSWER ANY FIVE PARTS FROM SECTION A AND FIVE QUESTIONS FROM SECTION B.

SECTION A

(a) Sketch the Body Centered Cubic (BCC) unit cell and derive a relationship between atomic radius 'r' and lattice parameter 'a'. Hence find a value for the lattice parameter of Tungsten. Atomic radius of Tungsten is 0.137nm. **(4 marks)**

(b) Calculate a theoretical value for the density of BCC Iron in g/cm^3 which has a lattice parameter of 0.2866 nm. The atomic weight of Iron is 55.847 g/mole and Avogadro's number is 6.023×10^{23} atoms/mole. **(4 marks)**

(c) Draw the following crystallographic plane and the direction in a cubic unit cell. **(4 marks)**

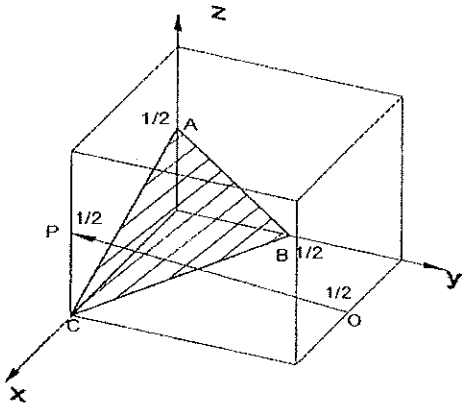
Plane : $(1\ 1\ \bar{3})$ Direction: $[1\ \bar{1}\ 3]$

(d) Show that the atomic packing factor for the Face Centered Cubic (FCC) crystal structure is 0.74. **(4 marks)**

(e) State Hund's rule on pairing of electrons in atoms. **(4 marks)**

(f) Calculate the planer atomic density in atoms per square millimeter for the (110) plane in BCC chromium, which has a lattice constant of 0.28846 nm. **(4 marks)**

(g) Identify the Miller indices of the plane ABC and the direction OP given in the figure below.



(4 marks)

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

SECTION B

1. (a) What are the types of primary bonds present in materials? Explain each of them briefly using examples.

(6 marks)

(b) List the types of point defects found in materials? Explain each of them briefly.

(6 marks)

(c) "Some metals contain a protective layer of oxide whereas the others do not". Explain this statement using the Pilling Bed worth ratio on oxidation.

(4 marks)

2. (a) Explain the terms "Phase" and "Equilibrium Phase Diagram" of materials.

(4 marks)

(b) Two pure metals A and B are partially soluble in one another in solid state. Metal A has melting point of 1000^0 C. Metal A will dissolve 15% of B at 500^0 C and 1% at 0^0 C. Metal B has melting point of 900^0C. Metal B will dissolve 10% of A at 500^0 C and 5% at 0^0C. The eutectic reaction occurs at 500^0C with composition of 55%B.

(i) Construct the thermal equilibrium diagram for the above system and label the axes and all phase fields. Assume all phase boundaries are straight lines (Use a graph paper).

(6 marks)

(ii) Briefly describe the solidification of an alloy containing 15% of metal B when cooled from 950^0C under equilibrium conditions. Use your graph in section (i) to answer this question.

(3 marks)

(iii) Calculate the percentage of liquid and solids present at 800^0C when the alloy containing 15% of metal B.

(3 marks)

3. (a) What are the factors that affect the diffusion constant?

(4 marks)

(b) An FCC Iron-Carbon alloy initially containing 0.20 wt % C is carburized at an elevated temperature and in an atmosphere, that gives a surface carbon concentration of 1.0 wt%. After 49.5 hr the concentration of carbon is 0.35 wt % at a position 4 mm below the surface. Determine the following.

(i) Diffusion constant of FCC Iron Carbon.

(6 marks)

(ii) Temperate at which the treatment was carried out.

(6 marks)

Gas constant(R)= 8.314 J/mol K, Activation Energy (Q) = 142 kJ/mol,
$D_0 = 20 \times 10^{-6}$ m^2/s

Error function Table is given below.

z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633
0.025	0.0282	0.60	0.6039
0.05	0.0564	0.65	0.6420
0.10	0.1125	0.70	0.6778
0.15	0.1680	0.75	0.7112
0.20	0.2227	0.80	0.7421
0.25	0.2763	0.85	0.7707
0.30	0.3286	0.90	0.7970
0.35	0.3794	0.95	0.8209
0.40	0.4284		
0.45	0.4755		
0.50	0.5205		

4. (a) Show that for a continuous and aligned fiber-reinforced composite, modulus of elasticity (E_c) in the longitudinal direction is $E_c = E_m V_m + E_f V_f$.

(6 marks)

(b) A continuous and aligned fiber-reinforced composite is to be produced consisting of 30% volume of silicon carbide fibers and 70% volume of polycarbonate matrix. Mechanical characteristics of these two materials are as follows.

	Modulus of elasticity (GPa)	Tensile strength (MPa)
Silicon Carbide	400	3900
Polycarbonate	2.4	65

The stress on the polycarbonate matrix when the silicon carbide fails is 45 MPa. For this composite, compute the following.

(a) the longitudinal modulus of elasticity

(5 marks)

(b) the longitudinal tensile strength

(5 marks)

5. (a) Differentiate Thermoplastic from Thermosetting polymers.

(4 marks)

(b) The following table gives the molecular weight data for a polymethyl methacrylate material.

Molecular weight range (g/mol)	X_i	W_i
8,000 -20,000	0.05	0.02
20,000 -32,000	0.15	0.08
32,000 -44,000	0.21	0.17
44,000 – 56,000	0.28	0.29
56,000 – 68,000	0.18	0.23
68,000 – 80,000	0.10	0.16
80,000 - 92,000	0.03	0.05

Compute the following.

(i) The number average molecular weight

(4 marks)

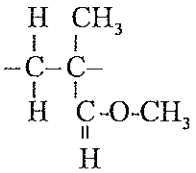
(ii) The weight average molecular weight

(4 marks)

(iii) Degree of polymerization for polymethyl methacrylate

(4 marks)

Mer structure of polymethyl methacrylate –



The atomic weight of Oxygen, Carbon and Hydrogen are respectively 16,12 and 1 g/mol.

6. (a) Briefly explain the types of stainless steels with the metallurgical differences.

(6 marks)

(b) Why do stainless steels have corrosion resistant properties?

(5 marks)

(c) Briefly explain the welding problems exist in stainless steels.

(5 marks)

7. (a) Discuss and analyze the significance of any **three** of the following from an Engineering point of view.

(i) Types of ductile failures present in materials.
(ii) Time Temperature Transformation curves.
(iii) Types of strengthening mechanisms available for strengthening materials.
(iv) Fracture mechanisms in composites
(v) Types of cast iron

(16 marks)

8. (a) Name **three** Mechanical properties which can be measured using Tensile Testing.

(3 marks)

(b) The Fig. (8) below shows a load-extension curve obtained in a tensile test on a specimen with 50mm gauge length and a cross-sectional area of 150 mm^2. Estimate the following properties.

(i) The Ultimate tensile strength

(2 marks)

(ii) The yield strength

(2 marks)

(iii) Proof stress at a strain off set of 0.1%

(3 marks)

(iv) Modulus of elasticity

(3 marks)

(v) The Ductility of the material in terms of percentage elongation, if the final gauge length is 60mm.

(3 marks)

Show how you obtained or worked out above properties and if applicable, indicate their corresponding load or extension on the Fig. (8). Return the figure with your answer.

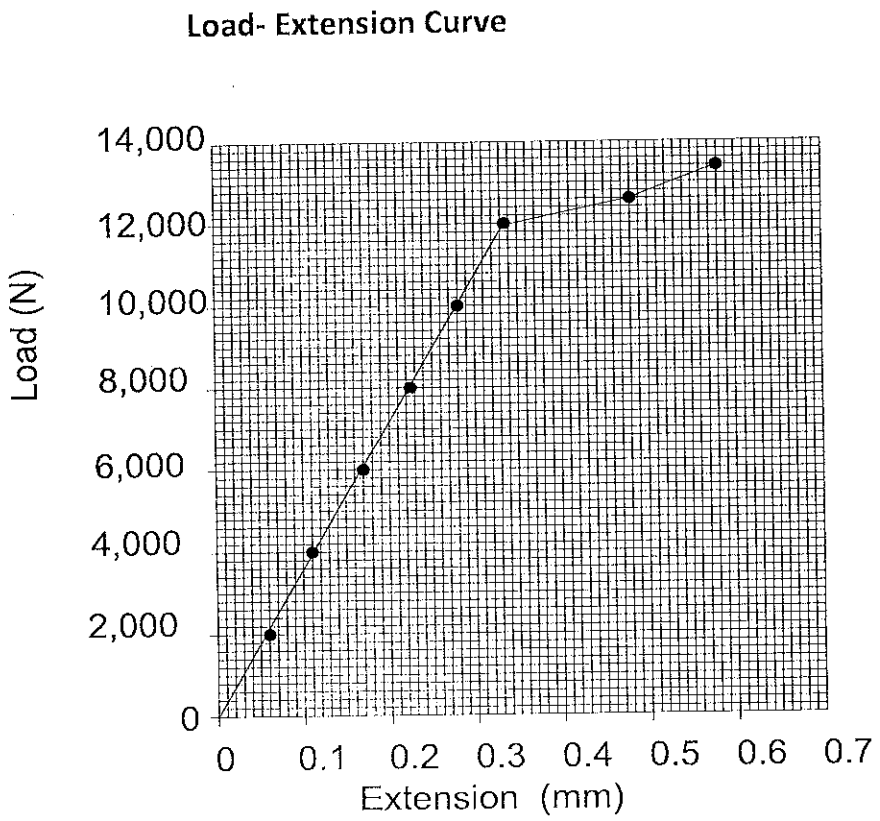


Fig. (8)