The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4233 Materials Engineering**
Academic Year	:	2016/17
Date	:	**15th NOVEMBER 2017**
Time	:	**0930 HRS. – 1230 HRS.**

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

SECTION A

(a) List the types of Primary bonds and Secondary bonds present in materials. Give one example for each type of bond. **4 marks**

(b) Define the terms Space lattice, Unit cell and Atomic Packing Factor. **4 marks**

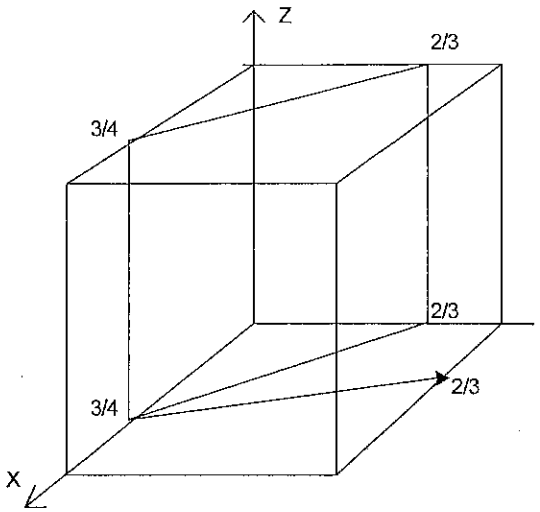
(c) Tungsten has a Body Centered Cubic (BCC) structure and an atomic radius of 0.137nm. Calculate the planer density of Tungsten in the (111) plane. **4 marks**

(d) Draw the following crystallographic plane and the direction in a cubic unit cell.
Plane : (3 0 3) Direction: [3 $\bar{2}$ 0]
4 marks

(e) A hypothetical metal has an orthorhombic unit cell for which the lattice parameters a, b and c are 0.413 nm, 0.665 nm, and 0.876 nm, respectively. If there are 8 atoms per unit cell and the atomic packing factor is 0.536, determine the atomic radius (in nm). **4 marks**

(f) For a metal that has the body-centered cubic crystal structure, calculate the atomic radius (in nm) if the metal has a density of 7.25 g/cm^3 and an atomic weight of 50.99 g/mol. **4 marks**

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



4 marks

(h) Differentiate Engineering stress-strain from True stress-strain.

4 marks

SECTION B

1. (a) Describe the following three major polymer categories with the aid of diagrams showing their micro-structure.

(i) Thermoplastics
(ii) Thermosetting plastics
(iii) Elastomers

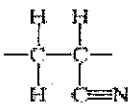
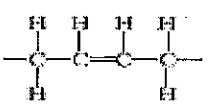
(6 marks)

(b) What is a copolymer? Discuss the types of copolymers available.

(4 marks)

(c) Calculate the number average molecular weight of random nitrile rubber (poly acrylonitrile- butadiene copolymer) in which the fraction of butadiene mers is 0.03. Assume that this concentration corresponds to a number average degree of polymerization of 2000. (Molecular weight of C-12, N-14, H-1 g/mol)

(6 marks)

Acrylonitrile  Butadiene 

2. (a) Write down the conditions under which two elements are soluble in each other in all proportions.

(4 marks)

(b)

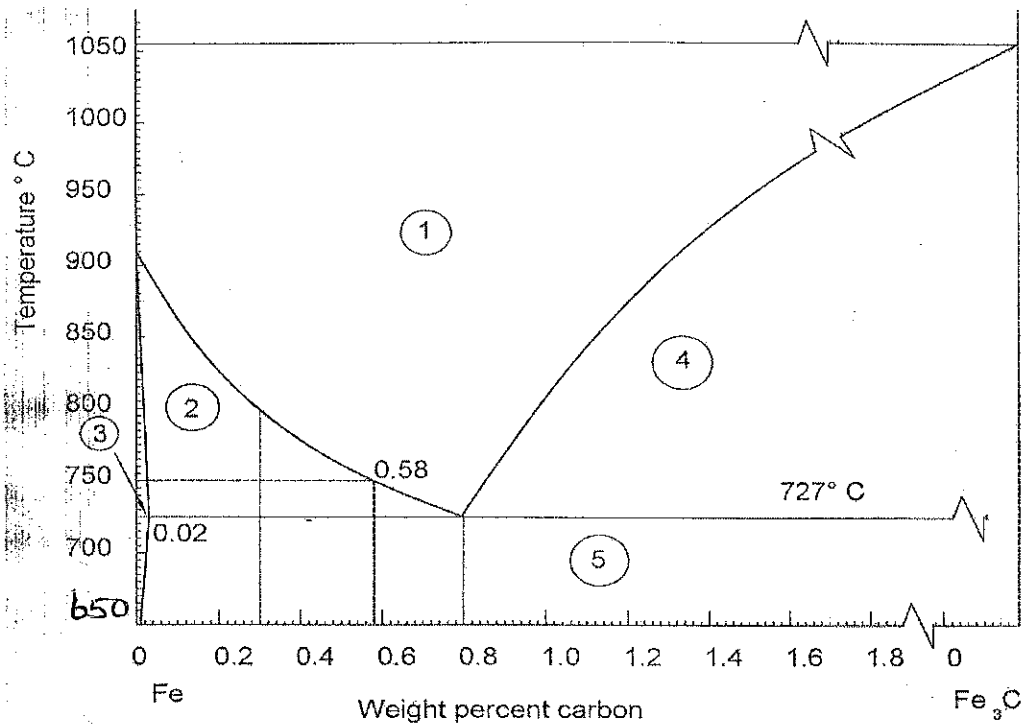


Fig. 2

Part of the Iron-carbon phase diagram is shown in Fig.2. Answer the following using the Phase diagram.

(i) Name the phase/s in areas marked 1-5 in the phase diagram.

(5 marks)

(ii) A sample of plain carbon steel containing 0.3 wt% carbon is heated in a furnace to a temperature of 1000^0C. It is then cooled down slowly to 700^0C in air.

Make a phase analysis of the material when the sample is cooling down to 700^0C.

(3 marks)

(iii) Calculate the amount of phases present at 750°C. Name the phases.

(4 marks)

3. (a) State Fick's First and Second law of diffusion.

(6 marks)

(b) Determine the carburizing time (in s) necessary to achieve a carbon concentration of 0.44 wt% at a position 1.9 mm from the surface into an iron-carbon alloy that initially contains 0.031 wt% C. The surface concentration is to be maintained at 1.2 wt% C, and the treatment is to be conducted at 1020°C. Assume that $D_0 = 5.1 \times 10^{-5}$ m^2/s and Q_d =154 kJ/mol.

(10 marks)

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 fibre-reinforced composite that is loaded in the longitudinal direction, the ratio of the load carried by the fibres to that carried by the matrix is given by,

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} = \frac{E_f V_f}{E_m (1 - V_f)}$$

Use usual notations of F-load, E-young's modulus, V-volume fraction for fibre and matrix.

(6 marks)

(b) In an aligned and continuous glass fiber-reinforced nylon 6,6 composite, the fibers are to carry 90% of a load applied in the longitudinal direction.

(i) Using the data provided below, determine the volume fraction of fibers that will be required.

(5 marks)

(ii) What will be the tensile strength of this composite (in MPa)? Assume that the matrix stress at fiber failure is 30 MPa.

(5 marks)

	Elastic Modulus (GPa)	Tensile Strength (MPa)
Glass fibers	72.5	3400
Nylon 6,6	3.0	76

5. (a) What is crevice corrosion?

(5 marks)

(b) Describe an electro chemical mechanism for the crevice corrosion of a stainless steel in an aerated sodium chloride solution.

(5 marks)

(c) From an Engineering design view point, what should be done to prevent or minimize crevice corrosion?

(6 marks)

6. (a) List the types of strengthening mechanisms available for strengthening of materials. Explain how dislocations are involved in each of the strengthening techniques.

(5 marks)

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

(5 marks)

(c) With reference to TTT curves, briefly explain the effects of carbon content and alloying elements on the curves.

(6 marks)

7.(a) List four important Mechanical properties of materials and name the tests that can be used to measure each of the properties.

(4 marks)

(b)

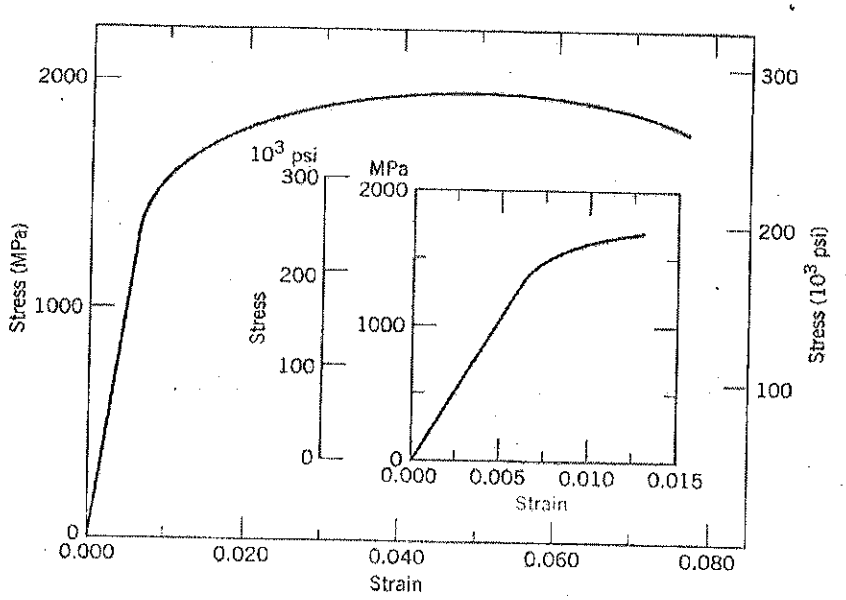


Fig.Q7

Fig.Q7 shows the stress-strain behaviour for a Brass specimen. Original diameter and the final diameter of the specimen used for the test are 12.0 mm and 10.0 mm respectively. Using the figure, determine the following.

(i) The modulus of elasticity.

(3 marks)

(ii) The proof stress at a strain offset of 0.25%.

(3 marks)

(iii) The maximum load that can be sustained by a cylindrical specimen.

(3 marks)

(iv) The percentage reduction in cross-sectional area of the specimen.

(3 marks)

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

   (i) Invariant reactions that occur in Iron-Carbon phase diagram

   (ii) Fatigue limit or the endurance limit

   (iii) Types of Cast iron

   (iv) Ductile failure of materials

   (v) Types of fibers and matrix materials used in composites

(16 marks)

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