# The Open University of Sri Lanka
# Faculty of Engineering Technology

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| Study Programme | : | Bachelor of Technology Honours in Engineering |
| Name of the Examination | : | Final Examination |
| **Course Code and Title** | : | **MEX4233 Materials Engineering** |
| Academic Year | : | 2015/16 |
| Date | : | **23rd NOVEMBER 2016** |
| Time | : | **0930 HRS. – 1230 HRS.** |

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

## SECTION A

(a) List the five important Mechanical properties of materials and name the tests that can be used to measure each of the properties. **(4 marks)**

(b) Calculate the percentage change in volume associated with the polymorphic transformation in pure metal from the FCC to BCC crystal structure assuming that there is no change in atomic radius. **(4 marks)**

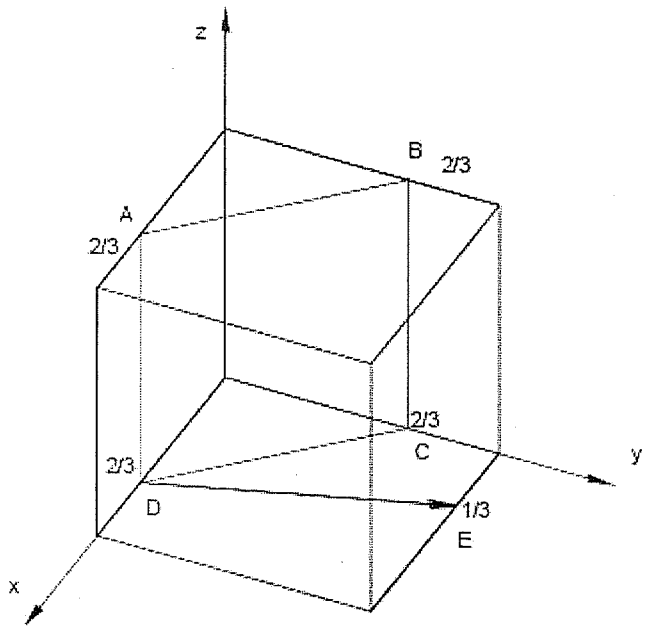
(c) Calculate a value for the density of FCC Platinum in grams per cubic centimeter from its lattice constant 'a' of 0.3923 nm and its atomic mass of 195.09 g/mol. $N_0$ – Avogadro's number is $6.02 \times 10^{23}$ $mol^{-1}$. **(4 marks)**

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

(e) Draw the following crystallographic plane and the direction in a cubic unit cell.
Plane : (202) Direction: $[32\bar{3}]$ **(4 marks)**

(f) Sketch the Body Centered Cubic (BCC) unit cell and derive a relationship between the atomic radius 'r' and unit cell parameter 'a'.
Hence find a value for the atomic radius of a Chromium atom in centimeters.
Chromium has BCC structure and lattice constant is 0.2885nm. **(4 marks)**

(g) Identify the miller indices of the plane ABCD and the direction DE shown in Figure below. **(4 marks)**




(h) Explain the process of work hardening or strain hardening.

**(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 and line defects found in materials. Explain each of them briefly.

**(6 marks)**

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

**(4 marks)**

2. (a) State Fick's second law of Diffusion.

**(4 marks)**

(b) What are the factors that affect the diffusion constant?

**(4 marks)**

(c) Consider a diffusion couple between metals A and B. After a 30-hr heat treatment at 1400°K, the concentration of A is 3.2 wt% at a distance of 1.5 mm from the interface. If an identical diffusion couple is instead heat treated at 1200°K for 30 hr, at what position will the concentration be 3.2 wt%?

Assume that the pre exponential factor and activation energy for diffusion are $1.8 \times 10^{-5}$ $m^2$/sec and 152 kJ/mol, respectively, and that the surface concentration of A is 100 wt%.

**(8 marks)**

Error function Table is given below.

| Z | Erf (Z) |
|---|---|
| 0 | 0 |
| 0.025 | 0.0282 |
| 0.05 | 0.0564 |
| 0.10 | 0.1125 |
| 0.15 | 0.1680 |
| 0.20 | 0.2227 |
| 0.25 | 0.2763 |
| 0.30 | 0.3286 |
| 0.35 | 0.3794 |
| 0.40 | 0.4284 |
| 0.45 | 0.4755 |
| 0.50 | 0.5205 |

3. (a) State the **four** factors that affect solubility in the formation of substitutional solid solutions.

**(4 marks)**

(b) Construct the phase diagram for two pure metals A and B which are partially soluble in one another in the solid state. Following information is given.

(i) The melting temperature of A is 640°C.
(ii) The maximum solubility of B in A is 4 wt% B, which occurs at 420°C.
(iii) The solubility of B in A at room temperature is 0 wt% B.
(iv) Eutectic reaction occurs at 420°C and 30 wt% A-70 wt% B.
(v) The melting temperature of B is 620°C.
(viii)The maximum solubility of A in B is 5wt%A, which occurs at 420°C.
(ix) The solubility of A in B at room temperature is 0 wt% A.

**(Draw all boundaries using straight lines.)**

**(3 marks)**

(c) Using the above phase diagram answer the following.

(i) Mark all phase fields. **(3 marks)**

(ii) For an alloy containing 20wt% A describe the process of solidification from 600°C.

**(3 marks)**

(iii) Calculate the amount of liquid and solid present at 450°C and at 20 wt% A.

**(3 marks)**

4. (a) Differentiate between thermoplastic and thermosetting plastics. Give one example for each type of plastics. **(5 marks)**

(b) Describe the Injection moulding process used for forming thermoplastic products. **(5 marks)**

(c) What are the advantages and disadvantages of this process over other processes used for the fabrication of thermoplastic products? **(6 marks)**

5. (a) Sketch and label a typical creep curve (strain vs time) for a hypothetical material and discuss the behavior of the material during three stages associated with the graph. **(5 marks)**

(b) Explain how the steady state creep rate can be determined from the graph. **(5 marks)**

(c) A shaft of 50 mm diameter is to carry a load of 30 kN at a temperature of $250^0$C. The material's steady state creep rate follows the Norton equation given by, $d\varepsilon/dt = C\,\sigma^n$, where $C = 4.5x10^{-4}$ and $n = 3.2$ ( when stress is given in MPa and strain rate is in m/m/hr)
If the allowable strain is 0.3%, determine the useful life expectancy of the shaft. **(6 marks)**

6. (a) Describe and differentiate between crevice corrosion cracking and stress corrosion cracking. **(6 marks)**

(b) Explain the method of minimizing crevice corrosion. **(5 marks)**

(c) Briefly explain the oxidation resistance of metals solely by considering the Pilling – Bed worth ratio. **(5 marks)**

7. (a) Derive an equation for Elastic modulus of a lamellar continuous fiber and plastic matrix composite for isostrain condition. **(5 marks)**

(b) A continuous and aligned glass fiber-reinforced composite consists of 40 vol% of glass fibers having a modulus of elasticity of 69 GPa and 60 vol% of a polyester resin that , when hardened, displays a modulus of elasticity of 3.4 GPa.

(i) Compute the modulus of elasticity of this composite in the longitudinal direction. **(5 marks)**

(ii) If the cross-sectional area is 250 $mm^2$ and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases. **(3 marks)**

(iii) Determine the strain that is sustained by each phase when the stress in part (ii) is applied. **(3 marks)**

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

(i) Time Temperature Transformation curves

(ii) Strengthening mechanisms in materials

(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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