

FINAL
Examination Paper
(COVER PAGE)

Session : January 2018

Programme : Diploma In Mechanical Engineering (DMEN)
Diploma In Electrical and Engineering (DEEI)

Course : EGM1182/EGM1184 : Structures and Properties of Materials

Date of Examination : March 6, 2018 (Tuesday)

Time : 11:00 am – 1:00 pm Reading Time: Nil

Duration : 2 Hours

Special Instructions :

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted : Calculator

Materials provided : List of Formulas, Periodic Table

Examiner (s) : Phua Chin Lai

Moderator : Dr How Ho Cheng

This paper consists of 8 printed pages, including the cover page.

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EGM1182 / EGM1184: STRUCTURES AND PROPERTIES OF MATERIAL
FINAL EXAMINATION: JANUARY 2018 SESSION

Instructions: This paper consists of **SIX (6)** questions. Attempt any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

- (a) Give the electron configurations for the following ions: Al^{3+} , Cu^+ and S^{2-} . (6 marks)
- (b) If there are 200 grains per square inch on a photomicrograph of a metal at $100\times$, what is its ASTM grain-size number? (3 marks)
- (c) Briefly explain the following primary bonding; (9 marks)
- (i) ionic bonding
 - (ii) covalent bonding
 - (iii) metallic bonding.
- (d) Show that the atomic packing factor for BCC is 0.68. (7 marks)

Question 2

- (a) Calculate the radius of an iridium atom, given that Ir has an FCC crystal structure, a density of 22.4 g/cm^3 , and an atomic weight of 192.2 g/mol . Given the Avogadro's number is $6.022 \times 10^{23} \text{ atoms/mol}$. (5 marks)
- (b) Rhodium has an atomic radius of 0.1345 nm and a density of 12.41 g/cm^3 . Determine whether it has an FCC or BCC crystal structure. (5 marks)

- (c) Determine the Miller indices for the planes A and B for an unit cell shown in Figure 2.

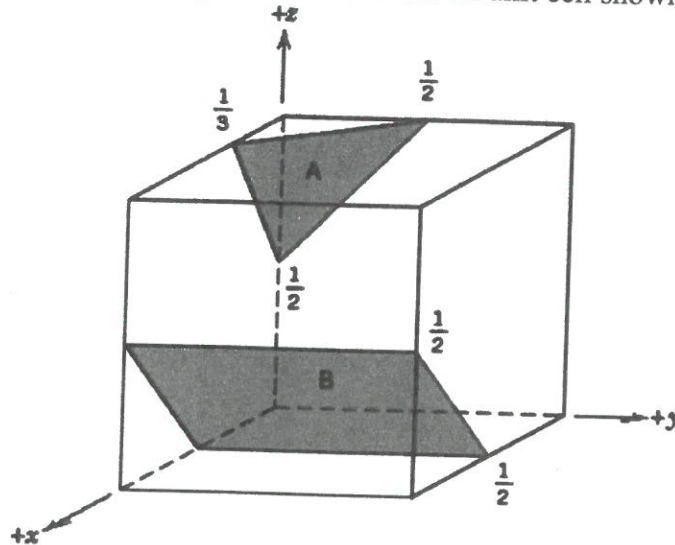


Figure 2

(8 marks)

- (d) Describe and illustrate with sketches the solidification process of a pure metal in terms of the nucleation and growth of crystals.

(7 marks)

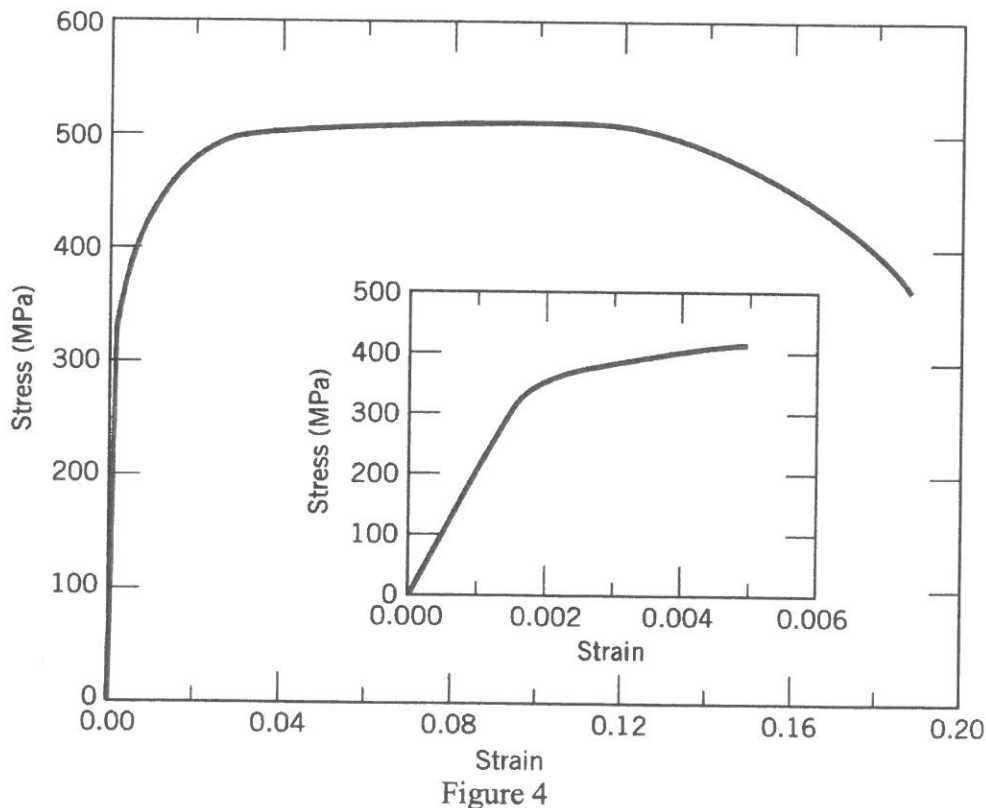
Question 3

- (a) Molybdenum (Mo) forms a substitutional solid solution with tungsten (W). Compute the weight percent of molybdenum that must be added to tungsten to yield an alloy that contains 1.0×10^{22} Mo atoms per cubic centimeter. The densities of pure Mo and W are 10.22 and 19.30 g/cm³, respectively.
- (b) Briefly explain the difference between self-diffusion and interdiffusion. Cite two reasons why interstitial diffusion is normally more rapid than vacancy diffusion.
- (c) A specimen of aluminum having a rectangular cross section 12 mm \times 12.9 mm is pulled in tension with 35,600 N force, producing only elastic deformation. Calculate the resulting strain. (Given the elastic modulus is 69 GPa (or 69×10^9 N/m²))
- (d) A cylindrical rod of copper (the elastic modulus is 110 GPa) having a yield strength of 240 MPa is to be subjected to a load of 6660 N. If the length of the rod is 380 mm, determine the diameter to allow an elongation of 0.50 mm?

(7 marks)

Question 4

- (a) A brass alloy is known to have a yield strength of 275 MPa, a tensile strength of 380 MPa and an elastic modulus of 103 GPa. A cylindrical specimen of this alloy 12.7 mm in diameter and 250 mm long is stressed in tension and found to elongate 7.6 mm. On the basis of the information given, is it possible to compute the magnitude of the load that is necessary to produce this change in length? If so, calculate the load. If not, explain why. (9 marks)
- (b) Figure 4 shows the tensile engineering stress–strain behavior for a steel alloy. Determine
- the modulus of elasticity (4 marks)
 - the proportional limit (2 marks)
 - the yield strength at a strain offset of 0.002 (2 marks)
 - the tensile strength (2 marks)

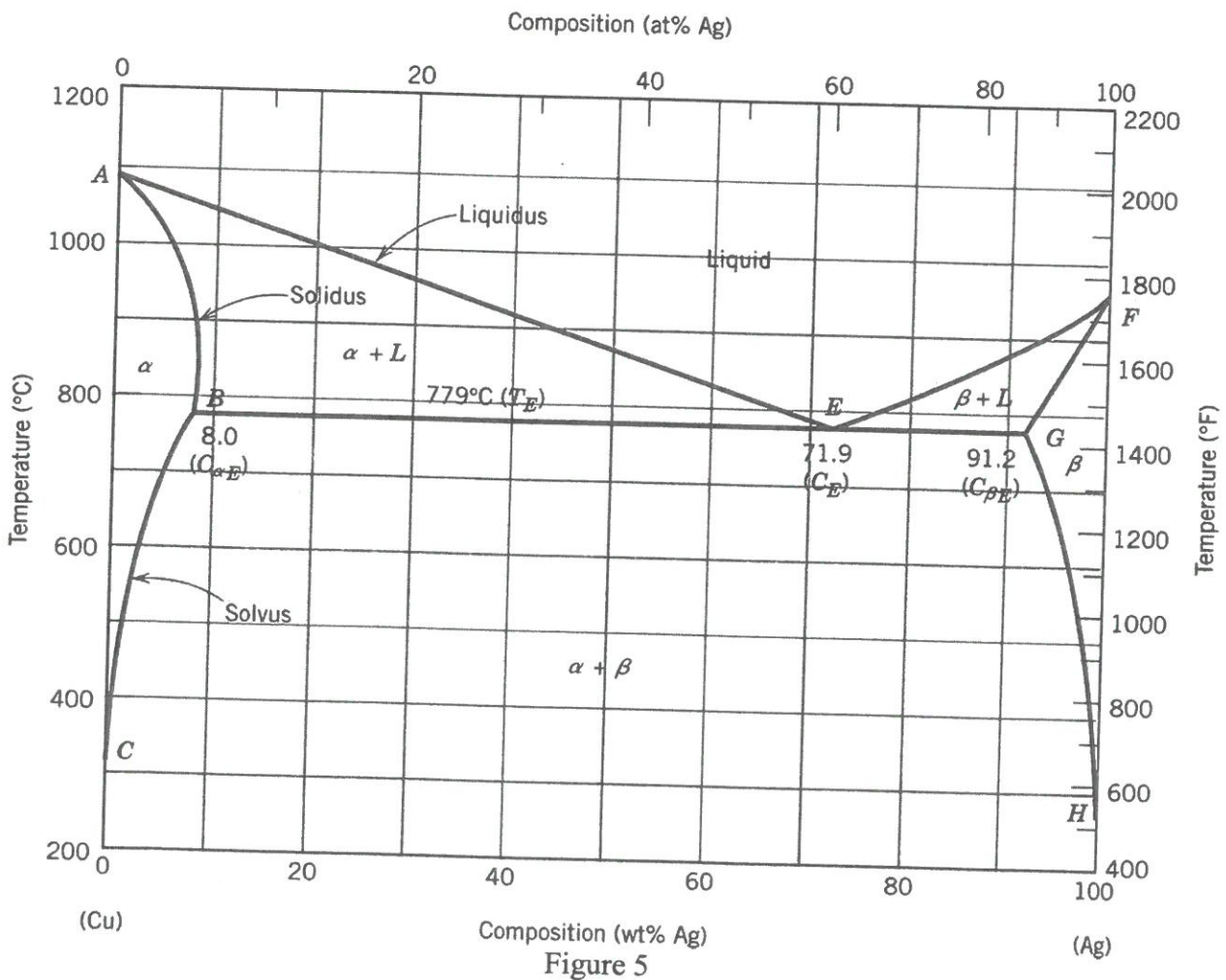


- (c) Distinguish between traditional ceramic and engineering ceramic materials and for each type of ceramic, gives **TWO (2)** examples. (6 marks)

Question 5

- (a) Describe the three stages in the ductile fracture of a metal under uniaxial tensile loading. (5 marks)
- (b) Consider the binary eutectic copper-silver phase diagram in Figure 5. Make phase analyses of an 88 wt % Ag–12 wt % Cu alloy at the temperatures
- 1000°C,
 - 800°C,
 - 779°C + ΔT , and
 - 779°C - ΔT . In the phase analyses, include:
 - The phases present
 - The chemical compositions of the phases
 - The amounts of each phase
 - Sketch and label the microstructure by using approximately 2 cm diameter circular fields.

(20 marks)



Question 6

- (a) 20cm length of rod with a diameter of 0.250 cm is loaded with a 5000 N weight. If the diameter decreases to 0.210 cm, determine
- (i) the engineering stress and strain at this load and
 - (ii) the true stress and strain at this load.
- (b) Define the polymeric materials (7 marks)
- (i) plastics
 - (ii) elastomers.
- (8 marks)
- (d) Assuming that all the valence electrons contribute to the current flow in copper (FCC structure):
- (i) Calculate the mobility of an electron in copper
 - (ii) Calculate the average drift velocity for electrons in a 100cm copper wire when 10V are applied.

Calculate the above with the given resistivity of copper at 0°C is $1.67 \times 10^{-6} \Omega \cdot \text{cm}$, charge of electron at $1.6 \times 10^{-19} \text{ C}$, lattice constant for copper is $3.62 \times 10^{-8} \text{ cm}$.

(10 marks)

-The end-

LIST OF FORMULA

1. Density, $\rho = \frac{\text{mass}}{\text{volume}} = \frac{n_1A_1+n_2A_2}{a^3N_A}$
2. Linear atomic density, $\rho_l = \frac{\text{no. of atom diameter}}{\text{linear length}}$
3. Atomic packing factor, $APF = \frac{\text{volume of atoms in unit cell}}{\text{volume of unit cell}}$
4. Engineering stress, $\sigma = \frac{\text{tensile force}}{\text{cross sectional area}} = \frac{F}{A_0}$
5. Modulus of Elasticity, $E = \frac{\text{stress}}{\text{strain}} = \frac{\sigma}{\epsilon}$
6. Lever rule, $x_s = \frac{w_0-w_l}{w_s-w_l}$ and $x_l = \frac{w_s-w_0}{w_s-w_l}$
7. Conductivity, $\sigma = nq\mu$
 $n = \text{number of conduction electrons per unit volume}$
 $q = \text{electron charge} = 1.602 \times 10^{-19} \text{ C}$
 $\mu = \text{electron mobility}$
8. Conductivity, $\sigma_{n^\circ\text{C}} = \frac{1}{\rho_{n^\circ\text{C}}}$
9. Resistivity, $\rho_T = \rho_{0^\circ\text{C}}(1 + \alpha\Delta T)$

-THE END-

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