

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1209 – ENGINEERING MATERIALS

BSc HONOURS PART I: JULY 2005

DURATION: 3 HOURS

ANSWER **ALL** QUESTIONS IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B.  
SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

SECTION A

1. (a) Classify the following as a metal, ceramic, polymer or composite materials.  
(i) concrete  
(ii) fibre glass  
(iii) alumina  
(iv) sodium chloride  
(v) carbon  
(vi) epoxy [3]
- (b) Show that the atomic packing in an FCC unit cell is given by 74%. [4]
- (c) Determine the planar density and packing fraction for BCC lithium on the (100) and (110) planes given that  $a_0 = 0.35089\text{mm}$   
[6]
- (d) Sketch the [110] direction and (110) plane within an unit cell. [4]
- (e) Calculate the equilibrium number of vacancies in pure copper at  $500^\circ\text{C}$ . Assume the energy of formation of a vacancy is  $0.90\text{eV}$ ,  
 $K$ , (Boltzman constant) =  $8.62 \times 10^{-5} \text{eV/K}^{-1}$ ,  $c$  (constant) = 1.  $N$ , Avogadro's number  $6.02 \times 10^{23}$ .  $\rho$  (density of copper) =  $8.96\text{g/cm}^3$ . [5]
- (f) Compare the percent covalent character for titanium carbide and silicone carbide. Use Pauling's equation. [4]
- (g) (i) Define a composite material. [2]  
(ii) How are composite materials classified? [3]
- (h) (i) What is the glass transition temperature. [2]  
(ii) Explain why compression testing is used more often for ceramics and concretes than for metals. [3]
- (i) A force of  $20\,000\text{N}$  causes a  $10\text{mm} \times 10\text{mm}$  bar of magnesium to stretch from

10cm to 10.045cm. Calculate the modulus of elasticity of the bar. [4]

SECTION B

2. (a) Draw a unit cell of a cube and mark the following: [5]  
(i)  $[110]$  and  $[0\bar{1}2]$  directions  
(ii)  $(120)$  and  $(\bar{1}01)$  planes.
- (b) Titanium is BCC at high temperatures and its atomic radius is 0.145nm. [1]  
(i) How large is the edge of the unit cell? [3]  
(ii) Determine the packing factor of Titanium. [3]  
(iii) Find the repeat distance and linear density in the  $[110]$  direction. [4]  
(iv) What is the planar density on the  $(100)$  and  $(200)$  planes? [4]  
(v) Determine the largest size of an atom that can fit in the largest void of Titanium. [3]
3. (a) Show that the strain can be expressed as  $\epsilon_t = \ln(1 + \epsilon_n)$  where  $\epsilon_n$  is the engineering stress. [5]
- (b) Sketch the stress/strain curve and label the following: [8]  
(i) Yield stress  
(ii) Tensile stress and  
(iii) The 1% offset yield stress.  
What is the industrial importance of the yield stress, and the Young's modulus of a material?
- (c) A 75mm diameter rod of copper is to be reduced to a 50mm diameter rod by pushing through an opening. What should the diameter of the opening be in order to account for the elastic strain. The modulus of elasticity is  $127 \text{ GPa}$  and its yield strength is  $275 \text{ MPa}$ . [7]
4. (a) (i) What is meant by metal creep? Give two examples of creep resistant metals. [4]  
(ii) Draw a typical creep curve and label all the creep stages. Discuss what occurs microstructurally at each stage of creep. [7]  
(iii) Explain how the strength of a material varies with an increase in temperature. [3]
- (b) (i) Describe the four major factors which affect the fatigue properties of a metal. [4]  
(ii) What is meant by the fatigue life and fatigue limit of a material? [2]

5. (a) (i) Draw on a graph paper the binary equilibrium diagram from the following information:
- (i) the melting point of lead is  $327^{\circ}\text{C}$  and that of tin  $232^{\circ}\text{C}$ .
  - (ii) The two metals form a eutectic containing 62% tin at  $182^{\circ}\text{C}$ . the maximum solid solubilities of tin in lead at this temperature is 19% and of lead in tin is 3%.
  - (iii) Assume the solubility of each at room temperature is 1%. [10]
  - (iv) Draw the cooling curve of a 70% tin alloy. [3]
- (b) (i) What are stainless steels? [2]
- (ii) What type of materials are used in the food processing industry. Give reasons for this choice. [5]
6. (a) (i) Define corrosion. [2]
- (ii) List the various methods of corrosion control. Discuss their advantages and limitations. [8]
- (b) (i) Classify polymeric materials giving at least two examples of each. [6]
- (ii) What is polymer degradation? [4]

- END OF EXAMINATION -