NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1209 - ENGINEERING MATERIALS

BSc HONOURS PART I: JUNE 2004 DURATION: 3 HOURS

ANSWER **ALL** PARTS OF SECTION A AND ANY **THREE** IN 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 $a_0 = 0.35089mm$
   [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 500^0C. Assume the energy of formation of a vacancy is 0.90eV,
   K, (Boltzman constant) = $8.62 \times 10^{-5} eVK^{-1}$, c (constant) = 1. N, Avogadro's number 6.02×10^{23}. ρ (density of copper) = $8.96 g/cm^3$. [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 000N causes a 10mm x 10mm bar of magnesium to stretch from

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

SECTION B

2. (a) (i) Distinguish hardness from toughness of a material. [4]
(ii) Briefly describe one method by which hardness can be measured. [4]

(b) (i) What is the carborization process and what is its purpose? [4]
(ii) A 0.02% carbon steel is to be carburized at 1200^{0}C in 4 hours, with a point 0.6mm beneath the surface reaching 0.45% carbon. Calculate the carbon content required at the steel surface.
$D_o = 2.3x10^{-5} cm^2 s^{-1}$, $Q = 137700 Jmol^{-1}$, $R = 8.314$ J/mol.K [8]

3. (a) Show that the strain can be expressed as $\varepsilon_t = \ln(1+\varepsilon_n)$ where ε_n is the engineering stress. [5]

(b) Sketch the stress/strain curve and label the following:
(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? [8]

(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 inorder to account for the elastic strain. The modulus of elasticity is *127 Gpa*$^{-1}$ and its yield strength is *275 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°C and that of tin 232°C.
(ii) The two metals form a eutectic containing 62% tin at 182°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 -