NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1209 - ENGINEERING MATERIALS

BSc HONOURS PART I: MAY 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) Which properties of a material would you need to consider, if you required them to be:

(i) stiff
(ii) capable of being bent into a fixed shape
(iii) capable of not fracturing when small cracks are present.
(iv) not easily breaking
(v) act as an electrical insulator
(vi) a good conductor of heat
(vii) capable of being used as a lining for a tank, storing acid. [7]

(b) Compare the specific strengths and costs per unit for equal volumes of the following materials

(i) low carbon steel
Cost per kg \$10.000, density 7 800kg/m^3
Strength 1000 MPa.

(ii) Poly propylene.
Cost per kg \$20.00, density 900kg/m^3
Strength 30 MPa. [6]

(c) In a scrap recycling plant for domestic refuse, a physical method is required to separate polymers, aluminium alloys and steel from each other. Suggest the properties of the materials on which the separation methods may be based. [6]

(d) An alloy contains 85 Wt% Copper and 15 Wt% Tin. Calculate the atom percent of each element. [5]

(e) FCC lead has a lattice parameter of 0.4949nm with one vacancy per 500 lead atoms. Calculate the density and the number of vacancies per gram of lead. [5]

(f) Cellulose acetate has a tensile modulus of 1.5 GPa and polythene with modulus of 0.6 GPa, which of the two plastics is stiffer? Why? [4]

(g) The impact strengths of samples of nylon 6 at a temperature of 22°C are found to be 3KJ/m^2 in the moulded condition but 25KJ/m^2 when the sample has gained 2.5% in weight through water absorption. What conclusions can you draw from these results? [3]

(h) In a Brinel hardness test, a 10mm diameter ball with a 3000kg load resulted in an indentation with a diameter of 4.10mm, determine the material's hardness. [4]

SECTION B

2. (a) Draw a unit cell of a cube and mark the following:
   (i) $[110]$ and $[0\bar{1}2]$ directions
   (ii) (120) and $(\bar{1}01)$ planes. [5]

   (b) Titanium is BCC at high temperatures and its atomic radius is 0.145nm.
   (i) How large is the edge of the unit cell? [1]

   (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) Give reasons why there is a need for the testing of materials. [5]

   (b) Specify the type of test that can be used in the following instances?
   (i) two steel batches have been mixed, one batch having been surface hardened and the other not, how can the two be distinguished? [2]

   (ii) A plastic is modified by inclusion of fibres, what test can be used to determine whether this has made the plastic stiffer? [2]

   (c) Show that true strain = ℓ_n or $\log e\frac{A_0}{A}$ where the notations have the usual meanings. [4]

   (d) Using the stress-strain sketch, explain the following terms:
   (i) Tensile strength [2]
   (ii) Limit of proportionality [2]
   (iii) Modulus of elasticity of a material. [3]

4. (a) Distinguish hardness from toughness. [4]

   (b) Differentiate between scratch, indentation and rebound hardness measurements. [9]

   (c) With the aid of a diagram, explain the primary, secondary and tertiary creep in metals. [7]

5. (a) (i) Describe either the carburization or nitriding process. [4]

(ii) A carbonization process is carried out on a 0.10% carbon steel by introducing 1.0%C at the surface at 980°C where the iron is FCC. Calculate the carbon content at 0.1mm and 1.0 mm from the surface after 1 hour. The diffusivity at 980°C is $4.8 \times 10^{-11} m^2/s$. [6]

(b) Define the following terms as used in materials science.
(i) fatigue limit
(ii) endurance ratio. [6]

(c) On what factors do the fatigue properties of a material depend on? [4]

6. (a) (i) Describe with examples (at least 2), the different classes of composite materials. [9]

(ii) Calculate the density of a composite which is made of 80% by volume of silicone carbide whiskers of density 3.10 Mg/m^3 and an aluminium matrix of density 2.77 Mg/m^3. [3]

(b) (i) What are the various types of corrosion? [3]

(ii) What is passivation? Distinguish between the two types of passivity. [5]