NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1209 – ENGINEERING MATERIALS

BSc HONOURS PART I: MAY 2006 DURATION: 3 HOURS

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

SECTION A

1. (a) Suggest the key property or properties required of a material (give one example of each) that might be used in the following situations:

   (i) a container to hold an acid,

   (ii) pipes used in the distribution of hot water,

   (iii) a component subjected to cyclic loading. [6]

   (b) Explain why the de-aeration of water in a boiler reduces corrosion. [4]

   (c) Sketch the following directions and planes in a unit cell:

   (i) [301], [112] [2]

   (ii) (110), (212) [4]

   (d) Calculate the atomic packing factor for the FCC crystal structure. [4]

   (e) (i) Distinguish between hard and soft glasses, and between long and short glasses. [4]

   (ii) What is a chemically strengthened glass? [2]

   (f) Explain the terms fatigue limit and endurance limit. [4]

   (g) Compare the percentage covalent character of titanium carbide and silicon carbide. Use Pauling's equation. [4]

   (h) Classify composites, giving one example of each. [6]

SECTION B

2. (a) A metal having a cubic structure has a density of 2.6 g/cm^3, an atomic weight 87.62 g and lattice parameter of 0.60849 nm. One atom is associated with each lattice point. Determine the crystal structure of the metal. [6]

(b) Titanium is bcc at high temperatures and its atomic radius is 0.145nm.

(i) How large is the edge of the unit cell? [2]
(ii) Find the repeat distance and linear density in the [111] direction. [4]
(iii) What is the planar density on the (200) plane? [3]
(iv) Comment on the directions of slip and slip planes within a unit cell in terms of linear packing/density and planar density. [5]

3. (a) Using the data in the table below, predict the relative degree of solid solubility of the following elements in aluminum: [8]

Element	Atom radius (mn)	Crystal structure	Electronegativity	Valence
Al	0.143	FCC	1.5	+3
Cu	0.128	FCC	1.8	+2
Zn	0.133	HCP	1.7	+2
Mn	0.112	Cubic	1.6	+2, +3, +6, +7

(b) How do subsititional atoms affect

(i) the strength of a metal and,
(ii) the electrical conductivity of a metal? [2]

(c) Using a graph paper, draw a fully labeled equilibrium phase diagram from the following information:

(i) the melting point of A is 200ºC and that of B is 300ºC, the eutectic composition of A and B is at 45% A at a temperature of 150ºC.The maximum solubility of A in B is 20% and that of B in A is 35% while the minimum solubility of A in B is 25 and B in A is 10% at room temperature. [8]

(ii) How does the strength of the alloy vary with the alloy composition? [2]

4. (a) (i) Define *specific strength* and *specific modulus*. [6]

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

low carbon steel - cost per kg $10 000.00,
density 7800kg/m3,
strength 1000 MPa

Polypropylene- cost per kg $ 20.00,
density 900kg/m3,
strength 30 MPa

[6]

(b) Of what importance is the tensile strength, yield strength and the Young's modulus in working of metals? [8]

5. (a) (i) Draw a typical creep curve of a metal and clearly label all the stages of creep. [5]

(ii) Explain the shape of the curve. [5]

(b) The Brinell on a test sample with a 10 mm diameter ball and 3000kg load gave an indentation with a diameter of 4.10mm. Determine the hardness of the sample.

[5]

(c) Define the glass transition temperature, T_g and discuss its significance in the selection of materials to be used under impact conditions. [5]

6. (a) The corrosion rate for mild steel test plates was found to give averages of 0.050mm per year in rural surroundings, 0.070 mm per year in marine surroundings, and 0.150 mm in heavy industrial surroundings. Discuss the significance of the data. [8]

(b) Give a brief description of the type of metal containers used in the food industry with respect to their corrosion properties. [6]

(c) Discuss briefly the environmental stability of polymers. [6]

- END OF EXAMINATION -