

**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**DEPARTMENT OF APPLIED PHYSICS**

**SPH 1209 ENGINEERING MATERIALS**

BSc HONOURS PART I : MAY 2002

DURATION : 3 HOURS

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

**SECTION A**

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1. (a) Classify the following as metal, polymer, ceramic or composite.
- |                     |                             |                   |
|---------------------|-----------------------------|-------------------|
| (i) Sodium chloride | (ii) Asphalt                | (iii) fibre glass |
| (iv) Brass          | (v) reinforced concrete and |                   |
| (v) graphite        |                             | [3]               |
- (b) Solder contains 60w/o tin and 40w/o lead, find the atom percentages of each element. [4]
- (c) Silver has an FCC crystal structure and its atomic radius is 0.1444nm. How large is the size of its unit cell? [4]
- (d) Show that the atomic packing factor for the body centered cubic systems is 0.68. [4]
- (e) Sketch the following within a unit cell
- |           |            |     |
|-----------|------------|-----|
| (i) [110] | (ii) (101) | [4] |
|-----------|------------|-----|
- (f) A steel cable, 31mm in diameter and 15.25 m long is used to lift a 0.2 MN load. What is the length of the cable during lifting? The modulus of elasticity of steel is 210 GPa. [5]
- (g) A polymer has  $C_2 H_2 Cl_2$  as a mer. It has an average mass of 60 000 amu per molecule. Determine
- |                                    |     |
|------------------------------------|-----|
| (i) the polymer mer mass and       | [1] |
| (ii) its degree of polymerization. | [3] |

- (h) What type of vacancies, anion or cation must be introduced with
- (i) Mg F<sub>2</sub> in order for it to dissolve in Li F? [4]
  - (ii) Li F to dissolve in Mg F<sub>2</sub>? [4]
- (i) Distinguish between toughness and hardness. [4]
- (j) Several types of metallic coatings are used to protect steel. Examples are zinc, lead, tin, cadmium, aluminium and nickel. In which of these cases will the coating provide protection even when the coating is locally disrupted? [4]

### SECTION B

2. (a) Compare a substitutional solution from an interstitial solution. [4]
- (b) State the conditions that are favourable for the extensive solid solubility of one element into another. [4]
- (c) The melting point of lead is 327<sup>o</sup>C and that of tin is 232<sup>o</sup>C. They form a eutectic, containing 62% tin at 182<sup>o</sup>C. The maximum solid solubility of tin in lead is 19% and of lead in tin is 3%. Assuming the solubility of each is 1% at room temperature:
- (i) Draw the equilibrium diagram to scale on a graph paper and label all lines, points and phase spaces. [7]
  - (ii) Describe the cooling of a 70% tin alloy. [3]
  - (iii) Sketch the cooling curve of a 70% tin alloy. [2]

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3. (a) (i) What is metal creep? [3]
- (ii) For which environmental conditions, is creep important industrially? [2]
- (b) Draw a typical creep curve for a metal under constant load at a relatively high temperature. Explain the nature of the curve. [10]
- (c) Describe briefly the metal fatigue failure. [5]

4. (a) (i) What is the difference between the true and the engineering stress – strain curves? [3]
- (ii) Show that the strain is given by  $\ln\left(\frac{A_0}{A}\right)$  where A is the final cross-sectional area of the sample and  $A_0$  is the initial cross sectional Area. [3]
- (iii) Define the terms yield point, tensile strength, and modulus of elasticity. Explain their importance in the design of structures. [8]
- (b) Differentiate between scratch, indentation and rebound hardness measurement methods. [6]
5. (a) (i) Describe, with suitable examples the different classes / groups of composite materials. [8]
- (ii) Silica flour of density  $2.65 \text{ g/cm}^3$  is used as a filler for polyvinyl chloride of density  $1.3 \text{ g/cm}^3$ . What volume fraction is required to give a density of  $1.70 \text{ g/cm}^3$ , and what is the w/o of silica? [4]
- (b) (i) Write the Fick's second law of diffusion equation for solids and define each of the terms. [2]
- (ii) Describe the gas-carburizing process and explain the importance of the carburization of steel parts. [6]
6. (a) (i) What is metal corrosion? [3]
- (ii) Discuss the various mechanisms of galvanic corrosion. [6]
- (iii) Briefly discuss the special types of steel alloys used in food and chemical industries in the context of their corrosion resistant properties. [5]
- (b) Write brief notes on any **two** of the following: ' LIBRARY USE ONLY'
- (i) Protective oxide coatings [3]
- (ii) Abrasive and adhesive wear [3]
- (iii) Polymer degradation [3]

- END OF PAPER -