

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1209 ENGINEERING MATERIALS

BSc HONOURS PART IV : JANUARY 2003

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. DRAW NEAT DIAGRAMS WHEREVER NECESSARY.

Avogadro numbers, N_0	=	$6.02 \times 10^{23} \text{ mol}^{-1}$
Molar gas constant, R	=	$8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Boltzman Constant, K	=	$1.38 \times 10^{-23} \text{ J K}^{-1}$

SECTION A

- 1 (a) Classify the following materials as metal, ceramic, composite or a polymer:
- (i) sodium chloride,
 - (ii) fibre glass,
 - (iii) concrete,
 - (iv) brass,
 - (v) polyvinyl chloride (PVC),
 - (vi) perspex. [3]
- (b) Consider an electrical cord for a house-hold appliance such as an electric kettle, list the materials used and the probable reason for their selection. [4]
- (c) Solder contains 60-weight percent tin and 40-weight percent lead. Calculate the atom percent of each element? [4]
- (d) Calculate the atomic packing factor for bcc tungsten. [3]
- (e) Sketch the following directions and planes in the unit cell:
- (i) $[101]$ $[10\bar{1}]$, [2]
 - (ii) (210) (111) $(\bar{1}\bar{1}\bar{1})$. [4]
- (f) Discuss the conditions favourable for a solid solution. [4]

- (g) Define the term *steel*. How does it differ from *cast iron*? [4]
- (h) What are the advantages and limitations of plastics? [4]
- (i) Differentiate between the terms *ceramic* and *clay*. [4]
- (j) Explain the terms *corrosion by oxidation* and *galvanic corrosion* [4]

SECTION B

- 2. (a) State Fick's laws of diffusion: [4]
 - (b) Explain the terms
 - (i) grain boundary diffusion,
 - (ii) volume diffusion, and
 - (iii) surface diffusion. [6]
 - (c) A 4 cm diameter 0.5 mm thick spherical container made of BCC iron, holds nitrogen at 700°C. The concentration of nitrogen at the inner surface is 0.05 atom percent and at the outer surface it is 0.002 atom percent.

Calculate the number of grams of nitrogen that are lost from the container per hour. [8]
 - (d) Explain why a polymer balloon filled with helium gas deflates with time. [2]
- 3. (a) Determine
 - (i) the planar density,
 - (ii) packing fraction on the (110) plane of FCC Nickel. The lattice parameter for nickel, $a_0 = 0.352\text{nm}$. [6]
 - (b) Draw a fully labeled diagram showing the stages of ~~match~~ creep. Explain what happens at each stage. [8]
 - (c) Briefly describe the principle of a fatigue test. [6]
- 4. (a) Differentiate between:
 - (i) scratch,
 - (ii) indentation, and
 - (iii) rebound hardness measurements. [6]
 - (b) Describe the method you would use to measure the hardness of a brittle material [4]

- (c) Define the following terms:
(i) true Strain,
(ii) tensile stress,
(iii) toughness,
(iv) yield point, and
(v) glass transition temperature. [10]
5. (a) (i) What is metal corrosion? [2]
(ii) Discuss with examples, the common types of corrosion. [8]
(b) What are the various types of corrosion control? Discuss their advantages and disadvantages. [10]
6. (a) (i) Classify composite material. Give two types of composite for each group [6]
(ii) Distinguish thermoplastics from thermosets. [6]
(b) Draw a fully labelled equilibrium phase diagrams for,
(i) two materials A and B completely miscible in both the liquid and solid state, and [2]
(ii) two materials A and B completely miscible in the liquid state but partially soluble in the solid state. [6]

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