

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SUPPLEMENTARY EXAMINATION

SPH 4204 – MATERIALS SCIENCE II

BSc HONOURS PART IV: JULY 2013 DURATION: 3 HOURS

ANSWER **ALL** QUESTIONS IN **SECTION A** AND ANY **THREE** QUESTIONS IN **SECTION B**. SECTION A CARRIES **40 MARKS** WHILE EACH QUESTION IN SECTION B CARRIES **20 MARKS**.

Boltzmann's constant, $k = 1.38 \times 10^{-23} \text{ J K}^{-1}$

Avogadro's number, $N = 6.022 \times 10^{23} \text{ mol}^{-1}$

SECTION A

1.(a) Given that the moduli of elasticity for aluminum and silicon carbide (SiC) are 69×10^3 and 430×10^3 MPa, respectively. Calculate the following for a metal-matrix composite of aluminum reinforced with 60 vol % SiC fibers:

(i) The modulus of elasticity under isostrain conditions, [2]

(ii) The modulus of elasticity under isostress conditions. [2]

(b) Discuss the elastic and quasi elastic behaviour of composites. [5]

(c) Describe the random network model of silicate glasses, explaining the role of network forming, modifying and intermediate oxides. [5]

(d) A three point bend test is performed on a block of Zirconia that is 200 mm long and 12 mm wide and 6 mm thick. The bar is resting on two supports 100 mm apart. The deflection of the bar is 0.94 mm when a force of 180N is applied. Calculate:

(i) The flexural strength, [3]

(ii) The flexural modulus. [3]

(e) The glass transition temperature of polyethylene is well below room temperature, but

the elastic modulus of high density polyethylene is nearly as high as that of a glassy polymer. Explain why this is so? [4]

(f) Calculate the minimum cation-to-anion radius ratio for a coordination number of 6. [4]

(g) What deformation mechanisms are involved during the elastic and plastic deformation of thermoplastics?[4]

(h) The maximum-sized internal flaw in a hot-pressed silicon carbide ceramic is 25 μm . If this material has a fracture toughness of $3.7 \text{ MPa}\cdot\text{m}^{1/2}$, what is the maximum stress that this material can support? [3]

(i) CdS has the Zinc blende crystal structure, describe with the aid of a diagram the CdS structure.[5]

SECTION B

2. (a) Calculate the tensile modulus of elasticity of a laminate composite consisting of 62 percent by volume of unidirectional Kevlar 49 fibres and an epoxy matrix stressed under isostress conditions. The tensile modulus of elasticity of the Kevlar 49 fibres is 170 GPa and that of the epoxy is 3.70GPa. [5]

(b) With reference to composites with discontinuous fibres, discuss the significance of the *critical length*. [5]

(c) Derive an equation relating the elastic modulus of a layered composite of unidirectional fibres and a plastic matrix that is loaded under isostrain conditions. [10]

3. (a) How do porosity and grain size affect the tensile strength of ceramic materials? [4]

(b) Discuss the mechanisms of plastic deformation for crystalline and non-crystalline ceramics. [4]

(c) Graphite and diamond are both made from carbon atoms.

(i) List two physical characteristics of each. [4]

(ii) Give one application for graphite and one for diamond. [2]

(d) Discuss the two common shaping techniques that are utilized for forming clay based compositions. [6]

4.(a) Explain why thermosetting plastics have in general high strengths and low ductilities.

[4]

(b) Describe the mechanism by which tempered glass is four times stronger than annealed glass. [5]

(c) With the aid of a clearly labeled diagram distinguish between the melting temperature T_m and transition temperature T_g for a glass. [5]

(d) How does the amount of crystallinity within a thermoplastic material affect the following:

(i) Its strength, [2]

(ii) Its tensile modulus of elasticity, [2]

(iii) Its density. [2]

5. (a) Explain why compression testing is used more often for ceramics and concretes than metals? [4]

(b) Discuss the main reactions occurring during the hydration of cement making reference to their heats of hydration and their contribution to strength. [6]

(c) Classify refractories on the basis of chemical composition, giving two examples for each class. [10]

6. (a) A polyvinyl chloride polymer, C_2H_3Cl has an average molecular weight of 72 130g/mol. Find its degree of polymerisation, n ? [4]

(b) What is meant by the term *polymerisation* and distinguish clearly between addition

and condensation polymerisation. [4]

(c) What are the two factors that influence the degree of crystallinity in polymers? [4]

(d) Explain why in visible light high-density polyethylene (HDPE) is opaque (white) while low-density polyethylene (LDPE) is transparent. [4]

(e) For thermoplastic polymers, cite four factors that favor brittle fracture. [4]

-----**END OF EXAMINATION**-----