NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4204 - MATERIALS SCIENCE II

BSc HONOURS PART IV: 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) Distinguish weight average molecular weight from the number average molecular weight for polymers. [4]

(b) Calculate the degree of polymerization if polyethylene has a molecular weight of 100 000g/g mole. [3]

(c) PVC has a glass transition temperature of 87°C. How would its properties below this temperature differ from those above it? [5]

(d) Explain the significance of the critical length when discontinuous fibres are used for a composite. [5]

(e) Boron nitride can easily be machined while silicon nitride cannot. What structural differences account for this? [5]

(f) An electrical contact material is produced by infiltrating copper into a porous tungsten carbide(WC) compact. The density of the final composite is 12.3 Mg/m^3. Assuming that all pores are filled with copper, calculate:

(i) the volume fraction of copper in the composite. [3]
(ii) the volume fraction of the pores in the tungsten carbide compact prior to infiltration. [2]
(iii) the original density of the WC compact before infiltration. [3]

(g) A stress of 7 MN/m^2 is applied to a polymer component that operates at a constant strain. After six months the stress drops to 5.9 MN/m^2 . It is required that the component must retain a stress of 6.2 MN/m^2 for 12 months. Determine the original stress that should be applied for the application. [6]

(h) What are closed and interconnected pores? Explain the use of pores in ceramic refractory materials. [4]

SECTION B

2. (a) For each of the following applications, select the most appropriate polymer. Give reasons for your selection.
   (i) The housing for a computer; polyethylene, polypropylene, ABS, PVC.
   (ii) An electrical insulator at room temperature; polyethylene, PVC, ABS, PET.
   (iii) A gasket exposed to fuels and oils: natural rubber, SBR, NBR. [12]

   (b) Describe the basic structure of a thermoplastic elastomer. [3]

   (c) How do the mechanical properties of thermosets differ in general from those of thermoplastics. [5]

3 (a) Discuss the principle and theory of glass fracture. [10]

   (b) A three point bend test is performed on a block of silicon carbide that is 10cm long, 1.5cm wide, and 0.6cm thick. The SiC block is resting on two supports 7.5cm apart. If the sample breaks when a deflection of 0.9mm is recorded, calculate
   (i) the force that causes the fracture. [5]
   (ii) the flextural strength of the silicon carbide. [5]

   The flextural modulus for silicon carbide are 480GPa. Assume no plastic deformation.

4 (a) (i) Show that for a laminate, the electrical conductivity of the laminate δ_c, in a direction perpendicular to the constituent layers is given by:

$$\frac{1}{\delta_c} = \frac{V_1}{\delta_1} + \frac{V_2}{\delta_2} + \frac{V_3}{\delta_3} + \text{---------}$$

   Where δ_1, δ_2, δ_3 are electrical conductivities of the layers 1, 2, 3 and V_1, V_2, V_3 are the corresponding volume fractions. [6]

   (ii) Also show that in the direction parallel to the plates the conductivity is $\delta_c = V_1\delta_1 + V_2\delta_2 + V_3\delta_3 + \text{-------}$ [6]

   (b) Calculate the tensile modulus in the aligned direction and at right angles direction for a composite consisting of 45% by volume of continuous aligned glass fibres, tensile modulus 76Gpa in a polymer matrix with a tensile modulus of 4 GPa. [8]

5 (a) (i) What are refractory materials? [2]
   (ii) Discuss briefly the various types of refractories giving examples and their applications. [10]

   (b) Toughened soda glass has a density of 2.5 Mg/m^3, specific heat capacity of $0.98Jg^{-1}k^{-1}$, fracture strength of 250 Mpa, Modulus of elasticity of 72 GPa, coefficient of expansion of $7.8 \times 10^{-6} k^{-1}$, thermal conductivity of 1.8 $Wm^{-1}K^{-1}$ and a Poisson's

ratio of 0.25. Determine the thermal shock resistance

(i) Assuming no heat is conducted through to the lower layers of the material from the surface. [2]

(ii) taking into account such conduction. [3]

(iii) assuming a steady rate of surface temperature change. [3]

6. (a) Using the combined Maxwell and Voigt model, explain the viscoelastic behaviour of polymeric materials. [10]

(b) Write brief notes on any two of the following.
(i) Polymeric semiconductors
(ii) Barium Titanate
(iii) Tetrahedral and Octahedral interstitial sites. [10]

- END OF EXAMINATION -