

# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

## APPLIED PHYSICS DEPARTMENT

### SPH 1209 ENGINEERING MATERIALS FINAL EXAMINATION

BSC HONOURS PART I: APRIL 2014

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**.

---

---

#### SECTION A

- 1 (a) Name and explain the significance of each of the four quantum numbers that are used in the configuration of electrons in atoms. [8]
- (b) What do you understand by Pauli's exclusion principle? [2]
- (c) Write down all possible values of the 4 quantum numbers for the *L* shell. [5]
- (d) (i) For a system of two atoms, sketch a graph that shows the dependence of the attractive, repulsive and net forces as a function of the inter atomic separation. [4]  
(ii) Sketch a similar diagram for attractive, repulsive and net potential energy [4]
- (e) (i) Using an appropriate sketch for illustration calculate the volume of an FCC unit cell in terms of the atomic radius *R*. [4]  
(ii) Gold has an atomic radius of 0.1442 nm, an FCC crystal structure and an atomic weight of 196.967 g/mol. Compute its density [3]
- (f) What is the importance of the ductility of a material? [4]
- (g) A steel wire 0.55 in cross section area (*A*) and 10 m long is extended elastically 1.68 mm by a force of 17.24 N. Calculate the modulus of elasticity of steel. [4]
- (h) Give any *two* objectives of non destructive testing of materials. [2]

## SECTION B

2. (a) Define the term ceramics. [2]  
(b) Outline the basic structure of silicate ceramics. [4]  
(c) Give three mechanical properties of ceramics and give examples of applications where each property is exploited. [6]  
(d) What should be considered in the selection of a material in the manufacture of a product? [8]
- 3 (a) Why are most alloys generally stronger when compared to their separate constituent elements? [6]  
(b) Distinguish between hardness and toughness of a material. [4]  
(c) The formula for vinyl acetate is  $CH_2CHCO_2CH_3$ .  
It forms a polymer by addition polymerization with an average molecular mass of  $4.5 \times 10^4$ .  
(i) What is meant by addition polymerization? [2]  
(ii) Find the degree of polymerization. [6]  
(d) Define a composite material. [2]
- 4 (a) Outline the following defects found in solids.  
(i) Point defects [3]  
(ii) Linear defects [3]  
(b) Why are materials with defects generally stronger than pure materials for the same type of the material. [4]  
(c) (i) Explain the process of annealing. [6]  
(ii) State four benefits derived from the annealing process. [4]
- 5 (a) Define the term *fatigue*. [2]  
(b) Distinguish between fatigue and creep in materials. [4]  
(c) Write short notes on fatigue failure in materials;  
(i) crack initiation, [4]  
(ii) crack propagation, [4]  
(iii) failure in materials. [4]  
(d) Suggest two methods of minimizing the effects of fatigue in materials [2]

- 6 (a) Give any *four* reasons for the need for testing of materials. [4]
- (b) A tensile test on plastics material gave the results shown in table 1 during the initial states of the test.

**Table 1 Test results on a plastic specimen.**

<b>Force (N)</b>	<b>Extension (mm)</b>
0	0
100	0.03
150	0.05
200	0.09
250	0.14
300	0.20
400	0.37
500	0.61

The test piece had a cross sectional area of  $50\text{mm}^2$  and a gauge length of 50 mm.

- (i) Plot the force-extension graph for the material over the range of the readings given. [6]
- (ii) Determine the tangent modulus at strain rate 0.2% [5]
- (iii) Determine the secant modulus at strain rate 0.5% [5]

**END OF EXAM**