



KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS 2022/2023 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER MAIN EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: SPM 311

COURSE TITLE: INTRODUCTION TO MATERIAL SCIENCE

DURATION: 2 HOURS

DATE: 13/12/2022

TIME: 9:00-11:00AM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
 - Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page

This paper consists of 3 printed pages. Please Turn Over

KIBU observes ZERO tolerance to examination cheating

Some constants which you may find useful

| | |
|----------------------------|----------------------------|
| Charge of an electron | $1.6 \times 10^{-19} C$ |
| Permittivity of free space | $8.85 \times 10^{-12} F/m$ |
| Madelung constant of NaI | 1.748 |
| Young Modulus of steel | $2 \times 10^{11} Pa.$ |

QUESTION ONE (30mks)

- a) What will be the nature of inter-atomic forces when deforming force applied on an object (i) increases, (ii) decreases the inter-atomic separation (2mks)
- b) Solids are more elastic than liquids and gases. Justify (2mks)
- c) Why steel is more elastic than rubber (3mks)
- d) Write down the atomic radii r in terms of the lattice constant a , for (i) Simple cubic structure (ii) FCC structure (iii) BCC structure (2mks)
- e) Explain what you understand by the following terms; (i) Notch sensitivity (ii) Creep (iii) Fatigue. (3mks)
- f) Explain the differences between soft and hard loading. (2mks)
- g) Explain the terms ductility and hardness as used in mechanical tests of materials. (4mks)
- h) State three differences between ionic compounds and covalent compounds. (3mks)
- i) Explain why metallic bonds are non directional. (2mks)
- j) State two disadvantages of centre point loading. (2mks)
- k) The potential energy of the sodium chloride system is written as;

$$U_p = -\frac{A}{r^n} + \frac{B}{r^m}$$

- i) Explain the meaning of each term on the right hand side of this equation. (2mks)
- ii) Describe the behavior of each term in this equation as r approaches zero. (2mks)

QUESTION TWO (20mks)

- a) Draw a well labeled load-extension curve for mild steel and describe all the main sections of this curve, stating clearly what happens at each part of the curve. (6marks)
- b) Show that 68% and 74 % of the available volume is occupied by hard spheres in contact in a body-centered cubic and Face-centered cubic arrangement (10marks)
- c) A cubic lattice has a cube edge $a=2.665\text{\AA}$. Find the spacing of adjacent planes with the miller indices. i) (101) ii) (111). (4marks)

QUESTION THREE (20mks)

- a) The force of attraction between ions of Na and Cl is $3.02 \times 10^{-9}\text{N}$ when the two ions just touch each other. Given: ionic radius of Na^+ ion is 0.95\AA , $e = 1.6 \times 10^{-19}\text{C}$, $\epsilon_0 = 8.854 \times 10^{-12} \text{C}^2/\text{N} \cdot \text{m}^2$. Find the radius of Cl^- ion. (6marks)
- b) The potential energy of a system of two atoms is given by the relation;

$$U = -A/r^2 + B/r^{10}$$

A stable molecule is formed with the release of 8 eV of energy when the interatomic distance is 2.8\AA . Find A and B and the force needed to dissociate this molecule into atoms and the interatomic distance at which the dissociation occurs (14marks)

QUESTION FOUR (20mks)

- a) Suppose a 2 kg mass is attached to the end of a vertical wire of length 2 m and diameter 0.64 mm, and the extension is 0.6 mm, calculate tensile stress, tensile strain and Young Modulus (6 marks)
- b) Briefly define stress and strain as applied to elastic properties of solids (2 marks)
- c) By using a clearly well labeled diagram, discuss THREE types of stress (6 marks)
- d) A 10 kg mass is attached to one end of a copper wire of length 5m long and 1 mm in diameter. Calculate the extension and lateral strain, if Poisson's ratio is 0.25. Given Young's modulus of the wire = $11 \times 10^{10} \text{N m}^{-2}$ (3 marks)
- e) A hydrostatic press contains 5 liters of oil. Find the decrease in volume of the oil if it is subjected to a pressure of 3000 kPa. (Assume that $B = 1700 \text{MPa}$.) (3 marks)

QUESTION FIVE (20mks)

- a) Briefly discuss the following types of magnetism giving clear differences between them. (12marks)
- (i) Ferromagnetism
 - (ii) Paramagnetism
 - (iii) Diamagnetism
 - (iv) antiferromagnetism
- b) Sketch a typical hysteresis loop, and explain the primary magnetic properties of a material that can be determined from it. (8marks)