KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023ACADEMIC 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

Some constants which you may find useful

Charge of an electron	$1.6\times10^{-19}C$
Permittivity of free space	$8.85\times10^{-12}F/m$
Madelung constant of NaI	1.748
Young Modulus of steel	$2\times10^{11}Pa$.

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) Fatique. (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-cantered cubic arrangement (10marks)

c) A cubic lattice has a cube edge a=2.665Å. 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 3.02×10^{-9}N when the two ions just touch each other. Given: ionic radius of Na+ ion is 0.95 Å, $e = 1.6 \times 10^{-19}$C, $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2/N-m^2$. 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 Å. 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 = $11 \times 10^{10} N\ m^{-2}$ (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 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) antifferromagnetism

b) Sketch a typical hysteresis loop, and explain the primary magnetic properties of a material that can be determined from it. (8marks)