



KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: SPM 311

COURSE TITLE: INTRODUCTION TO MATERIAL SCIENCE

DURATION: 2 HOURS

DATE: 31/8/2023

TIME: 8:00-10:00AM

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	$2 \times 10^{11} Pa$

SPM 311: INTRODUCTION TO MATERIAL SCIENCE

QUESTION ONE [30 Marks]

1. Write the electronic configuration for potassium whose atomic number is 19. How many unpaired electrons are there in a potassium atom. (3mks)
- b) Explain why metallic bonds are non directional. (2mks)
- c) State three differences between ionic compounds and covalent compounds. (3mks)
- d) Describe how the Izod test is used to determine the toughness of a metal. (3mks)
- e) Explain the terms ductility and hardness as used in mechanical tests of materials. (4mks)
- f) State four disadvantages of centre point loading. (4mks)
- g) 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)
- h) Show that inter-planar separation, d , lattice parameter, a and miller indices h, k, l is given by

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}} \quad (4mks)$$

- i) What do you mean by "coordination number" in a crystal structure? (1mk)
- j) Explain the differences between soft and hard loading. (3mks)

QUESTION TWO [20 Marks]

2. a) Show by clear derivations, that the packing fraction of body centred cubic lattice is 0.68 and that of F.C.C lattice is 0.740. (16mks)
- b) 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). (4mks)

QUESTION THREE [20 Marks]

3. State and explain any three methods which can be used in non destructive testing of materials. (6mks)
- b) Consider the case of sodium chloride crystal and derive an expression for the molar lattice energy (8mks)
- c) 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. (6mks)

QUESTION FOUR [20 Marks]

4. a) Explain what you understand by the following terms; (i) Notch sensitivity (ii) Creep (iii) Fatigue. (6mks)
- b) i) State Griffith's criterion for a crack formation and explain why it is not directly useful to the theory of ductile failure. (ii) Derive the necessary expressions to enable you calculate the tensile stress needed to fracture a glass plate which contains a sharp crack of length 1×10^{-6} m in its surface. (8mks)
- c) Derive an expression for the shear strength, σ_s in brittle materials. (6mks)

QUESTION FIVE [20 Marks]

5. a) In relation to alloys, explain the following:
- (i) Interstitial solid solution (3mks)
- (ii) Substitutional solid solution. (3mks)
- b) State the relative merits of the following materials: (i) solute hardened and (ii) precipitation hardened. (2mks)
- c) Describe how cooling can be produced by application of a potential difference to a metal wire heated at one end. (6mks)
- d) Describe the concept of thermoelectric power in metals. (6mks)