UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE MASTERS OF SCIENCE (PHYSICS)

COURSE CODE: SPH 821

COURSE TITLE: ELASTIC & THERMAL PROPERTIES OF SOLIDS

DURATION: 2 HOURS

DATE: 25/04/2023 **TIME: 9:00-11:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer **any three** 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

QUESTION ONE [20 Marks]

a) Define the term cohesive energy of a molecule [2 Marks]

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 8eV 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 [12 Marks]

c) The potential energy U of a system of two atoms varies as a function of their distance of separation r as;

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

Show that equilibrium:

i) $r = r_0 = \left(\frac{mB}{nA}\right)^{1/m-n}$ [2Marks]

ii) the energy of attraction is m/n times the energy of repulsion and [2 Marks]

iii) the bond energy is; [2 Marks]

$$U_0 = \frac{A}{r_0^n}\left(\frac{m-n}{m}\right)$$

QUESTION TWO [20 Marks]

a) Explain why steel is more elastic than rubber [2 Marks]

b) Differentiate between plastic and elastic behavior of materials [2 Marks]

c) Explain the molecular theory of elasticity [3 Marks]

d) Using clearly labeled diagrams, discuss the various types of stress and strain [6 Marks]

e) Calculate the maximum length of a steel wire that can be suspended without breaking under its own weight, if its breaking stress = $4.0 \times 10^8 Nm^{-2}$, density = $7.9 \times 10^3 kg\ m^{-3}$ and g= $9.80\ ms^{-2}$ [3 Marks]

f) 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 = $11 \times 10^{10} N\ m^{-2}$ [4 Marks]

QUESTION THREE [20 Marks]

a) Show that the strain energy stored in an elastic body per unit volume of the material, which is also called strain-energy density is given by;

$U_0 = \frac{1}{2}\sigma_x \varepsilon_x$ [4 Marks]

b) Given the following principal stresses at a point in a stressed material.

$\sigma_x = 200N/mm^2, \sigma_y = 150N/mm^2, \sigma_z = 120N/mm^2$

Taking;

$E = 210kN/mm^2$ and $\upsilon = 0.3$. Calculate the volumetric strain and the Lame's Constants [6 Marks]

c) The state of strain at a point is;

$\varepsilon_x = 0.001, \varepsilon_y = -0.003, \varepsilon_z = \gamma_{xy} = 0, \gamma_{xz} = -0.004, \gamma_{yz} = 0.001$

d) Determine the stress tensor at this point. Take $E = 210 \times 10^6 kN/m^2$ and Poisson's ratio as 0.28. Also find the Lame's constant [10 Marks]

QUESTION FOUR [20 Marks]

Discuss the Einstein's theory of specific heat of solids with regards;

i) Why was it necessary [1 Mark]

ii) Its assumptions [4 Marks]

iii) Derive the lattice heat capacity based on this model [9 Marks]

iv) Explain/Compare it with experimental observation at high and low temperature [6 Marks]

QUESTION FIVE [20 Marks]

a) Explaining the assumptions clearly, derive the expression for lattice specific on the basis of Debye model. [12 Marks]

b) Discuss the high and low temperature limits and define T^3 law [4 Marks]

c) Compare the Einstein and Debye models [4 Marks]