



KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2024/2025 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE MASTERS OF SCIENCE (PHYSICS)

COURSE CODE: SPH 821

COURSE TITLE: ELASTIC & THERMAL PROPERTIES OF SOLIDS

DURATION: 2 HOURS

DATE: 05/08/2025

TIME: 8:-10AM

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

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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;

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

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 = $4.0 \times 10^8 \text{Nm}^{-2}$, density = $7.9 \times 10^3 \text{kg m}^{-3}$ and $g = 9.80 \text{ms}^{-2}$ [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 = $11 \times 10^{10} \text{N m}^{-2}$ [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;

$$U_0 = \frac{1}{2} \sigma_x \epsilon_x \quad [4 \text{ Marks}]$$

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

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

Taking;

$$E = 210 \text{kN/mm}^2 \text{ and } \nu = 0.3. \text{ Calculate the volumetric strain and the Lamé's Constants} \quad [6 \text{ Marks}]$$

- c) The state of strain at a point is;

$$\epsilon_x = 0.001, \epsilon_y = -0.003, \epsilon_z = \gamma_{xy} = 0, \gamma_{xz} = -0.004, \gamma_{yz} = 0.001$$

- d) Determine the stress tensor at this point. Take $E = 210 \times 10^6 \text{kN/m}^2$ and Poisson's ratio as 0.28. Also find the Lamé'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]