NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF BIOLOGY, CHEMISTRY and PHYSICS

QUALIFICATION : BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE CODE: SSP701S	**COURSE NAME:** SOLID STATE PHYSICS
SESSION: JULY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	Prof Dipti Ranjan Sahu
MODERATOR:	Dr Zivayi Chiguvare

INSTRUCTIONS

1. Answer all five questions.
2. Write clearly and neatly.
3. Number the answers clearly.

PERMISSIBLE MATERIALS

Non-programmable Calculators

THIS QUESTION PAPER CONSISTS OF 3 PAGES (Including this front page)

Question 1 **[20]**

1.1 Explain the following terms as applied to crystals:
(i) Lattice parameters of a unit cell (ii) Primitive cell (4)

1.2 Sodium transform from bcc to hcp at about T = 23K. Assuming that the density remains fixed, and the *c/a* ratio is ideal, calculate the *hcp* lattice spacing *a* given that the cubic lattice spacing a' = 4.23 Å in the cubic phase. (6)

1. 3 Draw sketches illustrating a (100) plane, a (110) plane, and a (111) plane in a cubic unit cell. How many equivalent {100} planes are there in a cubic crystal? (10)

Question 2 **[20]**

2.1 Between covalent bonded materials and metallic bonded materials which are generally less dense and why? (4)

2.2 What is hydrogen bond? How it different from a dipole bond? Describe the role of hydrogen during formation of ice (6)

2.3 Magnesium Oxide ($Mg^{2+}O^{2-}$) and Sodium Chloride ($Na^{+}Cl^{-}$) have the same form of interatomic potential. The only difference is that z=2 for Magnesium Oxide and z=1 for Sodium Chloride. Find the ratio of their equilibrium separations. (10)

Question 3 **[20]**

3. 1 What do you mean by elastic wave in solids? (4)

3.2 Sketch schematically the dispersion relations of lattice vibrations for (a) a mono atomic linear chain and (b) a diatomic linear chain. Indicate in the figures how one can determine the velocity of sound by a geometrical construct. (6)

3.3 What is Einstein temperature and frequency? Explain Einstein theory of specific heat? (10)

Question 4 **[20]**

4.1 Find the drift velocity of the free electrons in a copper wire whose cross-sectional area (A) is 1×10^{-6} m^{-2} when the wire carries a current of 1.0 Amperes. Assume that each copper atom contributes one electron to the electron gas (Given: electron density in copper = 8.5×10^{28} electrons m^{-3}) (4)

4.2 What is the Lorentz number and explain it using the Wiedemann-Franz law? (6)

4.3 Explain free electron theory of metals and mention its advantages and drawbacks. (10)

Question 5 **[20]**

5.1 In what important respect does the conductivity of a conductor differ from that of an intrinsic semiconductor. (4)

5.2 The resistivity of pure silicon at room temperature is 3000 ohm-m. Mobilities of electrons and holes in silicon are 0.14 $m^2v^{-1}s^{-1}$ and 0.05 $m^2v^{-1}s^{-1}$ respectively. Calculate the intrinsic carrier density of silicon at room temperature. (6)

5.3 Describe Fermi-Dirac statistics. Sketch Fermi probability function at two different temperatures. (10)

Given fundamental constants.

Speed of light = $3x10^8$m/s
Planck constant = $6.626 x10^{-34}$ Js
Mass of electron= $9.1 x 10^{-31}$ kg
Charge of electron = $1. 6 x 10^{-19}$ C
Avogadro's number= $6.022 x 10^{23}$/mole
Boltzmann Constant =$1.38 x 10^{-23}$ JK^{-1}

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