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: JUNE 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	Prof Dipti R. 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)

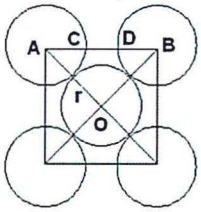
Question 1 **[20]**

1.1 *α-Co has* an hcp structure with lattice spacings of *a*= 2.51 Å and c = 4.07 Å, β-*Co* is *fcc, with* cubic lattice spacing of 3.55 Å. What is the difference in density between the two forms? (4)

1.2 Name various types of cubic class of crystalline structures. Explain their characteristics. Give the values of parameters which distinguish them from each other. (6)

1.3 (a) Calcium has a face-centered cubic structure with an ionic radius of 1.06 Å. Calculate the interplanar separation for (111) planes. (5)

(b) Show that the maximum radius of the sphere that can just fit into the void at the body centre of the fcc structure coordinated by the facial atoms is 0.414 r, where r is the radius of the atom. (5)



Question 2 ***[20]***

2.1 Between HF and HCl which have higher melting point and why? (4)

2.2 Mention the characteristics of ionic and metallic bonding (6)

2.3 The potential energy function for the force between two particular ions, carrying charges +e and -e respectively, may be written as,

$$V = -\frac{Ae^2}{r} + \frac{B}{r^9}$$

(i) Find the equilibrium separation distance for these ions. (5)
(ii) Find the potential energy at equilibrium separation (5)

Question 3 **[20]**

3.1 What are lattice vibrations? How to differentiate an acoustic mode and an optical mode of vibrations? (4)

3.2 The unit cell parameter of NaCl is $5.65A^0$ and the modulus of elasticity along [100] direction is 6×10^{10} N/m^2. Estimate the wavelength at which an electromagnetic radiation is strongly reflected by the crystal. The atomic weight of Na = 23 and of Cl = 37. Unit cell parameter (a) = 5.65×10^{-10}m, modulus of electricity (Y) = 6×10^{10} N/m^2. (6)

3.3 State Dulong and Petit law? How did the Einstein theory explain the failure of Dulong and Petit law? (10)

Question 4 **[20]**

4.1 What is classical free electron theory? Write the significance of the free electron theory. (4)

4.2 The conductivity of silver is 6.5×10^7 per Ohm per m and number of conduction electrons per m^3 is 6×10^{28}. Find the mobility of conduction electrons and the drift velocity in an electric field of 1 V/m. Given m = 9.1×10^{-31} kg and e = 1.602×10^{-19} C. (6)

4.3 Derive Wiedemann-Franz law? Mention which factors are affecting the Wiedemann Franz law? (10)

Question 5 **[20]**

5.1 What is density of energy states? Draw a plot between density of states and the energy of electrons (4)

5.2 In a semiconductor the effective mass of an electron is $0.07m_o$ and that of a hole is $0.4m_o$, where m_o is the free electron mass. Assuming that the average relaxation time for the holes is half that for the electrons, calculate the mobility of the holes when the mobility of the electrons is $0.8 m^2 volt^{-1} sec^{-1}$. (6)

5.3 What is direct and indirect band gap semiconductors, explain with diagram (10)

Given fundamental constants.

Speed of light = 3×10^8 m/s
Planck constant = 6.626×10^{-34} Js
Mass of electron= 9.1×10^{-31} kg
Charge of electron = 1.6×10^{-19} C
Avogadro number= 6.022×10^{23} /mole
Boltzmann Constant =1.38×10^{-23} JK^{-1}

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