JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

UNIVERSITY EXAMINATION FOR THE DEGREE OF BARCHELOR IN EDUCATION SCIENCE WITH IT

MAIN

REGULAR

COURSE CODE: SPB 9322

COURSE TITLE: INTRODUCTION TO SOLID STATE PHYSICS

EXAM VENUE: **STREAM: BACHELOR OF EDUCATION**

DATE: **EXAM SESSION:**

TIME: 2:00HRS

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1. **<u>Instructions:</u> Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Answer Question 1 (compulsory) and ANY other 2 questions**
3. **Candidates are advised not to write on the question paper.**
4. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

QUESTION 1 (30 MARKS)

a. Define the following terminologies

I. Phonon [2mks]

II. Bravais Lattice [2mks]

III. Coordination Number [2mks]

IV. Weigner-Seitz cell [2mks]

b) State the **Dulong-Petit Law** for crystalline matter [2mks]

c) Determine the Miller Indices of a plane which is parallel to y-axis and cuts intercepts of 3 and ¼ along x and z axes respectively [4mks]

d) Explain the following phenomena

i. The energy of a neutron is so much smaller than that of an electron in radiation beams but it is employed in crystal diffraction [2 mks]

ii. Light beam cannot be used in the analysis of crystal structure [2 mks]

iii. Neutrons are more useful than the proton in structure analysis [2 mks]

e) Calculate the total number of atoms that are present in a body centered cubic cell. Show your working [4 mks]

f) Give the difference between crystalline and amorphous crystals [4 mks]

g) Define a unit cell [2 mks]

h) A current of $2x10^{-7}$A is flowing in a certain PN junction at room temperature when a large reverse bias voltage is applied. Calculate the current when a forward voltage of 0.2 V is applied across the junction [4 mks]

i) An FCC unit cell contains 4 atoms, show that the Parking Ratio (PR) is given by 0.74 [4mks]

j) The Debye temperature θ for iron is known to be 360 K. Calculate ν_m, the maximum frequency [4mks]

QUESTION 2 (20MARKS)

a) Discuss any **Two types of defects** in a single crystal [6 mks]

b) Describe how the following create defects in crystals;

I. Thermal vibration [4 mks]

II. Impurities [4 mks]

c) Discuss the role of defects in electrical properties of a crystalline solid [6 mks]

QUESTION 3 (20MARKS)

a) Write down the definitions and formulae that describes the thermal conductivity in solids [5mks]

b) Identify and discuss the excitations that carry the heat current [5mks]

c) Sketch a graph of thermal conductivity as a function of temperature for a metal [4mks]

d) Identify the characteristic temperature dependence at high and low temperatures and describe the dominant physical effects in the two regions [6mks]

QUESTION 4 (20 MARKS)

The density of copper is 8.96 gm/cm^3 , and its atomic weight is 63.5 gm/mole.

a) Calculate the Fermi energy for copper. Assume q=1 and give your answer in eV [5 mks]

b) What is the corresponding electron velocity? (Assume that the electrons in copper are non-relativistic) [5 mks]

c) At what temperature would the characteristic thermal energy (k_BT, where k_B is Boltzman constant and T is Kelvin temperature) equal the Fermi energy for copper? [5 mks]

d) Calculate degeneracy pressure of copper, in the electron gas model [5 mks]

QUESTION 5 (20 MARKS)

a. Compare the specific heat per mole of a monoatomic and a diatomic gas at constant volume. Use appropriate equations to explain your answer. [5mks]

b. Calculate the specific heat capacity of a monoatomic crystalline solid [6mks]

c. Debye's model of solids gives the expression for specific heat $C_v = 9N_0k\frac{1}{x^3}\int_0^x \frac{\sigma^4 e^\sigma}{\left(e^\sigma - 1\right)^2}dE$

where σ=, $h\upsilon$- kT. , $x = \frac{h\upsilon_m}{kT}$ and $\theta_D = \frac{h\upsilon_m}{k}$ is the Debye's characteristic temperature. Show that

i. At high temperatures, Debye's model gives Dulong Petit law [6mks]

ii. At low temperatures it gives $\theta_D = \frac{h\upsilon_m}{k}$ $C_v \propto T^3$ in agreement with the experiment [3mks]