JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

3RD YEAR 2ND SEMESTER 2016/17

MAIN REGULAR

COURSE CODE: SPH 301

COURSE TITLE: INTRODUCTION TO SOLID STATE PHYSICS

EXAM VENUE: PHY LAB **STREAM: (BED SCI)**

DATE: 06/09/16 **EXAM SESSION: 2.00 – 4.00 PM**

TIME: 2:00HRS

Instructions:

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

QUESTION ONE (30 marks) (COMPULSORY)

(a) Explain the nature of the following forces between molecules of matter

i. Electrical force (2 marks)

ii. Gravitational force (2 marks)

(b) What is the difference between amorphous and crystalline solids? (2 marks)

(c) Account for the following energies in molecules of matter.

i. Potential energy (2 marks)

ii. Kinetic energy (2 marks)

(d) Explain the variation in phases of matter when temperature increases. (3 marks)

(e) Explain the effect of increase in temperature on

i. Thermal conductivity of matter (2 marks)

ii. Electrical conductivity of matter (2 marks)

(f) What is the meaning of **close-packing**? (1 mark).
(g) List any **two** most common examples of metallic structures. (2 marks)
(h) How does the presence of dislocations influence the mechanical properties of metallic crystals? (1 mark)
(i) Using well labeled diagrams, explain how the following extrinsic semiconductors are formed

i. P-type (3 marks)

ii. n-type (3 marks)

(j) Draw semiconductor photocell in a circuit and explain its operation. (3 marks)

QUESTION TWO (20 MARKS)

(a) Sketch diagrams of the following portions of some common types of crystal lattices (5 marks)
i. Simple cubic (sc)
ii. Face-centered cubic (fcc)
iii. Body-centered cubic (bcc)
iv. Hexagonal close packed (hcp)
v. Top view, hexagonal close packed
(b) Briefly describe the following crystals giving examples in each case.

i. Ionic crystals (2 marks)

ii. Covalent crystal (2 marks)

iii. Metallic crystal (2 marks)

(c) List and explain any **two** crystal disorders. (3 marks)

(d) Explain the electrical resistivity in

i. Covalent crystals (2 marks)

ii. Ionic crystals (2 marks)

iii. Metallic crystals (2 marks)

QUESTION THREE (20 marks)

(a) Using well labeled diagrams, draw the three types of energy-band structures (6 marks)

(b) Using the concept of energy bands, explain the properties of semiconductors when the temperature changes from absolute zero to ordinary (2 marks)

(c) Using a well labeled diagram explain covalent bonding in germanium. (2 marks)

(d) Using a well labeled diagram, describe the motion of charge carriers when an electric field is applied to an intrinsic semiconductor operating at room temperature. (6 marks)

(e) Using well labeled diagrams, illustrate the action of impurities on intrinsic semiconductors (4 marks)

QUESTION FOUR (20 marks)

(a) Look at the graph for a diode characteristic in Figure 1 below.

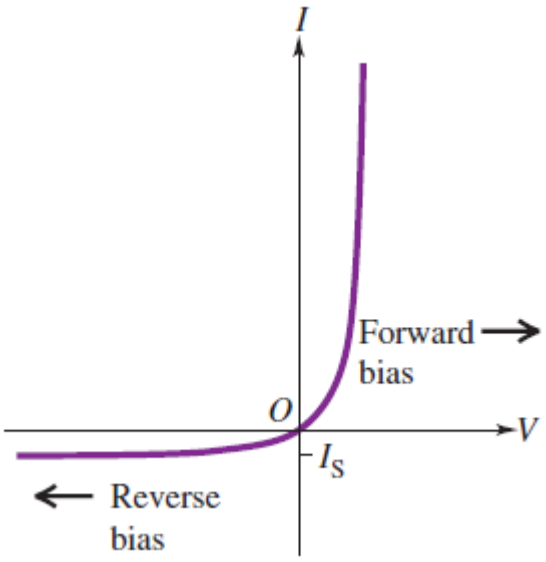


Figure 1

i. Use the Figure to explain what happens to a p-n semiconductor when it is

I. Forward biased (3 marks)

II. Reverse biased (3 marks)

ii. Why does this graph go below the horizontal axis to the left of the origin? (2 marks)

iii. Would it do this if the diode were replaced by an ordinary resistor? Explain (2 marks)

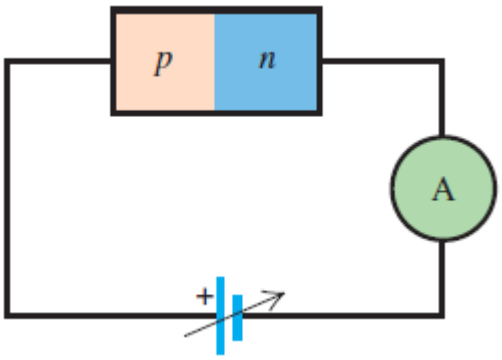
(b) The gap between valence and conduction bands in diamond is 5.47 eV.

(i) What is the maximum wavelength of a photon that can excite an electron from the top of the valence band into the conduction band? (3 marks)

(ii) In what region of the electromagnetic spectrum does this photon lie? (1 mark)

(c) A variable dc power supply having reversible polarity is connected to a diode having a *p*–*n* junction as shown in Figure 2.

Figure 2.



Starting with the power supply's polarity as shown in the figure, its potential is gradually decreased to zero and then gradually increased in the reverse direction.

i. Sketch a graph of the reading in the ammeter as a function of the potential difference *V* across the power supply. Make sign differences clear. (1 mark)

ii. Suppose now that the terminals of the diode are reversed and the same procedure is followed. Sketch a graph of the reading in the ammeter as a function of the potential difference *V* across the power supply. Make sign differences clear. (1 mark)

iii. Suppose now that the diode is replaced by an ordinary resistor and the same procedure is followed. Sketch a graph of the reading in the ammeter as a function of the potential difference *V* across the power supply. Make sign differences clear. (1 mark)

iv. Explain the reasons for the differences between the graphs in (c) parts (i) and (ii), (c) parts (i) and (iii). (2 marks)

QUESTION FIVE (20 marks)

(a) What is doping? (1 mark)

(b) What is the difference between

i. Intrinsic semiconductors and extrinsic semiconductors (2 marks)

ii. P type and n type semiconductors (2 marks)

iii. Donor impurity and acceptor impurity (2 marks)

iv. A hole and an electron (2 marks)

v. Majority charge carriers and minority charge carriers (2 marks)

vi. Insulators and semiconductors (2 marks)

(c) Describe the operation of Light-emitting diode and list any **three** areas of its application (4 marks)

(d) Explain the meaning of photovoltaic effect and its applications. (3 marks)