EMBU UNIVERSITY COLLEGE

(A Constituent College of the University of Nairobi)

2015/2016 ACADEMIC YEAR

SECOND SEMESTER EXAMINATION

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 303: SOLID STATE PHYSICS I

DATE: APRIL 11, 2016 **TIME: 02:00-04:00**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions

QUESTION ONE

a) Define the following terms.
   i) Ohmic conductors
   ii) Doping
   iii) P-type semiconductor (3 Marks)

b) Giving an example, explain key characteristic of covalent crystals. (3 Marks)

c) With aid of diagrams highlight three different possible arrangement of atoms in solids. (6 Marks)

d) i) Giving examples differentiate between ionic and covalent bonds. (4 Marks)
   ii) Other than ionic and covalent bonds, describe two other bonds. (4 Marks)

e) Find the electric potential energy of a Na^+ ion and a Cl^- ion separated by 0.24nm. Consider the ions as point charges., (4 Marks)

f) Calculate the barrier potential at room temperature for P-N junction in silicon which is doped to a carrier density of $10^{21}m^{-3}$ on the P-side and $10^{22}m^{-3}$ on the N-side. (4 Marks)

g) Name two main types of defects in crystals (2 Marks)

QUESTION TWO

a) With aid of a diagram explain Bragg's law (6 Marks)

b) For a semiconductor with two bands; the lower band is described by E(k), the upper band by E_0-E(k). The two bands are separated by an energy gap of 2Δ.

i) Calculate the chemical potential as a function of the temperature. (6 Marks)

ii) Show that the system can be treated using classical statistics at low temperatures. (8 Marks)

QUESTION THREE

a) With aid of three dimensional sketches show the seven crystal lattice structures showing the distances and the angles (14 Marks)

b) Show Bravais lattice structures for cubic crystal structures
State materials with cubic crystal structures in (i) above (6 Marks)

QUESTION FOUR

a) With an aid of energy band diagrams explain difference between insulators, semiconductors and conductors. (6 Marks)

b) A silicon diode in an adapter rectifying circuit has a carrier density of 10^{-21}in p material and $10^{22}m^{-3}$ in n material, the temperature of the charger changes from 24°C to 42°C, find the change in barrier potential of the diode. (6 Marks)

c) A conduction wire has a resistivity of $1.54 \times 10^{-8}\Omega m$ at room temperature. There are 5.8×10^{28} conduction electrons per m^3. Calculate the mobility and relaxation time of electronics. (8 Marks)

QUESTION FIVE

a) Consider a line of 2N ions of alternating charge ± q with a repulsive potential energy A/R^n between the nearest neighbours, show that at equilibrium separation

1. $U(R_0) = -\frac{2Nq^2 \ln 2}{R_0}\left(1-\frac{1}{n}\right)$ (10 Marks)

b) If the crystals be compressed so that $R_0 \rightarrow R_0(1-\delta)$. Show that the work done in compressing a unit length of the crystal has the leading term ½Cδ^2,

Where $$C = \frac{(n-1)q^2 \ln 2}{R_0}$$ (10 Marks)

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