# KIBABII UNIVERSITY

## UNIVERSITY EXAMINATIONS
## 2016/2017 ACADEMIC YEAR

### THIRD YEAR SECOND SEMESTER
### SUPPLEMENTARY/SPECIAL EXAMINATIONS

**FOR THE DEGREE OF B.ED (SCIENCE) AND BSC (PHYSICS)**

**COURSE CODE:** SPH 311

**COURSE TITLE:** SOLID STATE PHYSICS I

**DURATION:** 2 HOURS

**DATE:** 15TH SEPTEMBER 2017 **TIME:** 2:30 PM – 5:30 PM

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**INSTRUCTIONS TO CANDIDATES**

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **3** printed pages. Please Turn Over

## QUESTION ONE (30 MARKS)

a) i) Distinguish between Bravais and non–Bravaislattice. (2mks)

ii) Define the following terms as used in the study of crystals

-crystal

-Primitive unit cell. (2 mks)

iii) Show the plane represented by the following miller indices [0 1 0] , [2 1 0]and [0 0 2] (3mks)

iv) Determine the Miller indices for a plane when the intercepts along the axes are $2a$, $3b$ and $2c$. (3mks)

v) Name three types of cubic Unit cell. (3mks)

vi) The unit cell of metallic gold is face-centred cubic.

($a$) How many atoms occupy the gold unit cell ?

($b$) What is the mass of a gold unit cell?(3,2 mks)

vii) By X-ray diffraction it is found that nickel crystals are face-centred cubic. The edge of the unit cell is 3.52 Å. The atomic mass of nickel is 58.7 and its density is 8.94 $gcm^{-3}$.Calculate Avogadro's number from the data. (3 mks)

viii) Find the interplanar distance in a crystal in which a series of planes produce a first order reflection from a copper X-ray tube ($\lambda$ = 1.539 Å) at an angle of 22.5°C. (3 mks)

ix) In the case of sodium chloride the *first order* reflections from (100), (110) and (111) faces using$K$ line from palladium anti-cathode are 5.9°, 8.4° and 5.2° respectively. Calculatethe ratio of the spacing parallel to the three principal planes and then classify the crystal structure.(4 mks)

x) Work out the Packing efficiency of body centered cubic structure (3mks)

## QUESTION TWO (20 MARKS)

a) Diffraction angle $2\theta$ equal to $16.8^0$ for a crystal having inter planar distance in the crystal is $0.40nm$ when second order diffraction was observed. Calculate the wavelength of X-rays used ( 6 mks)

b) The density of fcc gold is 19300 $kgm^{-3}$and its atomic weight is 197. Calculate the separation between the close packed planes.(6mks)

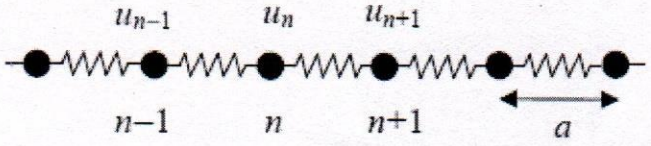
c) In an electric field $E$and magnetic field $B$ the force on an electron of charge $-e$ Is ;$F = -e[E + (V \times B)]$. Using Newton's law of motion derive the drift velocity when;

(i) $B = 0$ and ii) $B > 0$ (8mks)

## QUESTION THREE (20 MARKS)

a) When the lattice is at equilibrium each atom is positioned exactly at its lattice site. Now suppose that an atom displaced from its equilibrium site by a small amount. Due to force acting on this atom, it will

tend to return to its equilibrium position. This results in lattice Vibration. Due to interaction between the atoms, Various atoms move simultaneously, so we have to consider the motion of the whole lattice.




For simplicity consider a one dimensional crystal lattice (above) and assume that the force between atoms in this lattice are proportional to relative displacement from the equilibrium position. Hence find the dispersion relation for the frequency as

$$\omega = \sqrt{\frac{4C}{M}}\left|\sin\frac{qa}{2}\right|.$$

( 10 mks)

b) (i)Using a typical curve for the potential energy (binding energy) representing the interaction between two atoms describe cohesive force on a crystal.

(ii)Briefly discuss the principal types of crystal bonding giving at least one example in each case. ( 10 mks)

## QUESTION FOUR (20 MARKS)

a) In 1913 Bragg found that most methods for determining the atomic structure of crystal are based on the idea of scattering of radiation, X-ray being one of them. Name and describe at least three types of incident beams that may be used and the condition for their choice

[10 mks]

b) Show that the packing fraction for the fcc close-packed lattice is equal to 0.74. [10 mks]

## QUESTION FIVE (20 MARKS)

a) Show that the packing efficiency of a simple cubic structure is 52.4% ( 10 mks)

b) The orientation of a crystal plane in a lattice is specified by miller indices . Give a brief definition of the miller indices and sketch the planes defined by [1 0 0], [1 1 0] and [1 1 1] (10 mks)