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**NATIONAL OPEN UNIVERSITY OF NIGERIA**

**PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA**

**FACULTY OF SCIENCES**

**DEPARTMENT OF PURE AND APPLIED SCIENCE**

 **JULY 2018 EXAMINATIONS**

**COURSE CODE: PHY 307**

**COURSE TITLE: SOLID STATE PHYSICS I**

**CREDIT UNIT 2**

**TIME ALLOWED (2 HRS)**

**INSTRUCTION: *Answer question one (1) and any other three (3) questions***

**QUESTION 1**

Q1. a) Define the following:

 ( i) crystalline solid **2 ½ marks** (ii) lattice **2 ½ marks**

 (iii) crystal structure **2 ½ marks** (iv) Bravais and non-Bravais lattice.

 **2 ½ marks**

b) Prove that the only allowed rotation axis in a two dimensional Bravais lattice are two-, three-, four- and six-folds. **5 marks**

 c) What are rules for Miller indices? **4 marks**

 d) Sketches the following planes (100), , (200), (1 1 0), (111), (222) **6 marks**

**QUESTION 2**

Q2. (a) State Bragg’s law of diffraction and give two geometrical facts that are necessary for

 the derivation of the law. **4 marks**

 (b) An x-ray diffractometer recorder’s chat for an element, which has a cubic crystal

 structure, shows diffraction peaks at the following 40, 58, 73, 86.8, 100.4 and

 114.7. The wavelength of the incoming x-rays used was 1.540Ao.

 determine:(i) the type of the cubic structure possessed by the element.

 (ii) the lattice constant of the element. **6 marks**

(c) Prove that the reciprocal lattice vectors is given as **5 marks**

**QUESTION 3**

Q3. (a) Explain the following: (i) Inter atomic forces (ii) Vander Waals (Inter atomic) bonding

 (iii) Ionic bonding (iv) Covalent bonding (**2 marks each x 4 = 8marks)**

 (b) Solid Ar has an Fcc structure with cubic lattice constant $α= $5.26Ao atomic mass M*AR*

 = 6.67×10-26kg and a Debye temperature $θ=92k.$

 (i) Estimate the phonon velocity using the Young modulus of Ar*,* C11 = 1.6×109N/m2

 **3 marks**

 (ii) Using the expression K =1/3 Cvl in which C is the phonon heat capacity per unit

 volume. Find the thermal conductivity, K (in unit of Jm-1 K-1) a 1mm3 crystal of *Ar* at

 10K, assuming that phonon scattering occurs only at the boundaries of the sample.

 **4 marks**

**QUESTION 4**

Q4. (a) Define crystal binding **2 marks**

(b) Consider two-dimensional electrons subjected to a weak periodic potential coming from

 a square lattice of spacing. For a **K** vectors far away from the Brillouin zone boundary,

 the wave function can be well described by planes waves. Assume we want to write the

 wave function in the Bloch form and considering a state of energy E and wave vector.

(i)What will the three lowest energies be at this wave number? **4 marks**

(ii)What are the corresponding u(**r**) functions **4 marks**

 Note that h2/2m = 3.806 eVAo

 (c) At room temperature, KBT/e = 26mV. A sample of cadmium sulphide displays a mobile

 carrier density of 1016 cm-3 and a mobility coefficient $µ$ = 102 cm/volt sec. Calculate the

 electrical conductivity of this sample. **5 marks**

**QUESTION 5**

Q5. (a) Define the following (i) Simple lattices (ii) Body centered cubic lattice

 (iii) Face centered cubic lattice (iv) States the elementary properties of simple lattices

 (**2 marks each x 4 = 8marks)**

(b) If the charge carriers have an effective mass equal to 0.1 times the mass of a free

 electron, what is the average time between successive scatterings. **3 marks**

 (c) The London equation for simple superconductor is a phenomenological equation relating

 the supercurrent ***j***s to the magnetic vector potential A.

 ***j***s = $\frac{-ne^{2}}{mc}A$

 Where m is the electron mass. Using the appropriate Maxwell equation, show how the

 above equation leads to Meissner effect. **4 marks**