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PHE-13

BACHELOR OF SCIENCE (B. Sc.)
Term-End Examination
June, 2019
PHE-13 : PHYSICS OF SOLIDS

Time : 2 Hours *Maximum Marks : 50*

Note : *All questions are* ***compulsory;*** *however internal choices are given. You may use a calculator. Symbols have their usual meanings. The values of physical constants are given at the end.*

1. Attempt any *five* parts : 5×3=15

   (a) Boron hydride (BH_3) forms a planar trigonal molecule. Write down its symmetry elements.

   (b) Draw the first Brillouin zone for a 2-D oblique reciprocal lattice.

   (c) Explain, with the help of diagrams, the different types of interactions giving rise to van der Waals bonding.

   (d) The Debye temperature for chromium is 630 K. Calculate the frequency of highest possible lattice vibration in chromium.

   (e) The experimentally observed value of room temperature electrical conductivity for

aluminium is $3.8 \times 10^7 \Omega^{-1}\,m^{-1}$. Calculate the relaxation time for electron-ion collision. Given that the free electron concentration is $1.98 \times 10^{29}\,m^{-3}$.

(f) What do you understand by the critical magnetic field and critical current density of a superconductor ?

(g) Describe the different classes of polymers based on their structure.

(h) Distinguish between substitutional, interstitial and self-interstitial defects in a crystal with the help of labelled diagrams.

2. Answer any *two* parts : 2×5=10

(a) Define the atomic packing fraction for a crystal structure. Calculate the atomic packing fraction for a bcc structure. 1+4

(b) The primitive translation vectors of a crystal lattice are given by : 2+3

$$\vec{a}_1 = \frac{\sqrt{3}\,a}{2}\hat{i} + \frac{a}{2}\hat{j}$$

$$\vec{a}_2 = -\frac{\sqrt{3}\,a}{2}\hat{i} + \frac{a}{2}\hat{j}$$

$$\vec{a}_3 = c\,\hat{k}.$$

Calculate the volume of the primitive cell and obtain the primitive translation vectors of the reciprocal lattice.

(c) Explain the Laue method of X-ray diffraction. What are the limitations of this method ? 4+1

3. Answer any ***one*** part : 1×5=5

(a) Consider a chain of identical atoms of mass m, held together by elastic springs, each of force constant K. Write the equation of motion for the nth atom displaced from its equilibrium position. Using a solution in the form of a progressive wave, derive the expression relating the angular frequency and wave number of the longitudinal wave. 1+4

(b) Discuss the classical theory of heat capacity and derive the expression for the molar heat capacity. 2+3

4. Answer any ***two*** questions : 2×5=10

(a) Describe Hall effect and derive the expression for the Hall coefficient. How does band theory explain the positive Hall coefficient in metals ? 4+1

(b) Explain the formation of the depletion region in a *p-n* junction. What is the built-in potential ? What are the factors on which it depends ? 2+1+2

(c) A monovalent bcc solid has a lattice constant 5.0Å. Calculate its Fermi energy.

5. Answer any ***two*** parts : 2×5=10

(a) Write down the characteristics of a ferrite in an inverse spinal structure. Hence calculate the magnetic moment of magnetite in unit of Bohr magneton. 2+3

(b) With the help of a diagram explain the float zone technique of crystal growth. 5

(c) What are liquid crystals ? Explain the structure and working of a liquid crystal display. 1+4

Physical constants :

$h = 6.62 \times 10^{-34}$ Js; $N_A = 6.02 \times 10^{23}$ mol^{-1}

$e = 1.6 \times 10^{-19}$ C; $k_B = 1.38 \times 10^{-23}$ JK^{-1}

$m_e = 9.1 \times 10^{-31}$ kg