[1118]

SEAT No._____ [No. of Printed pages : 02]

SARDAR PATEL UNIVERSITY

M.Sc. Physics I[st] Semester Examination

Day: Monday Date: 29/10/2018, Time: 10:00 A.M. to 01:00 P.M.

Subject: PHYSICS, Subject Code : PS01EPHY21

Title: Elements of Solid State Physics and error analysis

Instruction:
Figure to the right indicates marks. **Total Marks: 70**

Q.1 **Write answer of all questions by showing your choice against the question number.** **[8]**

(i) Which of the following rotational symmetry is forbidden in crystals?
(a) 4-fold (b) 3-fold (c) 6-fold (d) 5-fold

(ii) In a cubic crystal with the lattice parameter 3.6 Å, the interplanar spacing for (122) planes will be
(a) 3.6 Å (b) 1.2 Å (c) 10.8 Å (d) 1.8 Å

(iii) According to Pauling's rules, the strength of the electrostatic bond between Mg and O in $Mg^{+2}O_6$ will be
(a) 1/2 (b) 1/6 (c) 1/3 (d) 1/4

(iv) For the elastic waves propagating in a crystal with monatomic basis, the group velocity will be zero when the propagation vector k is equal to
(a) $\frac{\pi}{a}$ (b) $\frac{2\pi}{a}$ (c) zero (d) $\frac{\pi}{2a}$

(v) The elastic energy density is calculated by:
(a) u = (stress x strain)/2 (b) u = stress x strain
(c) u = 2 stress x strain (d) u=stress/strain

(vi) In an intrinsic semiconductor, the Fermi level (E_F) lies almost _____ .
(a) at middle of valence band and conduction band
(b) above the valence band (c) below the conduction band
(d) in the conduction band

(vii) A _____ lies half way between upper and lower class boundaries.
(a) class mark (b) class boundary (c) class interval (d) ogive

(viii) For an exponential type curve, $y= ae^{bx}$, if we plot log(y) as ordinate and log(x) as abscissa, then its slope will be _____ .
(a) log(a) (b) log(b) (c) alog(b) (d) blog(a)

Q.2 **Attempt any Seven of the following:** **[14]**

(i) Write the crystal systems along with the relationships among its lattice parameters.

(ii) Explain Miller-Bravais indices. How is it different from Miller indices? Explain with the help of appropriate examples.

(iii) Describe the continuum (long-wavelength) limit of the dispersion of elastic waves in a crystal with monatomic basis.

(iv) Define the phase velocity (v_p) and group velocity (v_g)of waves. Consider the dispersion relation $\omega^2 = \omega_0^2 + c^2k^2$, where ω is the angular frequency, c is the speed of light and k is the propagation vector. Obtain v_p and v_g.

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(v) Explain elastic compliance and stiffness constants.
(vi) What is Hall effect? Describe applications of Hall effect?
(vii) Distinguish between intrinsic semiconductor and extrinsic semiconductor with suitable examples.
(viii) What is histogram? Mention requirements of histogram.
(ix) For power law type curve and hyperbolic type curve, write its governing equation, ordinate, abscissa, recommended graph paper and graphical representation showing slope and intercepts.

Q.3(a) Describe the rotation, roto-reflection and roto-inversion symmetry operations using associated matrices and appropriate illustrations. [6]

Q.3(b) Obtain the packing efficiency of hexagonal closed-packed(HCP) structure of equal hard spheres. Draw appropriate diagrams. [6]

OR

Q.3(b) Describe voids in close-packed structure of hard spheres. If the radius of all the hard spheres is R, calculate the size of the tetrahedral void in terms of R. Draw appropriate diagrams. [6]

Q.4(a) Describe the longitudinal lattice vibrations in a crystal with monatomic basis. Derive the expression for the dispersion relation. Draw a schematic sketch illustrating the dispersion relation in the first Brillouin zone. [6]

Q.4(b) Write short notes on: (i) quantization of elastic waves, (ii) phonon momentum. [6]

OR

Q.4(b) Describe the lattice vibrations in a crystal with diatomic basis. Derive the dispersion relations for the optical and acoustical branch of lattice vibrations. [6]

Q.5(a) For elastic constants, prove that $C_{11}+2C_{12}=\frac{1}{S_{11}+2S_{12}}$ and $C_{44}=\frac{1}{S_{44}}$ [6]

Q.5(b) Derive the wave equation for elastic waves in a cubic crystal in three directions. [6]

OR

Q.5(b) Give detail description of the experimental set up to determine elastic constants taking example of cubic crystal. [6]

Q.6(a) A company manufactured steel wires. To measure the breaking strength (in tones) of ten selected steel wires in a testing machine is observed as given below: [6]

4.5 4.6 4.9 4.2 4.5 4.6 4.4 4.5 4.7 4.3

Calculate: (i)The mean value of breaking strength, (ii) Mean deviation.
(iii) Standard deviation, (iv) Best estimate precision (v) Internal standard error or best estimated uncertainty and (vi) The breaking strength of wire.

Q.6(b) (i) Obtain the expression for the best estimate of uncertainty and show that [3]

$X=\bar{X}_n+U_n$.

(ii) Prove that arithmetic mean is the best estimated true value of the data. [3]

OR

Q.6(b) Explain linear least square curve fitting using necessary diagram in detail. [6]

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