Question Bank of Physics

PHY-609: Physics of Materials (Honours)

Ninth Paper- PHY: SE H-609

Q1. Unit I : Crystal structure :20 marks

(a) Derive Bragg's law for X-ray diffraction in crystals. Explain the working of X-ray spectrometer. How is it used to determine the wavelength of X-rays. 3+3+4=10 (2017)
Or Define crystal lattice basis and crystal structure. Describe the seven systems of crystals with suitable diagrams. 3+7=10

(b) Show that for a simple cubic lattice d_{100}: d_{110}: d_{111}= √6: √3: √2, where d is the spacing between consecutive parallel planes. 5 (2017)
What is reciprocal lattice? Show that b.c.c lattice is the reciprocal lattice of f.c.c. lattice. 1+4=5 (2017)

(c) Draw the planes (001), (110), (200), and (020) in a simple cubic cell. 5 (2017)

(d) What is atomic scattering factor? Derive the general expression for the atomic scattering factor using spherical polar coordinates. 3+7=10
Or Describe geometrical structure factor. How is it related to the atomic scattering factor? Calculate the structure factors of b.c.c and f.c.c lattices. 1+1+4+4=10 (2018)

(e) In a cubic unit cell, find the angle between normal to the planes (111) and (121). 5 (2018)

(f) Determine the interplanar spacing between two parallel planes with Miller indices (h,k,l) in a cubic crystal of side a. 5 (2018)

(g) Show that a simple cubic lattice is self-reciprocal but with different cell dimensions. 5 (2018)

(h) Derive Laue's equations of diffraction of x-rays. Obtain Bragg's diffraction condition from them. 7+3=10 (2020)
Or
What is atomic scattering factor? Derive an expressionfor it. Explain its significance. 2+7+1=10 (2020)

(i) What is reciprocal lattic? Derive expressions for the primitive translation vectors of the reciprocal lattice. 2+3=5 (2020)

(j) Prove that for a simple cubic lattice d_{100}: d_{110}: d_{111}= √6: √3: √2, where d is the spacing between consecutive parallel planes. 5 (2020)

(k) Prove that fivefold axis of rotationis not compatible withlattice. 5 (2020)

(l) Show that the Bragg's condition in the reciprocal lattice is $2K.G+ G^2 = 0$. 5 (2021)

(m) The lattice constant of a cubic lattice is a. Calculate the spacing between (011), (101), and (112) planes. 3 (2021)

(n) If the plane intercepts of a crystal are 3a,2b, 2c. Whatwill be the indices? 5 (2021)

Q2. Unit II- Electrical properties of Materials : 20 marks

(a) State any two limitations of classical free electron theory of metals. Derive an expression for the energy spectrum of electrons in metals on the basis of Sommerfeld's model. 3+7=10

Or(2017)Derive an expression for Fermi energy in an intrinsic semiconductor. Justify that the Fermi level of an intrinsic semiconductor lies very close to the middle of the band gap. 9+1=10

(b) Derive an expression for the effective mass of electron in a one-dimensional crystal. Explain briefly the distinction among metals, insulators and semiconductor on the basis of band theory of solids. 5+5=10 (2017)

(c) State Bloch theorem and show how Kronig-Penney model leads to the formation of energy bands for an electron in a periodic crystal potential. 2+8=10 (2018)

(d) Show that the concentration of electrons in the conduction band of an n-type semiconductor is proportional to the square root of donor concentration. 10

Or (2018)

What are intrinsic and extrinsic semiconductors produced? Indicate donor and acceptor states on an energy level diagram of conduction and valence bands. What are the positions of Fermi levels for-(i) an intrinsic semiconductor, (ii) an n-type semiconductor, (iii) a p-type semiconductor?
2+2+3+3=10

(e) Derive expression for density of free electrons and holes in an intrinsic semiconductor.Show that the Fermi level lies halfway between the valence band and conduction band. 4+4+2=10 (2020)

(f) Show and prove Bloch theorem. 10 (2020)

Or

Discuss the formation of allowed and forbidden energy bands on the basis of Kronig-Penny model.
Derive an expression for the effective mass of an electron in one dimensional crystal. 5(2021)

(g) Write down the electrical conductivity of an intrinsic semiconductor. How does it vary with temperature? 1+2=3 (2021)

(h) Describe the Kronig-Penny model of an electronmoving in a periodic potential. 7 (2021)

(i) Calculate the value of Fermi energy for Mg(S). The density of Mg is 1.74 gm cm^{-1}. 3 (2021)

Q3. Unit-III 20 marks

(a) Describe Weiss molecular field theory of ferromagnetism and hence derive the Curie-Weiss law. 10 (2017)

(b) Define the following terms: 1×5=5
   (i) Magnetic lines of force
   (ii) Lines of magnetization
   (iii) Intensity of magnetization
   (iv) Magnetic permeability
   (v) Magnetic susceptibility

(c) What are soft and hard magnetic materials? Mention their uses. 2+3=5 (2017)

(d) Explain the origin of diamagnetism in a free atom. 5 (2017)

(e) Obtain an expression for magnetic susceptibility of a diamagnetic substance using Langevin's theory. 10 (2018)

(f) Give an account of the quantum theory of paramagnetism. 10 (2018)

(g) Distinguish among the characteristics of diamagnetism, Paramagnetism and ferromagnetism. 6 (2020)

(h) Explain how and why are the ferromagnetic domains formed. 4 (2020)

(i) Derive an expression for diamagnetic susceptibility using Lengevin's theory. What is the significanceof negative susceptibility?

   Or Give an account of the quantum theory of paramagnetism. What do you understand by quenching of angular momentum?8+2=10 (2020)

(j) How is a Weigner-Seitz cell constructed? 3 (2021)

(k) Explain the origin of diamagnetism in a free atom. 3 (2021)

(l) Explain the existence of ferromagnetic domain. 5 (2021)

Q4. Unit- IV 15 Marks

(a) Work out an expression for the specific heat of solids following Einstein's model. How does specific heat depend on temperature and to what extent does this model agree with the experimental results? 8+2=10 (2017)

(b) In aluminium, $v_{l=6.23\times10}{}^{3}$ m/s and $v_t=3.1\times10^3$m/s. The density of aluminium is 2.7×10^3kg/m^3 and its atomic weight is 26.97. 3+2=5 (2017)
   (i) Calculate the Debye cutoff frequency (v_D) for aluminium from these data.
   (ii) The Debye temperature (Θ_D) for aluminium, as obtained from specific heat measurements, is 375 K. Find (v_D) from this data and compare it with the results obtained in (a). [Boltzman constant k= 1.38×10^{-23}joule/Kelvin and Plank's constant h=6.62×10^{-34} joule-second]

(c) Derive the dispersion relation for the vibrations of one-dimensional diatomic lattice taking separation between the nearest neighbours as a. Identify the acoustic and optic modes.

Or

Write down the assumptions on which the Debye's theory of specific heat of solids is based. Obtain the expression for C_v according to this theory at very low temperatures.

8+2=10 (2018)

(d) The Debye temperature of carbon (diamond structure) is 1850 K. Calculate the specific heat per Kmol for diamond at 20 K. Also, compute the highest lattice frequency involved in the Debye theory. [Take $k=1.38\times10^{-23}$ joule/kelvin]
3+2=5 (2018)

(e) Derive the dispersion relation for the vibrations of one-dimensional diatomic lattice taking separation between the nearest neighbours as a. Identify and discuss the acoustic and optic. 8+2=10 (2020)

Or

Deduce an expression for the specific heat of a solid according to Debye's theory. 10 (2020)

(f) How does Debye's model differ from Einstein's model of lattice heat capacity?

5 (2020)

(g) Differentiate between optical and acoustical branch of diatomic linear lattice. Why are these branches named so? 5 (2021)

Q5. Unit-V 15 Marks

(a) The London penetration depth for Pb at 3K and 7.1 K are respectively 39.6 nm and 173 nm. Calculate its transition temperature as well as depth at 0 K. 3+2=5 (2017)

(b) What are superconductors? Mention four important property changes that occur in materials when they change from normal to superconducting state.
1+4=5 (2017)

(c) Explain Meissner effect in superconductors. 5 (2017)

(d) Explain the term 'critical magnetic field' in a superconductor. What are type I and type II superconductors? How does the critical magnetic field vary with temperature in type II superconductors? 1+2+2=5 (2017)

(e) Derive the London equations in superconductivity. Define penetration depth and express the above equations in terms of it. 6+2+2=10 (2018)

(f) Give an elementary idea of high T_C superconductivity. 5 (2018)

(g) Derive the London equations in superconductivity. Explain London penetration depth. 8+2=10 (2020)

(h) Give an elementary idea of high T_C superconductivity. 5 (2020)

(i) Lead in superconducting state has critical temperature of 6.2 K at zero magnetic field and a critical field of 0.064 Mam^{-1} at 0 K. Determine the critical field at 4K.
3 (2021)

(j) Write a short note on high temperature superconductors with reference to 1-2-3 superconductors. 3 (2021)

(k) Derive the London equations in superconductivity. Define penetration depth in terms of it. 6+1=7 (2021)

Q6. Unit-VI 10 Marks

(a) What are nanomaterials? State three main applications of nanomaterials. 1+4=5 (2017)

(b) What do you mean by shifting? How does blue shifting exhibit in nanomaterials? 2+3=5 (2017)

(c) Explain the uses of quantum wells in the operation of infrared detectors. 5 (2017)

(d) How does the density of states in nanostructures behave as a function of energy for delocalized conduction electrons in one,two, and three dimensions? Derive the relations in brief and plot. 4+4+2=10 (2018)

(e) Explain the conductivity properties of nanowires. Describe the use of nanowires. 5(2018)

(f) Explain the use of quantum wells in the operation of infrared detectors. 5 (2018)

(g) Describe a quantum dot laser diode grown on an n-doped GaAs substrate with an illustration. 5 (2020)

(h) Explain the conductivity properties of nanowires. Describe the use of nanowires. 3+2=5 (2020)

(i) How does the density of states in nanostructures behave as a function of energy for delocalized conduction electrons in one,two, and three dimensions? Derive the relations. 4+6=10 (2020)

(j) What are nanomaterials ? Explain the tpo-down method of penetration of quantum nanostructures. 2+5=7 (2021)

(k) Explain the use of quantum wells in the operation of infrared detectors. 3 (2021)

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