

I B.Tech Supplementary Examinations, Aug/Sep 2008**SOLID STATE PHYSICS**

(Common to Electrical & Electronic Engineering, Electronics & Communication Engineering, Computer Science & Engineering, Electronics & Instrumentation Engineering, Bio-Medical Engineering, Information Technology, Electronics & Control Engineering, Computer Science & Systems Engineering, Electronics & Telematics, Electronics & Computer Engineering and Instrumentation & Control Engineering)

Time: 3 hours**Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

1. (a) Explain the terms
 - i. basis
 - ii. space lattice and
 - iii. unit cell.(b) Describe the seven crystal systems with diagrams. [6+10]
2. (a) Deduce the expression for the inter-planar distance in terms of Miller indices for a cubic structure.
(b) Sketch the following planes of a cubic unit cell: $(0\ 0\ 1)$, $(1\ 2\ 0)$ and $(\bar{2}\ 1\ 1)$.
(c) Calculate the ration $d_{100} : d_{110} : d_{111}$ for a simple cubic structure. [8+4+4]
3. (a) Derive time independent Schrodinger's wave equation for a free particle.
(b) Explain the physical significance of wave function.
(c) An electron is bound in a one-dimensional infinite well of width $1 \times 10^{-10}\text{m}$. Find the energy values in the ground state and first two excited states. [8+4+4]
4. (a) Explain the salient features of quantum free electron theory.
(b) Discuss the Kronig-Penny model for the motion of an electron in a periodic potential.
(c) Fermi energy of copper is 7 eV at room temperature. What is the total number of electrons per unit volume with the energy greater than 8 eV? [4+8+4]
5. (a) What is local field? Explain. Show that the local electrical field E_{loc} is given by $E_{loc} = E \left(\frac{\epsilon_r + 2}{3} \right)$ where E is the applied electric field.
(b) An air-filled capacitor has a capacitance of 1.3 pf. The separation of the plates is halved and a dielectric is inserted between them. The new capacitance is 3.9 pf. Find the dielectric constant of the dielectric. [10+6]
6. (a) Draw the B-H curve for a ferro-magnetic material and identify the retentivity and the coersive field on the curve.

- (b) What are paramagnetic and diamagnetic materials.
 - (c) An atom contains 10 electrons revolving in a circular path of radius 10^{-11} m. Assuming homogeneous charge distribution, calculate the orbital dipole moment of the molecule in Bohr magneton. [6+6+4]
7. (a) Explain n-type and p-type semiconductors. Indicate on an energy level diagram the conduction and valence bands, donor and acceptor levels for an intrinsic and extrinsic semiconductors.
- (b) Explain the detailed mechanism of current conduction in n and p type semiconductors. [10+6]
8. (a) Derive expressions for the numerical aperture and the fractional index change of an optical fiber.
- (b) Write a note on the applications of optical fibers.
- (c) Calculate the fractional index change for a given optical fiber if the refractive indices of the core and the cladding are 1.563 and 1.498 respectively. [8+4+4]

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1. (a) Explain the bonding in NaCl.
(b) Calculate the bond energy for NaCl molecule.
(c) Calculate the potential energy of the system of Na^+ and Cl^- ions when they are 0.25 nm apart. [6+6+4]
2. (a) What are Miller indices? How are they obtained?
(b) Explain Schottky and Frankel defects with the help of suitable figures. [6+10]
3. (a) Explain the physical significance of wave function.
(b) Assuming the time independent Schrodinger's wave equation, discuss the solution for a particle in a one-dimensional potential well of infinite height.
(c) A quantum particle confined to one-dimensional box of width 'a' is known to be in its first excited state. Determine the probability of the particle in the central half. [4+6+6]
4. (a) Explain the origin of energy bands in solids.
(b) Assuming the electron - lattice interaction to be responsible for scattering of conduction electrons in a metal, obtain an expression for conductivity in terms of relaxation time and explain any three draw backs of classical theory of free electrons.
(c) Find the temperature at which there is 1% probability of a state with an energy 0.5 eV above Fermi energy. [6+6+4]
5. (a) What are the important characteristics of ferro-electric materials?
(b) Describe the possible mechanism of polarization in a dielectric material.
(c) The dielectric constant of Helium gas at NTP is 1.0000684. Calculate the electronic polarisability of He atoms if the gas contains 2.7×10^{25} atoms / m^3 . [6+6+4]
6. (a) Define the terms magnetic susceptibility, magnetic induction and permeability. How is magnetic susceptibility of a material measured?

- (b) Explain the salient features of anti-ferromagnetic materials. [10+6]
7. (a) Explain the difference between metals and semiconductors from the consideration of temperature coefficient of resistivity.
- (b) The electron and hole mobilities in a Si sample are 0.135 and $0.048 \text{ m}^2/\text{V-S}$ respectively. Determine the conductivity of intrinsic Si at 300 K if the intrinsic carrier concentration is $1.5 \times 10^{16} \text{ atoms/m}^3$. The sample is then doped with 10^{23} phosphorus atoms/ m^3 . Determine the equilibrium hole concentration, conductivity and position of the Fermi level relative to the intrinsic level. [10+6]
8. (a) Explain the characteristics of a laser beam.
- (b) Mention any two applications of laser, each in the field of scientific research, engineering and medicine.
- (c) Describe the construction and working of a Ruby laser. [6+4+6]

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1. (a) Explain the formation of an ionic crystal.
 (b) Derive an expression for the cohesive energy of an ionic crystal.
 (c) Calculate the cohesive energy of NaCl from the following data: [4+8+4]
 Equilibrium separation between the ion pair = 0.281 nm.
 Ionization energy of Na = 5.14 eV.
 Electron affinity of Cl = 3.61 eV.
 Born repulsive exponent = 9
 Madelung constant = 1.748.

2. (a) Explain Bragg's law of X-ray diffraction.
 (b) Describe Laue's method for determination of crystal structure.
 (c) A beam of X-rays is incident on a NaCl crystal with lattice spacing 0.282 nm. Calculate the wavelength of X-rays if the first order Bragg reflection takes place at a glancing angle of $8^\circ 35'$. Also calculate the maximum order of diffraction possible. [4+6+6]

3. (a) Derive time independent Schrodinger's wave equation for a free particle.
 (b) Explain the physical significance of wave function.
 (c) An electron is bound in a one-dimensional infinite well of width 1×10^{-10} m. Find the energy values in the ground state and first two excited states. [8+4+4]

4. (a) Explain the concept of "Effective Mass".
 (b) Discuss the motion of an electron in a periodic potential field and explain the formation of energy bands.
 (c) An electron is confined in a one-dimensional potential wall of width 3×10^{-10} m. Find the kinetic energy of electron when it is in the ground state. [4+8+4]

5. (a) With usual notation show that $P = \epsilon_o (\epsilon_r - 1)E$

- (b) What is dipolar relaxation? Discuss the frequency dependence of orientational polarization.
- (c) A solid elemental dielectric, with density 3×10^{28} atoms / m^3 shows an electronic polarisability of 10^{-40} farad- m^2 . Assuming the internal electric field to be a Lorentz field, calculate the dielectric constant of the material. [6+6+4]
6. (a) Explain the origin of diamagnetism. Obtain an expression for the diamagnetic susceptibility of a magnetic material.
- (b) An electron in a hydrogen atom circulates with a radius 0.052 nm. Calculate the change in its magnetic moment if a magnetic induction of 3 weber/ m^2 acts at right angles to the plane of orbit. [12+4]
7. (a) Describe the drift and diffusion currents in a semiconductor.
- (b) Derive their expressions.
- (c) Deduce Einstein relation. [6+6+4]
8. (a) State the differences between ordinary light and laser light.
- (b) Explain the characteristics of laser light.
- (c) Write about stimulated emission, spontaneous emission. [4+6+6]

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1. (a) Explain the forces between the two interacting atoms when they are brought nearer to form a molecule.
(b) Derive the expression for the equilibrium spacing of two atoms for which the potential energy is minimum and hence obtain the dissociation energy. [6+10]
2. (a) What are Miller indices? How are they obtained?
(b) Explain Schottky and Frankel defects with the help of suitable figures. [6+10]
3. (a) Derive time independent Schrodinger's wave equation for a free particle.
(b) Explain the physical significance of wave function.
(c) An electron is bound in a one-dimensional infinite well of width 1×10^{-10} m. Find the energy values in the ground state and first two excited states. [8+4+4]
4. (a) What is Fermi level?
(b) Explain Fermi-Dirac distribution for electrons in a metal. Discuss its variation with temperature.
(c) Calculate the free electron concentration, mobility and drift velocity of electrons in aluminum wire of length of 5 m and resistance 0.06Ω carrying a current of 15 A, assuming that each aluminum atom contributes 3 free electrons for conduction.
Given: Resistivity for aluminum = $2.7 \times 10^{-8} \Omega\text{-m}$.
Atomic weight = 26.98
Density = $2.7 \times 10^3 \text{ kg/m}^3$
Avagadro number = 6.025×10^{23} [2+8+6]
5. (a) What is intrinsic break down in dielectric materials?
(b) Explain electronic polarization in atoms and obtain an expression for electronic polarisability in terms of the radius of the atom.
(c) A parallel plate capacitor has an area of 100 cm^2 , with a separation of 1 cm and is charged to a potential of 100 V. Calculate the capacitance of the capacitor and the charge on the plates. [4+8+4]

6. (a) What is meant by hysteresis in magnetic materials?
(b) What are magnetic domains? Explain hysteresis basing on domain theory. [6+10]
7. (a) Obtain an equation for the conductivity of an intrinsic semiconductor in terms of carrier concentration and carrier mobilities. Suggest a method for evaluating the energy gap of a semiconductor. Explain the temperature dependence of intrinsic conductivity.
(b) The variation of the resistivity of intrinsic germanium with temperature is given in the following table: [10+6]

T(K)	385	455	556	714
ρ (Ohm-m)	0.028	0.0061	0.0013	0.000274

Determine the value of E_g .

8. (a) Explain the characteristics of a laser beam.
(b) Mention any two applications of laser, each in the field of scientific research, engineering and medicine.
(c) Describe the construction and working of a Ruby laser. [6+4+6]
