Code No: RR10201 **Set No. 1**

I B.Tech Supplementary Examinations, November/December 2005
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

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1. (a) Explain the terms [6]
   i. basis
   ii. space lattice and
   iii. unit cell.
   (b) Describe the seven crystal systems with diagrams. [10]
2. (a) What are Miller indices? How are they obtained? [6]
   (b) Explain Schottky and Frankel defects with the help of suitable figures. [10]
3. (a) Explain the concept of matter waves. [6]
   (b) Describe Davison and Germer's experiment and explain how it enabled the verification of wave nature of matter. [6]
   (c) Calculate the velocity and kinetic energy of an electron of wavelength 1.66×10^{-10}m. [4]
4. (a) How does the electrical resistance of a metal change with temperature? [4]
   (b) Discuss the motion of an electron in a periodic lattice. [8]
   (c) Find the relaxation time of conduction electrons in a metal having resistivity 1.54×10^{-8} Ω-m, if the metal has 5.8×10^{28} conduction electrons per cubic meter. [4]
5. (a) With usual notation show that $P = \in_o (\in_r -1)E$ [6]
   (b) What is dipolar relaxation? Discuss the frequency dependence of orientational polarization. [6]
   (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. [4]
6. (a) Explain the phenomenon of spontaneous magnetization in magnetic materials. [8]

(b) Discuss the characteristic features of ferromagnetic materials. [8]

7. (a) Describe the drift and diffusion currents in a semiconductor. [6]

(b) Derive their expressions. [6]

(c) Deduce Einstein relation. [4]

8. (a) Explain the principle behind the functioning of an optical fibre. [4]

(b) Derive an expression for acceptance angle for an optical fibre. How it is related to numerical aperture? [8]

(c) An optical fibre has a numerical aperture of 0.20 and a cladding refractive index of 1.59. Find the acceptance angle for the fibre in water which has a refractive index of 1.33. [4]

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the terms [6]
   i. basis
   ii. space lattice and
   iii. unit cell.
   (b) Describe the seven crystal systems with diagrams. [10]
2. (a) What are Miller indices? How are they obtained? [6]
   (b) Explain Schottky and Frankel defects with the help of suitable figures. [10]
3. (a) Derive time independent Schrodinger's wave equation for a free particle. [8]
   (b) Explain the physical significance of wave function. [4]
   (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. [4]
4. (a) What are the salient features of the "free electron gas" model? Obtain Ohm's law based on it. [10]
   (b) Explain the concept of "effective mass". [6]
5. (a) With usual notation show that $P = \in_o (\in_r -1)E$ [6]
   (b) What is dipolar relaxation? Discuss the frequency dependence of orientational polarization. [6]
   (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. [4]
6. (a) How magnetic materials are classified? Explain with suitable examples. [10]
   (b) Write notes on the following: [6]
   i. Curie temperature
   ii. Magnetic Susceptibility.

7. (a) Explain the difference between metals and semiconductors from the consideration of temperature coefficient of resistivity. [10]

   (b) The electron and hole mobilities in a Si sample are 0.135 and 0.048 m^2/V-S respectively. Determine the conductivity of intrinsic Si at 300 K if the intrinsic carrier concentration is 1.5×10^{16} 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. [6]

8. (a) Derive expressions for numerical aperture and acceptance angle of an optical fibre. [10]

   (b) What is the principle of optical fibre communication? [6]

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Code No: RR10201 **Set No. 3**

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the formation of an ionic crystal. [4]
   (b) Derive an expression for the cohesive energy of an ionic crystal. [8]
   (c) Calculate the cohesive energy of NaCl from the following data: [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 the various point defects in a crystal. [10]
   (b) Obtain the expression for the equilibrium concentration of vacancies in a solid at a given temperature. [6]

3. (a) Derive time independent Schrodinger's wave equation for a free particle. [8]
   (b) Explain the physical significance of wave function. [4]
   (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. [4]

4. (a) Discuss the origin of electrical resistance in metals. [6]
   (b) Show that the resistivity of a metal above room temperature varies directly with temperature. [6]
   (c) Find the relaxation time of conduction electrons in a metal of resistivity 1.54 $\times 10^{-8}$ ohm-m, if the metal has 5.8×10^{28} conduction electrons per m^3. [4]

5. (a) What is Piezo-electricity? [4]
   (b) Obtain an expression for the internal field seen by an atom in an infinite array of atoms subjected to an external field. [8]
   (c) The dielectric constant of He gas at NTP is 1.0000684. Calculate the electronic polarizability of He atoms if the gas contains 2.7×10^{25} atoms per m^3. [4]

6. (a) Draw the B-H curve for a ferro-magnetic material and identify the retentivity and the coersive field on the curve. [6]
   (b) What are paramagnetic and diamagnetic materials. [6]
   (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. [4]
7. (a) Describe the drift and diffusion currents in a semiconductor. [6]
   (b) Derive their expressions. [6]
   (c) Deduce Einstein relation. [4]
8. (a) Explain the following: [6]
      i. Life time of an energy level.
      ii. Optical pumping processes.
      iii. Metastable states.
   (b) Distinguish between spontaneous and stimulated emission processes of light. [5]
   (c) Discuss briefly the different methods of producing laser light. [5]

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the terms [6]
   i. basis
   ii. space lattice and
   iii. unit cell.
   (b) Describe the seven crystal systems with diagrams. [10]

2. (a) Explain Bragg's law of X-ray diffraction. [4]
   (b) Describe Laue's method for determination of crystal structure. [6]
   (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^o 35. Also calculate the maximum order of diffraction possible. [6]

3. (a) Explain the concept of matter waves. [6]
   (b) Describe Davison and Germer's experiment and explain how it enabled the verification of wave nature of matter. [6]
   (c) Calculate the velocity and kinetic energy of an electron of wavelength 1.66×10^{-10}m. [4]

4. (a) What is Fermi level? [2]
   (b) Explain Fermi-Dirac distribution for electrons in a metal. Discuss its variation with temperature. [8]
   (c) Calculate the free electron concentration, mobility and drift velocity of electrons in aluminum wire of length of 5 m and resistance 0.06 Ω carrying a current of 15 A, assuming that each aluminum atom contributes 3 free electrons for conduction.
   Given: Resistivity for aluminum = 2.7×10^{-8} Ω-m.
   Atomic weight = 26.98
   Density = 2.7×10^3 kg/ m^3
   Avagadro number = 6.025×10^{23} [6]

5. (a) What is intrinsic break down in dielectric materials? [4]
   (b) Explain electronic polarization in atoms and obtain an expression for electronic polarisability in terms of the radius of the atom. [8]
   (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]

6. (a) Define magnetic moment. Explain the origin of magnetic moment at the atomic level. What is Bohr magneton? [8]
   (b) In hydrogen atom an electron 'e' revolves around the nucleus at a distance of 'r' meter with an angular velocity 'ω' rad/s. Obtain an expression for magnetic moment associated with it due to its orbital motion. [8]

7. (a) Distinguish between metals, semiconductors and insulators. [6]
   (b) Explain the effect of temperature on resistivity of a semiconductor. [4]
   (c) Derive an expression for the number of electrons per unit volume in the conduction band of an intrinsic semiconductor. [6]

8. (a) With neat diagrams, describe the construction and action of ruby laser. [10]
   (b) Write the applications of laser. [6]

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