PG/IIIS/PH 2104/08

2008

PHYSICS

PAPER—PH-2104

Full Marks : 40

Time : 2 hours

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

(*Solid State Physics Special*)

Answer **Q. No. 1** and any *three* from rest

1. Answer any *five* : 2 x 5

(*i*) Explain why some metals become an insulator if the lattice constant is increased beyond a critical limit.

(*ii*) Although lattice defects cost energy to produce, at any finite temperature there are always defects in a solid. Why ?

(*iii*) The E-k relation in a particular solid is given by $E = Ak^2 + Bk^3$ where A and B are positive constants. Determine the phase velocity of electron waves for wavevector values at which group velocity vanish.

(*iv*) The average energy required to create a Frenkel defect in an ionic crystal is 1·4 eV. Calculate the ratio of Frenkel defects at 300 K and 600 K.

(*v*) Assuming that there are 10^{27} molecules/m^3 in HCl vapour, calculate the orientational polarization at room temperature if the vapour is subjected to an electric field of 10^6 V/m. The dipole moment of HCl molecule is $3{\cdot}46 \times 10^{-30}$ C - m.

(*vi*) Explain what is meant by dielectric loss.

(*vii*) What is meant by soft optical phonons and what is its significance.

2. Take a square lattice of unit lattice constant having N sites. Find out the energy dispersion in the tight binding approximation and show that it is

$$E = -2r(\cos k_x + \cos k_y),$$

r is the overlapping integral in TBA. How many electrons will it take to (*a*) fill up this band? (*b*) Fill the band such that it is 1/2 filled and draw the corresponding Fermi surface in the 1st Brillouin zone. 4 + (2 + 4)

3. Discuss in detail the theory of dielectrics in alternating field. Obtain an expression for the dielectric constant in terms of frequency and relaxation time. 3 + 7

4. (*a*) Electrons in a solid try to screen the Coulomb interaction while a gas of electron does not—why? Find an expression for the screening length of the electrons in a solid and find how does it depend on the density of electrons.

(*b*) Why is the Plasmon frequency independent of k in the simplest approximation. 10

5. Find out the degeneracy of a Landau levels of electrons at high magnetic field and low temperature. If the magnetic field applied is 10 Tesla, what is the gap (Δ) between 1st and 2nd Landau level. If the temperature is raised such that $k_B T = \Delta$, find the corresponding T. 10

6. (*a*) What are the different processes by which a luminescent center can be excited.

   (*b*) Assuming diffusion in an ionic crystal find an expression of diffusion coefficient.

   (*c*) What is a V center. 3 + 6 + 1

7. (*a*) What is meant by local field in a dielectric and how is it calculated for a cubic structure.

   (*b*) Show that transition from ferroelectric phase to paraelectric phase is of first order in $BaTiO_3$.

   (*c*) What is meant by Screw dislocation. 2 + 6 + 2

(*Applied Electronics Special*)

GROUP — A

(*Analog Electronics*)

[*Marks* : 20]

Attempt **Q. No. 1** and any *one* from the rest

1. Attempt any *five* of the following: 2 x 5

(*a*) Design a first order High Pass Butterworth filter, whose cut-off frequency is 4 kHz and pass band gain is 10.

(*b*) Draw the circuit diagram of a voltage controlled oscillator.

(*c*) Draw the circuit diagram of a 2nd order Low pass Butterworth filter and write the expression for the transfer function.

(*d*) Draw the circuit diagram of a triangular wave generator and write down the expression for the frequency of oscillation.

(*e*) Explain the operation of Ex-OR type phase detector with proper diagrams.

(*f*) Draw the circuit diagram of an analog multiplier which can multiply both +ve and -ve signals.

(*g*) What is a chopper stabilized amplifier ?

2. (*a*) Draw the circuit diagram of a very high input impedance difference amplifier using 3 op-amps and derive the expression for the output voltage.

   (*b*) Draw the circuit diagram of a series voltage regulator with current limit using a OP-Amp, a pass transistor and a current limit transistor. 6 + 4

3. (*a*) With suitable circuit diagram, describe the operation of a logarithmic amplifier using matched pair of transistor and find out the expression for the output voltage.

   (*b*) Explain how two analog signals can be multiplied using log and antilog amplifiers. (2 + 5) + 3

GROUP—B

(*Digital Electronics*)

[*Marks* : 20]

Attempt **Q. No. 1** and any *one* from the rest

1. Answer any *five* bits: 2 x 5

(*a*) ECL is much faster than TTL but TTL is better in noise margin. Why ?

(*b*) Give the internal structure of DRAM unit cell.

(*c*) Give example of volatile, non-volatile, sequential and semiconductor memory.

(*d*) Show the circuit of a three input NOR gate using CMOS transistors.

(*e*) Show how to solve the equation

$$Y = A\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C}$$

by using 8 : 1 multiplexer IC.

(*f*) Explain the wire'd logic using any gate.

2. Explain how to use de-multiplexer ?

(*a*) As a decoder.

(*b*) Design the circuit to convert octal number into binary number.

(*c*) Explain the working principle of ECL OR-NOR gate.

(*d*) What do you mean by a CMOS transmission gate? 2 + 3 + 4 + 1

3. (*a*) Explain the working principle of charge coupled device memory.

(*b*) Give the basic concept of two-phase ratio less shift register.

(*c*) Store the following two outputs in a single FPLA memory circuit:

$$X = \bar{A}B + A\bar{B}$$

$$Y = AB + \bar{A}\bar{B}.$$ 4 + 3 + 3