St. Philomena’s College (Autonomous), Mysore

Question Bank
Programme: M. Sc. Physics
III Semester

Course Title: Condensed Matter Physics-1

Course Type: Soft Core
Q.P Code: 58203

Q.N.	Question	Marks
1	What are the main sources of electrical resistivity in metals? Explain	4
2	What are plasmons? Explain.	4
3	Write a note on polaritons.	4
4	Define the following terms (i) Mean free path (ii) Relaxation time	4
5	Define the following terms in the case of metals (i) Thermionic emission (ii) High field emission.	4
6	What are excess free charge carriers ? Explain.	4
7	Show that dc current gain (α) of the transistor in its common-base configuration is $\alpha = \frac{\beta}{1+\beta}$	4
8	Show that dc current gain (β) of the transistor in its common-emitter configuration is $\beta = \frac{\alpha}{1-\alpha}$	4
9	What is mean free path? Explain.	4
10	Explain why are alkali metals transparent to UV radiation for frequencies greater than $\omega > \omega_p$.	6
11	Write a note on Matthiessen's rule.	6
12	Discuss the effect of impurities on the resistivity of metals.	6
13	Differentiate between normal process and Umklapp process in electron-phonon interactions.	6
14	What is skin effect? Differentiate between normal and anomalous skin effect.	6
15	State and explain Bloch theorem.	6
16	What are Brillouin zones? Discuss the construction of Brillouin zone in one dimension.	6
17	Explain what is Hall effect in semiconductors.	6
18	Explain the phenomenon of magnetoresistance in semiconductors.	6
19	Explain what is magnetoresistance in semiconductors.	6
20	Explain what is Cyclotron resonance in semiconductors.	6
21	Explain how more than two cyclotron frequencies are observed in Si and Ge using cyclotron resonance technique.	6
22	Describe the band structure of Si as determined by cyclotron resonance technique.	6

23	Define the terms the following terms with respect to free charge carriers in semiconductors (i) Generation rate (ii) Recombination rate and (iii) Life time, of the free charge carriers.	6
24	Explain the concept of hot electrons in the case of extrinsic n-type Ge.	6
25	Derive the expression for the average drift velocity associated with the electrons of the central and secondary valleys.	6
26	Explain the mechanism responsible for the formation of space charge region in the case of an abrupt pn junction diode.	6
27	Define the terms (i) space charge region (ii) width of the space charge region (iii) barrier height.	6
28	Write the energy band diagram for an unbiased pn junction diode.	6
29	Write the energy band diagram for a forward biased pn junction diode.	6
30	Explain the working of pnp transistor in its common-base configuration.	6
31	Write a note on a cut-off frequency.	6
32	Write a note on b cut-off frequency.	6
33	Explain with relevant theory the effect of temperature on the resistivity of metals.	8
34	Obtain an expression for plasma frequency in the case of metals.	8
35	What is magnetoresistance? Discuss the variation of electrical resistivity in metals on application of magnetic field.	8
36	What are Brillouin zones? Draw the Brillouin zone for two dimensional square lattice of side a .	8
37	On basis of tightly bound electron approximation, show that for a simple cubic lattice the width of energy band is equal to 12 γ.	8
38	Discuss with suitable equations the effect of the applied magnetic field on the resistivity of a purely p-type semiconductor.	8
39	Explain with necessary theory how the cyclotron resonance frequency (ω) is very much altered as the orientation of the crystal (θ) is changed with respect to the direction of magnetic field H_0.	8
40	Show that at a given orientation θ of the crystal w.r.t the direction of the applied magnetic field the cyclotron frequency w is given as $\omega = (\omega_\perp^2 \cos^2\theta + \omega_\parallel \omega_\perp \sin^2\theta)^{1/2}$	8
41	Obtain Einstein relation's in semiconductor.	8
42	Show that the diffusion length L_p of a hole in semiconductor is given as, $L_p = \sqrt{D_p \tau_p}$	8
43	Show that the diffusion length L_n of an electron in semiconductor is given as, $L_n = \sqrt{D_n \tau_n}$	8
44	Derive an expression for the temperature (T_e) of hot electrons in terms of applied electric field and lattice temperature (T_L).	8
45	What is Gunn effect? State and explain with a special reference to n-GaAr.	8

46	Explain with suitable diagrams what are abrupt and graded p-n junctions.	8
47	Obtain expression for transition capacitance associated with pn junction diode.	8
48	Set up Boltzmann transport equation and solve it in relaxation time approximation.	10
49	What is Umklapp process? Explain how this process leads to thermal conductivity in insulators.	10
50	Discuss with relevant theory the high frequency behaviour of electrical conductivity of metals at room temperature.	10
51	On basis of nearly free electron model, explain the formation of band structure in solids at zone boundary.	10
52	On basis of nearly free electron model, explain the formation of band structure in solids near the zone boundary.	10
53	Derive continuity equation for excess charge carriers holes (L_p) in a given semiconductor.	10
54	Derive continuity equation for excess charge carriers electrons (L_n) in a given semiconductor.	10
55	Explain the mechanism responsible for NDC in n-GaAr.	10
56	Outline the Sommerfeld theory for electrical conductivity of metals.	12
57	Discuss Schottky effect and arrive at an equation for work function of metals.	12
58	Discuss the phenomenon of thermionic emission in metals and obtain Richardson-Dushman equation for the emission of current density.	12
59	What is Hall effect? Derive an expression for Hall co-efficient of metals.	12
60	Outline the electron-phonon interaction in metals.	12
61	What is skin depth? With relevant theory derive an expression for anomalous skin depth in the case of metals.	12
62	Discuss the theory of high-field emission of electrons for a metal at low temperature on the assumption that the potential barrier through which tunneling takes place is of simple triangular form.	12
63	Arrive at an expression for thermionic work function by describing the modification made by Schottky to Richardson-Dushmann expression.	12
64	Obtain an expression for electrical conductivity of metals on application of an alternating electric field and hence discuss the variation of elctrical conductivity at different angular frequencies of the applied electric field.	12
65	Describe in detail the tightly bound electron approximation for calculating the energy states of an electron in a solid.	12
66	On basis of tightly bound electron approximation, explain the formation of band structure in solids.	12
67	Discuss the motion of an electron in a periodic potential and show from E-K graph that materials can be classified into conductors, semiconductors and insulators.	12
68	On basis of nearly free electron model, explain the formation of band structure in solids.	12

69	Derive an expression for the Hall co-efficient in the case of a semiconductor in terms of mobilities and densities of free charge carriers.	12
70	Show that the Hall co-efficient R_H in the case of a purely n-type semiconductor is given as, $R_H = \frac{-1}{n_0 ec}$ i.e is equal to negative.	12
71	Show that the Hall co-efficient R_H in the case of a purely p-type semiconductor is given as, $R_H = \frac{1}{p_0 ec}$ equal to positive.	12
72	Obtain the expression for Hall co-efficient in the case of a purely n-type semiconductor.	12
73	Obtain the expression for Hall co-efficient in the case of an intrinsic semiconductor.	12
74	Show that the Hall co-efficient R_H in the case of a semiconductor is given by $R_H = \frac{1}{ec}\left(\frac{p_0 - n_0 b^2}{(p_0 + n_0 b)^2}\right) \text{ with } b = \frac{\mu_n}{\mu_p}$	12
75	Show that the Hall co-efficient in the case of an intrinsic semiconductor is given as, $R_H = \frac{1}{n_i ec}\left(\frac{1-b}{1+b}\right) = -ve \quad where, b = \frac{\mu_n}{\mu_p}$	12
76	Derive continuity equations for excess free charge carriers holes and electrons in semiconductor.	12
77	Obtain the expression for the width of the space charge region in the case of an unbiased pn junction diode in terms of barrier potential V_0 and densities of donor and acceptor impurities N_d and N_a per unit volume.	12
78	Obtain the expression for the width of the space charge region in the case of a forward biased pn junction diode in terms of barrier potential V_0 and densities of donor and acceptor impurities N_d and N_a per unit volume.	12
79	Using continuity equations for excess minority carriers, derive the expression for the forward current in the case of a forward biased pn junction diode.	12
80	Obtain an expression for the current in the case of a reverse biased pn junction diode.	12
	Model problems	
81	Calculate the plasma frequency for sodium metal. Given: density of sodium is $970 kg/m^3$ and M=23.	4
82	The work function of tungsten is 4.5eV. Calculate the thermionic emission of a filament 0.05m long and 10^{-4}m diameter at 2400K. Given: $A=1.20 \times 10^6 Am^{-2}K^{-2}$.	4
83	Consider a two dimensional lattice site of 0.3nm. What is the electronic momentum value at the corner of the first Brillouin zone ? What is the energy of the electron with its momentum?	4

84	Silicon has electron and hole concentration $n_0 = p_0 = n_i = 1.0x10^{16}/m^3$. Calculate the Hall co-efficient of Si.	4
85	Find the diffusion co-efficient of electrons and holes in a silicon single crystal at 27^0C. Given the mobility of electrons and holes are respectively 0.17 and $0.0225m^2/V.s$.	4
86	At room temperature the hole mobility in a p-type silicon is 400 $cm^2/V.s$. Calculate the diffusion length of the electrons.	4

MODEL QUESTION PAPER

Q.P Code: 16MSPCS304

St. Philomena's College (Autonomous) Mysore
III Semester M.Sc. – C3 - Final Examination Oct 2017
Subject: PHYSICS
Title: CONDENSED MATTER PHYSICS I (SC)

Time: 3 Hrs **Max Marks: 70**

PART –A

1. a. Outline the Sommerfeld theory of electrical conductivity of metals. **12**
   b. Describe the effect of temperature and impunity on the electrical resistivity of metals. **06**

OR

2. a. Obtain an expression for the thermal conductivity of an insulator **08**
   b. Discuss with relevant theory the high frequency behavior of electrical conductivity of metals at room temperature. **10**

PART –B

3. a. On the basis of tight bound electron approximation explain the formation of energy bands in metals and show that for a cubic lattice the width of the energy band is equal to 12γ. **12**
   b. Write a note on Fermi surfaces. **06**

OR

4. a. Obtain expression for the Hall coefficient of the given semiconductor at thermal equilibrium in terms of the densities and mobilities of free charge carriers. **12**
   b. Write a note on magneto-resistance in semiconductors. **06**

PART –C

5. a. Obtain continuity equations for excess carriers generated in a semiconductor due to drift, diffusion, and, generation and recombination, processes. **12**
   b. Derive the general expression for the diffusion coefficient of holes in semiconductors in the form: $D_P = \frac{\mu_P kT}{e}$. **06**

OR

6. a. Show that the width of the space charge region (x_0) in an unbiased *p-n* junction diode is equal to $\left[\frac{\varepsilon_o V_0}{2\pi e}\left(\frac{N_a + N_d}{N_a \times N_d}\right)\right]^{1/2}$. **10**
   b. Explain with necessary theory the effect of an externally applied electric field on the transition capacitance associated with a *p-n* junction diode. **08**

PTO

PART –D

Answer any FOUR of the following questions: 4x4=16

7. An alloy of a metal is found to have a resistivity of 10^{-6} Ω m at 300 K. When it is heated to a temperature of 1000 K the resistivity is increased by 7%. Using Matthiessen's rule determine the resistivity of the alloy at 1000K..

8. Calculate the plasma frequency for a free electron gas in a metal with electron density $10^{28}/m^3$.

9. Calculate the value of the magnetic field required to observe cyclotron resonance due to electrons in a semiconductor at a frequency of 12 GHz. Assume that the effective mass of the electron is equal to its rest mass.

10. Find the diffusion coefficient of electrons in a silicon single crystal at 300 K, if the mobility of electrons is 0.17 m^2 / V.s.

11. The minority carrier life time in p-type silicon is 10^{-7} seconds. If the electron mobility at 300 K is 0.15 m^2 / V.s calculate the diffusion length of electrons.

12. Find the value of the applied forward voltage for a p-n junction diode if the reverse saturation current is $30\,\mu A/cm^2$ and the forward current is $2A/cm^2$.

Given $\left(\frac{e}{kT}\right)=\frac{39}{V}$.

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