St. Philomena's College (Autonomous), Mysore

Question Bank
Programme: M. Sc. Physics
III Semester

Course Title: Condensed Matter Physics

Course Type: Hard Core
Q.P Code: 58201

Sl. No.	Questions	Marks
1	Explain crystallographic axes for a given crystal.	2
2	Define crystalline state.	3
3	Describe the seven systems of crystals.	4
4	Obtain an expression for equation of a plane in three-dimensional space.	4
5	What are point groups and space groups? Explain giving two examples for each.	4
6	Find the reciprocal lattice of fcc lattice.	4
7	Write a note on Miller Indices.	4
8	How does neutron diffraction differs from X-ray diffraction from a single crystal? Explain.	4
9	Explain diamagnetism.	4
10	Define paramagnetism with an example.	4
11	Define ferromagnetism with an example.	4
12	Describe how to draw a reference axes for a given crystal.	5
13	What are type I superconductors? Explain with examples.	5
14	What are type II superconductors? Explain with examples.	5
15	Explain symmetry operations in crystals.	6
16	Define lattice? Explain two and three-dimensional lattices.	6
17	Explain screw and glide operations.	6
18	Explain reciprocal lattice.	6
19	What are Miller Indices? Obtain Miller Indices for a plane with Intercepts (a/p, b/q, c/r) along the crystallographic axes.	6
20	Describe the oscillation method for collecting X-ray diffraction data.	6
21	Describe the crystal growth from Bridgemann technique.	6
22	Explain the basic principles of neutron and electron diffraction.	6
23	Explain neutron diffraction method of collecting data.	6
24	Explain electron diffraction method of collecting data.	6
25	Write a note on ferromagnetic domains.	6
26	Distinguish among paramagnetic and ferromagnetic materials.	6
27	Obtain an expression for the Fermi energy in the case of an intrinsic semiconductor at a given temperature T.	6

28	Show that the Fermi energy of an intrinsic semiconductor at a given temperature T is, $\boxed{E_{F_i} = \frac{E_C + E_V}{2} + \frac{3}{4} kT \log\left(\frac{m_p^*}{m_n^*}\right)}$	6
29	Based on thermodynamical theory of superconductors explain the variation of entropy change S_S-S_n at the normal-superconducting transition temperature.	6
30	Based on thermodynamical theory of superconductors explain the variation of heat capacity change C_S-C_n at the normal-superconducting transition temperature.	6
31	Explain the zone refining method of purification of crystals.	7
32	Explain residual magnetism for a ferromagnetic material.	7
33	Describe the Czochralski's method of crystal growth.	8
34	Obtain the disperson relation for a chain of identical atoms using dispersion curve.	8
35	Explain the vibrational modes of an one dimensional linear monoatomic lattice and obtain dispersion relation.	8
36	Discuss with relevant theory the effect of temperature on the magnetic susceptibility in the case of Ferrormagnetic material in its paramagnetic phase.	8
37	Explain the salient features of intrinsic and compound semiconductors.	8
38	Explain with relevant theory the effect of temperature on the electrical conductivity of an intrinsic semiconductor.	8
39	Explain the salient features of intrinsic and extrinsic semiconductors.	8
40	Explain qualitatively the effect of temperature and impurity concentration on the Fermi energy of a purely n-type semiconductor in the low temperature region.	8
41	Describe briefly the following experimental facts in superconductors (i) Zero resistivity and (ii)Meissner effect.	8
42	Describe the following experimental facts in superconductors (i) Critical magnetic field and critical temperature and (ii) Perfect diamagnetism.	8
43	Based on elctrodynamical theory of superconductors show that,	8
44	Based on the thermodynamical theory of superconductors show that, at $T=T_C$ $\boxed{C_S - C_n = \frac{T_C}{4\pi}\left(\frac{\delta H}{\delta T}\right)^2 \quad >> 0}$	8
45	Based on thermodynamical theory of superconductors show that the entropy change at the normal-superconducting transition i.e, $(S_S - S_n)$ at $(T=T_C=0)$	8
46	Describe the following experimental facts in superconductors (i) Persistent current and (ii) Isotope effect	8
47	Explain with suitable diagrams the effect of high frequency electric field on the resistivity of the superconductors.	8
48	Write the energy band diagrams for (i) an intrinsic semiconductor (ii) a purely n-type semiconductor (iii) a purely p-type semiconductor	9
49	Describe the powder method of X-ray diffraction from a crystal and mention its advantages.	10

50	Describe the Weissenberg method of photographing the X-ray diffraction maxima from a single crystal.	10
51	Describe the quantum theory of paramagnetism and comment on Curie's law.	10
52	Explain the theory of ferromagnetism and also discuss temperature dependance of spontaneous magnetism.	10
53	Obtain expressions for electron and hole concentration in an intrinsic semiconductor at thermal equilibrium.	10
54	Obtain expression for an intrinsic carrier concentration (N_i) in the case of an intrinsic semiconductor at a given temperature T.	10
55	Explain with necessary theory the effect of temperature on the electron and hole concentrations in an intrinsic semiconductor.	10
56	Explain with relevant theory the effect of temperature on the intrinsic charge carrier concentration (N_i) in an intrinsic semiconductor.	10
57	Explain, with a neat circuit diagram, the determination of the energy gap of the given semiconductor in the laboratory.	10
58	Obtain expressions for carrier concentrations in an extrinsic material containing N_d and N_a number of donor and acceptor impurity atoms per unit volume at thermal equilibrium.	10
59	Obtain expressions for carrier concentrations in the case of a purely n-type semiconductor containing N_d number of donor impurity atoms.	10
60	Obtain expressions for carrier concentrations in a purely p-type semiconductor containing N_a number of acceptor impurity atoms.	10
61	Obtain an expression for the electrical conductivity of an extrinsic semiconductor containing N_d and N_a number of donor and acceptor per unit volume at thermal equilibrium.	10
62	Derive London equations and hence explain the observed Meissner effect.	10
63	Describe the high frequency behaviour of superconductors.	10
64	Obtain Laue equations and show how they lead to Bragg's law.	12
65	Explain classical theory of diamagnetism using Langevin's theory.	12
66	Obtain the dispersion relation for an one dimensional linear monoatomic lattice and hence sketch the dispersion curve.	12
67	Obtain the disperson relation for an one dimensional linear diatomic lattice and discuss its optical and acoustic modes.	12
68	Obtain the disperson relation for an one dimensional linear diatomic lattice and hence sketch the dispersion curve.	12
69	With relevant theory explain Curie-Weiss law for ferromagnetics.	12
70	Give the theory of diamagnetism and obtain an expression for diamagnetic susceptibility.	12
71	Obtain the expression for the Fermi energy of an extrinsic material when the Boltzmann approximation is valid for electrons in the conduction band and holes in the valence band .	12
72	Explain with relevant theory the effect of temperature and impurity density (N_d and Na) on the electrical conductivity of an extrinsic semiconductor.	12

73	Based on the thermodynamical theory of superconductors obtain the expressions for entropy change S_S-S_n and heat capacity change C_S-C_n at any given temperature $T<T_C$.	12

Model Problems

74	Draw the Miller planes (110) and (112) in a cubic crystal.	4
75	Obtain the reciprocal cell of the monoclinic cell. Given: a = 10 Å, b =15 Å, c =8 Å, and b = 102^0.	4
76	For a monoatomic lattice with Young's modulus equal to $0.05x10^{11}$ dynes/cm and mass of the atom being unity, calculate the frequency of the vibrating lattice. Given the lattice constant = 8Å	4
77	A paramagnetic material has a magnetic field intensity of 10^4 A/m. If the susceptibility of the material room temperature is $3.7x10^{-5}$ emu then calculate the magnetization and flux density in the material.	4
78	For an intrinsic semiconductor with gap width 0.7eV, determine the position of the Fermi level at 300^0 K. Given: $m_p^*=6m_n^*$	4
79	The material lead has density of 11.3g//cc, atomic weght 207.19 and T_C=7.22K. Calculate its London penetration depth at 0K.	4

MODEL QUESTION PAPER

Q.P Code: 16MSPCH301

St. Philomena's College (Autonomous) Mysore

III Semester M.Sc. – C3 - Final Examination Oct 2017

Subject: PHYSICS

Title: CONDENSED MATTER PHYSICS (HC)

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

PART –A

1. a. Describe the seven systems of crystals. **04**
   b. Explain the terms 'point groups' and 'space groups'. **04**
   c. Derive Lane equations and show how they lead to Bragg's law. **10**

OR

2. a. Describe the normal beam Weissenberg method of X-ray diffraction to determine the lattice parameters. **10**
   b. Describe the growth of a crystal by Czochralski's method. **08**

PART –B

3. a. i) Obtain the dispersion relation for an one dimensional linear monatomic lattice in the nearest – neighbour approximation. **10**
   ii) Sketch the above dispersion relation and show that the lattice behaves like a low pass filter. **04**
   b. Show that for a finite lattice, the number of possible modes of vibration is equal to the number of mobile atoms. **04**

OR

4. a. Distinguish among diamagnetic, paramagnetic and ferromagnetic materials. **06**
   b. Discuss with necessary theory the temperature variation of magnetic susceptibility in the case of a paramagnetic solid. **12**

PART –C

5. a. Obtain expressions for electron and hole concentrations in an intrinsic semiconductor at thermal equilibrium. **06**
   b. Show that the Fermi energy of an intrinsic semiconductor at a given temperature T is equal to $E_{F_i} = \frac{E_C + E_V}{2} + \frac{3}{4} kT \ln\left(\frac{m_p^*}{m_n^*}\right)$ **04**
   c. Derive an expression for the electrical conductivity of an extrinsic semiconductor containing N_d and N_a number of donor and acceptor impurity atoms. **08**

OR

6. a. Write short notes on type I and type II super conductors. **08**
   b. Obtain London equation based on classical electrodynamics and hence explain the observed Meissner effect in superconductors. **10**

PTO

PART –D

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

7. Show that 5-fold symmetry does not exist in crystals.

8. Show that $d_{100} : d_{110} : d_{111} = a : \frac{a}{\sqrt{2}} : \frac{a}{\sqrt{3}}$.

9. Given the ratio of force constant to mass of an atom to be equal to 2, for a linear lattice of lattice constant $2\,\mathring{A}$. At the wave vector $K = \frac{\pi}{3a}$ find the angular frequency of vibration of the lattice..

10. A paramagnetic solid has $10^{22}\ atoms/cm^3$,the magnetic moment of each atom is $10^{-20}\ ergs/Gauss$. Calculate the paramagnetic susceptibility and the magnetization in an uniform magnetic field of 10^4 Gauss, at 300 K.

11. For an intrinsic semiconductor with a gap width 0.7 eV determine the position of the Fermi level at 300 K. Given $m_p^* = 6m_n^*$.

12. The critical temperature of mercury with isotopic mass 199.5 amu is 4.185K. Calculate its critical temperature when the isotopic mass changes to 203.4 amu.

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