

D 132060

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY]  
EXAMINATION, NOVEMBER 2025**

(CBCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

**Section A***Answer all questions, each carries weightage 1.*

1. Distinguish between para and ferromagnetism.
2. Explain the indirect band gap semiconductors.
3. What are Miller indices ?
4. What do you mean by perfect diamagnetism in superconductors ?
5. Give example of material exhibiting SC and BCC structure.
6. Explain the Wiedemann-Franz law.
7. What are the importances of hall co-efficient in material analysis ?
8. What are piezoelectric materials ? Give applications of it.

(8 × 1 = 8 weightage)

**Section B***Answer any two questions, each carries weightage 5.*

9. Prove that the motion of electrons through the periodic potential in solids give rise to band structure.
10. Describe the Einstein model of lattice heat capacity. Discuss the success and failure of this model at different temperatures.

**Turn over**

11. Derive an expression for diamagnetic susceptibility using the quantum theory. Explain the temperature dependence of susceptibility.
12. Give an account of the phenomenon of superconductivity. Distinguish between type I and type II superconductors. List out few applications of superconductors.

(2 × 5 = 10 weightage)

### Section C

Answer any **four** questions, each carries weightage 3.

13. Derive the relationship between dielectric constant and atomic polarizability.
14. N-type Ge sample has donor concentration  $10^{21}/\text{m}^3$  and thickness = 3 mm. is used in a Hall Effect experiment set up. Find the Hall voltage, if  $B = 0.5 \text{ T}$  and  $J = 500 \text{ A/m}^2$ . Also find the hall co-efficient.
15. The energy near the valence band edge of a crystal is given by  $E = -Ak^2$ , where  $A = 10^{-39} \text{ Jm}^2$ . An electron with wave vector  $k = 10^{10} k_x \text{ m}^{-1}$  is removed from an orbital in the completely filled valence band. Determine the effective mass, velocity and momentum of the hole.
16. The lead material works as superconductor at a temperature of  $T_c = 7.26 \text{ K}$ . If the constant characteristic field of the lead material at 0 K is  $H_0 = 8 \times 10^5 \text{ A/m}$ . Calculate the magnetic field in the lead at 5 K.
17. A ferromagnetic material with  $J = 3/2$  and  $g = 2$  has a Curie temperature of 125 K. Calculate the intrinsic flux density near 0 K. Also, calculate the ratio of the magnetization at 300 K in the presence of an external field of 1 mT to the spontaneous magnetization at 0 K.
18. Two dimensional lattice has the basis vectors :  
 $a = 2\hat{x}$ ,  $b = \hat{x} + 2\hat{y}$ . Find the reciprocal lattice vectors.
19. The Debye temperature of diamond is 2000 K. Calculate the mean velocity of sound in diamond, given the density and atomic mass of diamond as  $3500 \text{ kgm}^{-3}$  and 12 amu respectively.

(4 × 3 = 12 weightage)

D 111208

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. (CBCSS) [REGULAR / SUPPLEMENTARY]  
EXAMINATION, NOVEMBER 2024**

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

**Section A***Answer all questions.**Each question carries 1 weightage.*

1. Discuss the Weiss theory of ferromagnetism.
2. What are symmetry operations ? Name the symmetry elements of a crystal.
3. What are the importance of Miller indices ?
4. Give example of material exhibiting FCC and HCP structure.
5. Briefly explain Hall Effect.
6. Distinguish between type I and type II superconductors.
7. What do you meant by direct band gap semiconductors ?
8. Discuss the ferroelectric and paraelectric states.

(8 × 1 = 8 weightage)

**Section B***Answer any two questions.**Each question carries 5 weightage.*

9. Discuss the formation of allowed and forbidden energy bands on the basis of the Kronig Penny model.
10. Derive expression for electron and hole concentration for an intrinsic semiconductors. Use these results to obtain intrinsic carrier concentration.

**Turn over**

11. Discuss the Debye model of lattice heat capacity. Give drawbacks of the Debye model.
12. Describe the Langevin's theory of paramagnetism and obtain an expression for paramagnetic susceptibility. Mention the temperature dependence of susceptibility.

(2 × 5 = 10 weightage)

### Section C (Essay Questions)

Answer any **four** questions.

Each question carries 3 weightage.

13. The energy  $E(k)$  of electrons of wave vector  $k$  in a solid is given by  $E(k) = Ak^2 + Bk^4$ , where  $A$  and  $B$  are constants. Find the effective mass of electrons at  $[k] = k_0$ ?
14. Find out reciprocal lattice vectors for a space lattice defined by the following primitive translation vectors :

$$a = 5\hat{i} + 5\hat{j} - 5\hat{k}, b = -5\hat{i} + 5\hat{j} + 5\hat{k}, c = 5\hat{i} - 5\hat{j} + 5\hat{k}.$$

15. The critical fields at 6 K and 8 K for a NbTi alloy are  $7.616 \times 10^6$  and  $4.284 \times 10^6$  A/m respectively. Determine the transition temperature and the critical field at 0 K.
16. The mobility of hole is  $\mu_h = 0.025 \text{ m}^2/\text{Vsec}$ . What would be the resistivity of p-type silicon if the hall coefficient of the sample is  $2.25 \times 10^{-5} \text{ m}^3/\text{C}$ ?
17.  $\text{Dy}^{3+}$  has outer electronic configuration of  $4f^9 6s^0$ . Calculate the magnetic susceptibility for a salt containing one kg mole of  $\text{Dy}^{3+}$  ions at 300 K.
18. The unit cell volume of sodium is  $7.93 \times 10^{-29} \text{ m}^3$ . Calculate the Fermi energy of sodium at absolute zero.
19. Derive the Clausius-Mossotti relation by considering the local field effects.

(4 × 3 = 12 weightage)

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Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY)  
EXAMINATION, NOVEMBER 2023**

(CBCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

**Section A***Answer all questions.**Each question carries weightage 1.*

1. Distinguish between para and ferromagnetism.
2. What are symmetry operations ? Name the symmetry elements of a crystal.
3. What are Miller indices ?
4. Give example of material exhibiting SC and BCC structure.
5. Briefly explain Hall effect.
6. Distinguish between Type I and Type II superconductors.
7. What do you meant by indirect band gap semiconductors ?
8. Discuss the ferroelectric and paraelectric states.

(8 × 1 = 8 weightage)

**Section B***Answer any two questions.**Each question carries weightage 5.*

9. Give an account of the phenomenon of superconductivity. Distinguish between Type I and Type II superconductors. List out few applications of superconductors.
10. Discuss the formation of allowed and forbidden energy bands on the basis of the Kronig Penny model.

**Turn over**

11. Describe the Einstein model of lattice heat capacity. Discuss the success and failure of this model at different temperatures.
12. Describe the Langevin's theory of paramagnetism and obtain an expression for paramagnetic susceptibility. Mention the temperature dependence of susceptibility.

(2 × 5 = 10 weightage)

### Section C

Answer any **four** questions.

Each question carries weightage 3.

13. A ferromagnetic material with  $J = 3/2$  and  $g = 2$  has a Curie temperature of 125 K. Calculate the intrinsic flux density near 0 K. Also, calculate the ratio of the magnetization at 300 K in the presence of an external field of 1 mT to the spontaneous magnetization at 0 K.
14. The critical fields at 6 K and 8 K for a NbTi alloy are  $7.616 \times 10^6$  and  $4.284 \times 10^6$  A/m respectively. Determine the transition temperature and the critical field at 0 K.
15. Two dimensional lattice has the basis vectors  
 $a = 2\hat{x}$ ,  $b = \hat{x} + 2\hat{y}$ . Find the reciprocal lattice vectors.
16. The mobility of hole is  $\mu_h = 0.025 \text{ m}^2/\text{Vsec}$ . What would be the resistivity of p-type silicon if the hall co-efficient of the sample is  $2.25 \times 10^{-5} \text{ m}^3/\text{C}$  ?
17. The energy near the valence band edge of a crystal is given by  $E = -Ak^2$ , where  $A = 10^{-39} \text{ Jm}^2$ . An electron with wave vector  $k = 10^{10} k_x \text{ m}^{-1}$  is removed from an orbital in the completely filled valence band. Determine the effective mass, velocity and momentum of the hole.
18. Derive the Clausius-Mossotti relation by considering the local field effects.
19. The unit cell volume of sodium is  $7.93 \times 10^{-29} \text{ m}^3$ . Calculate the Fermi energy of sodium at absolute zero

(4 × 3 = 12 weightage)

D 71327

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2014**

(CUCSS)

Physics

**PHY 3C 11—SOLID STATE PHYSICS**

(2012 Admission onwards)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. Define : (a) Primitive (b) Unit cell.
2. What is Cohesive energy and electron affinity ?
3. Why does density of iron increase when metallic iron changes from bcc structure to fcc structure ?
4. What are the salient features of quantum theory of specific heat of solids ?
5. What are the drawback of classical free electron theory ?
6. What is meant by imperfections in a crystal ?
7. What is Fermi energy and Fermi momentum ?
8. Give the nature of motion of an electron in a periodic potential.
9. Explain hysteresis in magnetic materials.
10. What is magnetostrictive energy ?
11. What is Superconductivity ? Give one use.
12. Explain the principle of SQUID. Give its engineering applications.

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

1. Explain symmetry elements in crystals. Describe the various types of symmetry elements and symmetry operations of a cubic crystal.
2. Discuss the Kronig-Penney model for the motion of an electron in a periodic potential.
3. Derive an expression for the specific heat capacity of solid using Deby's theory. How does the result agree with experimental data ?

Turn over

4. Discuss Weiss theory of ferromagnetism. How is hysteresis and Curie point explained based on this theory ?

(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.  
Each question carries 3 weightage.*

1. Calculate the compressibility of sodium chloride assuming a repulsive potential of the form  $B/r^2$  to act between nearest neighbours, of distance 0.281nm. Madelung constant = 1.7476.
2. In a one dimensional crystal with atomic spacing  $2.5\text{\AA}$ , calculate the free electron energy at which the first Bragg reflection occurs.
3. Evaluate the carrier concentration and conductivity of the intrinsic Ge at  $T = 300\text{ K}$ .  $m = 9.1 \times 10^{-31}\text{kg}$ ,  $E_g = 0.68\text{eV}$ ,  $\mu_e = 0.38\text{m}^2/\text{V-sec}$ ,  $\mu_h = 0.18\text{m}^2/\text{V-sec}$ ,  $k_B = 1.38 \times 10^{-23}\text{J/K}$  and  $h = 1.055 \times 10^{-34}\text{ J-sec}$ .
4. A paramagnetic salt contains  $10^{28}$  ions/ $\text{m}^3$  with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptibility and the magnetization produced in a uniform magnetic field of  $10^6$  amp/meter at 300K.
5. Calculate the change in magnetic moment of an electron in a hydrogen atom orbiting in an orbit of radius  $0.5\text{\AA}$  if a magnetic field of induction 2 weber/ $\text{m}^2$  acts at right angles to the plane of the orbit.
6. Define London Penetration depth. Calculate the value of the London Penetration depth  $\lambda_0$  at 0 K for lead whose density is  $11.3 \times 10^3\text{kg}/\text{m}^3$  and the atomic weight is 207.19 ( $T_c = 7.22\text{K}$ ). Calculate the increase in  $\lambda$  at 3.61K from 0 K.

(4 × 3 = 12 weightage)

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Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2015**

(CUCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2012 Admission onwards)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. What are Miller indices ? How are they determined ?
2. What is the structure of Germanium and Silicon ? How many molecules per unit cell are there ?
3. What is the difference between a crystal lattice and reciprocal lattice ?
4. Explain Ionic cohesive energy.
5. Define relaxation time and collision time of free electrons in metals.
6. What is an infinite potential well ?
7. What are Brillouin zones ? How are they related to the energy of an electron in a metal ?
8. Explain Neel's theory of antiferromagnetism.
9. Distinguish between hard and soft magnetic materials.
10. What are ferrites ? In what ways are they superior to ferromagnetic materials ?
11. What are cooper pairs ? Where are they formed ?
12. At what temperature the band gap of a superconductor vanish ? Why ?

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

1. Explain Packing density or packing factor in crystals. Show that the packing factor for bcc and fcc structures are  $\sqrt{3}\pi/8$  and  $\sqrt{2}\pi/6$  respectively.
2. Deduce Weidmann and Franz law. Explain its significance.

**Turn over**

3. Discuss the Kronig-Penney model for the motion of an electron in a periodic potential. What is meant by density of energy states ?
4. Derive the London equations and explain how its solutions accounts Meissner effect.

(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.  
Each question carries 3 weightage.*

1. Prove that the reciprocal lattice for a bcc lattice is a fcc structure.
2. Show that the number of Frenkel defects in equilibrium at a given temperature is proportional to  $(NN_2)^{1/2}$  where N is the number of atoms and  $N_2$  be the interstitial atoms.
3. Calculate the Debye temperature for diamond given Young's modulus =  $10^{12}$  N/m<sup>2</sup> and density = 3500 kg/m<sup>3</sup>.
4. The critical temperature  $T_c$  for mercury with isotopic mass 199.5 is 4.185 K. Calculate the critical temperature when its isotopic mass changes to 203.4.
5. What is a Bohr Magneton ? A typical magnetic field achievable with an electromagnet with iron core is  $10^4$ G. Compare the magnetic interaction energy  $\mu H$  of an electron spin magnetic dipole moment with  $K_B T$  at room temperature and show that at ordinary temperature the approximation

$$\frac{K_B T}{\mu H} \gg 1 \text{ is valid.}$$

6. What is London Penetration depth ? The London Penetration depths for Pb at 3 K and 7.1 K are respectively 39.6 nm and 173 nm. Calculate its transition temperature as well as Penetration depth at OK.

(4 × 3 = 12 weightage)

**D 6725**

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2016**

(CUCSS)

Physics

**PHY 3C 11—SOLID STATE PHYSICS**

(2012 Admissions)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.  
Each question carries 1 weightage.*

1. What are Brillouin Zones ?
2. Explain covalent bonding.
3. What are imperfections in crystals ?
4. Explain the term effective mass.
5. What is a direct gap material ? Give an example.
6. What are phonon modes ?
7. Explain the origin of diamagnetism.
8. What are ferrites ?
9. Explain the term polarization catastrophe.
10. Show how thermal conductivity changes with temperature.
11. What is isotope effect in superconductivity ?
12. Explain the term single particle tunnelling.

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.  
Each question carries 6 weightage.*

1. Explain the various methods in X-ray diffraction used to elucidate the structure of crystals.
2. Discuss Langevin's theory of paramagnetism. Explain Hund's rule.

**Turn over**

3. Obtain an expression for carrier concentration in conduction band for a semiconductor.
4. Explain flux quantization. Describe Josephson effect and give a brief account of SQUIDS.

(2 × 6 = 12 weightage)

### Part C

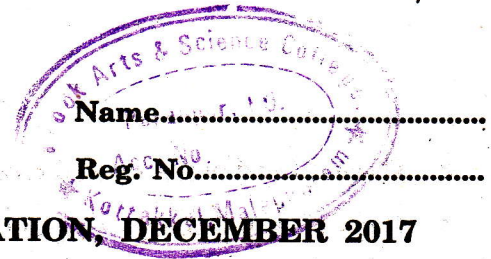
*Answer any four questions.  
Each question carries 3 weightage.*

1. Show that the reciprocal lattice for a BCC lattice is FCC lattice.
2. A lattice is characterised by the primitive vectors  $\bar{a} = 2(\hat{i} + \hat{j})$ ;  $\bar{b} = 2(\hat{j} + \hat{k})$  and  $\bar{c} = 2(\hat{k} + \hat{i})$ . Find the reciprocal lattice to the original one and the cubic edge.
3. Two branches of a phonon spectrum of a cubic lattice is  $\omega_1(\hat{k}) = A|\sin k|$  and  $\omega_2(\hat{k}) = B(2 + \cos k)$ . In the Debye approximation find the phonon dispersion relations for each branch.
4. Find the Fermi velocity of electrons in Potassium if its Fermi energy is 2.1 eV.
5. Calculate the frequency of the AC current produced when a DC voltage of 5  $\mu$ V is applied across the Josephson junction.
6. A paramagnetic material with spin magnetic dipole moment is placed in a magnetic field of  $10^5$  A/m. Evaluate the average magnetic moment per dipole at 300 K.

(4 × 3 = 12 weightage)

**C 31291**

**(Pages : 2)**



**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2017**

**(CUCSS)**

**Physics**

**PHY 3C 11—SOLID STATE PHYSICS**

**(2012 Admissions)**

**Time : Three Hours**

**Maximum : 36 Weightage**

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. Enumerate the Bravais lattices for an orthorhombic system.
2. What is the volume ratio of a conventional unit cell and its Wigner unit cell ?
3. Explain the physical significance of ionic radii.
4. Give the number of optical phonon modes for  $\text{CaF}_2$  (3 atoms per unit cell).
5. How is electronic specific heat dependent on temperature ?
6. What is Wiedmann-Franz law ?
7. What is an infinite potential well ?
8. Explain the concept of effective mass.
9. What is Hall effect ?
10. What are ferroelectric domains ?
11. What is Meissner effect ?
12. What is flux quantization ?

**(12 × 1 = 12 weightage)**

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

1. What are Miller indices ? Draw neat diagrams to indicate Miller indices of the important planes in a simple cubic crystal.
2. Discuss the Einstein model of lattice heat capacity and derive an expression for it.

**Turn over**

3. Discuss Landau theory of ferroelectric phase transitions.
4. Derive London equations and hence obtain an expression for London penetration depth.

(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.*

*Each question carries 3 weightage.*

1. Calculate the density of atoms in (1 0 0), (1 1 0) and (1 1 1) planes of BCC Barium whose lattice parameter is 5.02 Å.
2. The Debye temperature of diamond is 1850 K. Calculate the specific heat per Kmol for diamond at 20 K. Also compute the highest lattice frequency involved in the Debye theory.
3. Silver metal has FCC structure and its atomic radius is 1.4 Å. Determine the Fermi energy at 0 K.
4. Show that the wavelength of a moving electron having an energy equal to the

Fermi energy at absolute zero is given by  $\lambda_F = 2 \left( \frac{\pi}{3\pi} \right)^{\frac{1}{3}}$ .

5. A magnetic material has a magnetisation of 3200 A/m and flux density of 0.0045 Wb/m<sup>2</sup>. Determine the magnetic field and the relative permeability of the material.
6. Calculate the wavelength of the photon required to break a Cooper pair in a superconductor whose critical temperature is 1.2 K.

(4 × 3 = 12 weightage)

**D 52334**

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018**

(CUCSS—PG)

Physics

**PHY 3C 11—SOLID STATE PHYSICS**

(2012 Syllabus Year)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. Briefly discuss the structure of diamond.
2. Explain what is meant by Madelung interactions.
3. Differentiate between acoustic and optical phonons.
4. Write a short note on thermal conductivity of solids.
5. Explain qualitatively how the discrepancy in heat capacity was solved by the free electron model.
6. Define Hall coefficient. Discuss its significance.
7. Distinguish between direct and indirect band gap semiconductors.
8. Explain the term polarization catastrophe.
9. What is the origin of paramagnetism ?
10. Distinguish between antiferro and ferromagnetic materials.
11. What is Meissner effect ? Explain the perfect diamagnetism in superconductors.
12. What is single particle tunneling? How does it differ from Josephson tunneling ?

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

1. Explain the principle of X-ray diffraction. Discuss the different methods of X-ray diffraction to determine the structure of crystals.
2. Prove that the motion of electrons through a periodic potential in a solid gives rise to the band structure.

**Turn over**

3. Explain the origin of diamagnetism in materials. Obtain an expression for diamagnetic susceptibility using Langevin's theory.
4. What is Josephson Tunneling ? Discuss the d.c. Josephson effect in a superconductor.  
(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.  
Each question carries 3 weightage.*

1. Show that for a simple square lattice, the kinetic energy of a free electron at the corner of the first Brillouin zone is larger than that of an electron at the midpoint of a side face of the zone by a factor of 2.
2. Gold has the same structure as copper. The velocity of sound in gold is  $2100 \text{ ms}^{-1}$  and that in copper is  $3800 \text{ ms}^{-1}$ . If the Debye temperature of copper is 348 K, determine the Debye temperature of gold. The densities of gold and copper are  $1.93 \times 10^{-4} \text{ kg.m}^{-3}$  and  $8960 \text{ kgm}^{-3}$  and their atomic weights are 197 and 63.54 amu respectively.
3. Derive the expression for the thermal conductivity of a solid.
4. Derive an expression for the average kinetic energy per electron for a three dimensional free electron gas at 0K.
5. State and explain Hunds' rules. Using these rules to find out the electronic configuration of  $\text{Ce}^{3+}$  which has a single f electron.
6. What is the frequency of the alternating waveform obtained from a Josephson junction when a voltage of 2 mV is applied across it ?

(4 × 3 = 12 weightage)

**D 52342**

**(Pages : 2)**

**Name.....**

**Reg. No.....**

**THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018**

**(CUCSS—PG)**

**Physics**

**PHY 3C 11—SOLID STATE PHYSICS**

**(2017 Syllabus Year)**

**Time : Three Hours**

**Maximum : 36 Weightage**

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. Mention the 14 Bravais lattices and specify the restrictions on lattice parameters and angles on each case.
2. What is a reciprocal lattice ? What is its importance in x-ray diffraction ?
3. Plot the dispersion curves for lattice vibrations of a crystal with one and two atoms in the primitive cell.
4. Explain the concept of phonons.
5. What is Hall effect ? Give the expression for Hall co-efficient as predicted by free electron theory.
6. Describe how to calculate the number of orbitals in an energy band.
7. Distinguish between direct and indirect bandgap semiconductors. Give examples.
8. Define electric polarization. Give the relation connecting macroscopic electric field with polarization vector.
9. Distinguish between pyroelectric and piezoelectric materials.
10. State Hund's rules to obtain the ground state of an atom.
11. Explain the concept of Cooper pairs in superconductors.
12. What is the importance of high temperature superconductors ? Give one example with transition temperature.

**(12 × 1 = 12 weightage)**

**Turn over**

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

13. Describe various kinds of bonding in crystals.
14. Obtain the dispersion relation for vibrations of monatomic lattices. Show that the group velocity is zero at zone boundary.
15. Derive the expression for intrinsic carrier density in semiconductors.
16. What is a Josephson junction ? Derive expressions for (i) dc and (ii) ac Josephson effects.

(2 × 6 = 12 weightage)

**Part C**

*Answer any four questions.*

*Each question carries 3 weightage.*

17. Calculate the energy required for a beam of (i)  $x$ -rays, (ii) neutrons and (iii) electrons in a scattering experiment to determine the crystal structure if the wavelength of the beam is  $5\text{\AA}$ .
18. Specific heat capacity for Cu at 300K is  $1688\text{ J/mol}\cdot\text{K}$ . Calculate the Debye temperature for Cu. (given  $k_B = 1.38 \times 10^{-23}\text{ JK}^{-1}$ ,  $N = 6.02 \times 10^{23}$  atoms/mole).
19. Valence electron density for monovalent potassium is,  $N/V = 1.402 \times 10^{28}\text{ m}^{-3}$ . Calculate the Fermi energy and Fermi temperature of electrons in potassium.
20. Estimate Curie constant for Fe ( $N = 9 \times 10^{28}\text{ m}^{-3}$ ,  $\mu_B = 9.27 \times 10^{-24}\text{ JT}^{-1}$ ).
21. Show that energy level for a single electron with no orbital angular momentum splits to  $\pm \mu_B B$  in a magnetic field directed along the positive  $z$ -axis.
22. Show that London equation leads to Meissner effect.

(4 × 3 = 12 weightage)

**D 70981**

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION  
NOVEMBER 2019**

Physics

PHY3C11—SOLID STATE PHYSICS

(2012 Admissions)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. Obtain Bragg's law in reciprocal lattice.
2. Distinguish between ionic and covalent bonding.
3. Write down the dispersion relation for phonons in a monoatomic crystal.
4. Explain how anharmonicity explains thermal expansion in solids.
5. What is Bloch theorem ? Express the Bloch function mathematically.
6. Discuss the origin of effective mass of an electron in a lattice.
7. What is an indirect band gap material ? Give example.
8. How do you classify ferroelectric materials ?
9. Explain why diamagnetic materials have a negative susceptibility.
10. Briefly explain spin waves.
11. Distinguish between Type I and Type II superconductors.
12. Write a short note on High  $T_c$  superconductors.

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

1. What are symmetry operations ? Describe the principal symmetry operations applicable to a three dimensional lattice and show that five-fold rotational axis is not possible in case of lattices.
2. Deduce vibrational modes of a finite one dimensional monoatomic lattice.

**Turn over**

3. Describe the free electron gas model of metals. Explain why the electronic heat is much less than that expected from the classical value.
4. S. T. the current flowing across a Josephson junction is oscillatory when a voltage is applied across the junction.

(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.*

*Each question carries 3 weightage*

1. Determine the value of cohesive energy for crystals of inert gases
2. The Debye temperature of diamond is 2000 K. Calculate the mean velocity of sound in diamond, given the density and atomic mass of diamond as  $3500 \text{ Kg m}^{-3}$  and 12 amu respectively. If the interatomic spacing is  $1.54 \text{ \AA}$ , estimate the frequency of the dominant mode of lattice vibration.
3. Define Hall coefficient and explain its significance.

An electric field of  $100 \text{ V/m}$  is applied to a sample of semiconductor whose Hall coefficient is  $0.0125 \text{ m}^3/\text{C}$ . Determine the current density. Given the electron mobility is  $0.36 \text{ m}^2/\text{V-s}$ .

4. Discuss the Landau theory of ferroelectric phase transition.
5. A ferromagnetic material with  $J = 3/2$  and  $g = 2$  has a Curie temperature of 125 K. Calculate the intrinsic flux density near 0 K. Also calculate the ratio of the magnetisation at 300 K in the presence of an external field of 1 mT to the spontaneous magnetisation at 0K.
6. Derive London equations in superconductivity. Explain how these equation explain Meissner effect.

(4 × 3 = 12 weightage)

D 70986

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION  
NOVEMBER 2019**

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2017 Admissions)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. What is a symmetry operation ? Mention different types of symmetry elements and symmetry operations in a cubic crystal.
2. What are Brillouin zones ? Construct first Brillouin zone for a two dimensional square lattice.
3. Show that the group velocity for elastic waves of lattice vibrations are zero at the edges of Brillouin zones.
4. Discuss the limitations of Einstein model for lattice heat capacity in solids.
5. What is the limitation of free electron model in explaining Hall coefficients of metals ?
6. Explain the concept of holes in semiconductors.
7. What is effective mass of a charge carrier ? What is its importance ?
8. Distinguish between paramagnetic and ferromagnetic materials.
9. Briefly explain the concept of magnons in ferromagnetic materials.
10. Briefly explain the origin of ferrimagnetic moments.
11. What are superconductors ? What is the importance of transition temperature of superconductors ?
12. Certain superconductor has an energy gap of  $10^{-4}$  eV. Calculate the wavelength of electromagnetic radiation to which this superconductor respond.

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

13. What are reciprocal lattices ? Show that reciprocal lattice to BCC lattice is an FCC lattice and reciprocal lattice to FCC lattice is BCC lattice.

**Turn over**

14. Derive an expression for lattice heat capacity using Debye model. Discuss how this model differs from Einstein model.
15. Derive Curie-Weiss law for ferromagnetism.
16. Explain flux quantization in superconductors and use it to explain the principle of macroscopic quantum interference.

(2 × 6 = 12 weightage)

### Part C

*Answer any four questions.*

*Each question carries 3 weightage.*

17. An orthorhombic crystal has a ratio  $a : b : c = 0.429 : 1 : 0.377$ . find the Miller indices of the faces whose intercepts are (i)  $0.214 : 1 : 0.188$  and (ii)  $0.429 : \infty : 0.126$ .
18. If phonon mean free path length in quartz crystal is  $30 \text{ \AA}$  and the specific heat capacity per unit volume is  $4 \times 10^3 \text{ J m}^{-3}\text{K}^{-1}$  at 300 K, calculate lattice thermal conductivity in quartz, (assume phonon velocity =  $5 \times 10^3 \text{ ms}^{-1}$ ).
19. Valence electron density for monovalent potassium is,  $N/V = 1.402 \times 10^{28} \text{ m}^{-3}$ . For a typical current density of  $10^6 \text{ Am}^{-2}$ , obtain the drift velocity in terms of Fermi velocity for electrons in potassium.
20. Prove that the Fermi level in an intrinsic semiconductor lies in the middle of the forbidden gap if the effective masses of electrons and holes are equal.
21. Calculate the value of magnetic susceptibility for a paramagnetic material ( $N = 9 \times 10^{28} \text{ m}^{-3}$ ,  $\mu_B = 9.27 \times 10^{-24} \text{ JT}^{-1}$ ) at 0.1 K.
22. A superconducting material has a transition temperature of 3.7 K at zero magnetic field and a critical field of  $3 \times 10^5 \text{ A/m}$  at 0 K. Find the critical field at 2K.

(4 × 3 = 12 weightage)

**D 90746**

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION  
NOVEMBER 2020**

(CUCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2017 Admissions)

Time : Three Hours

Maximum : 36 Weightage

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. What are Miller indices ? Outline the procedures to determine it.
2. Distinguish between metallic and ionic bonding in solids.
3. Define crystal momentum. What is its importance ?
4. Distinguish between Umklapp and normal processes in phonon collisions.
5. What are the assumptions of free electron model of metals ?
6. Explain temperature dependence of resistivity in metals using Matthiessen's rule.
7. Discuss Wiedemann-Franz law for metals. What is the reason for the failure of this law at very low temperatures ?
8. Briefly explain the origin of permanent magnetic dipoles in magnetic materials.
9. Discuss the concept of ferromagnetic domains.
10. Briefly explain any *one* of the applications of piezoelectric crystals.
11. Distinguish between type-I and type-II superconductors.
12. What is Meissner effect ?

(12 × 1 = 12 weightage)

**Turn over**

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

13. Explain BCC, FCC and HCP structures with the help of neat diagrams. Discuss the co-ordination numbers and packing fraction in each case.
14. Derive the dispersion relation for vibrations of diatomic lattices.
15. Obtain the expression for ground state energy (Fermi energy) of free electron gas in metals.
16. Derive the Curie law for paramagnetic materials.

(2 × 6 = 12 weightage)

**Part C**

*Answer any four questions.*

*Each question carries 3 weightage.*

17. Show that the volume of the first Brillouin zone is  $(2\pi)^3/V_c$ , where  $V_c$  is the volume of a primitive cell of real lattice space.
18. Debye characteristic frequency for carbon (diamond) is  $3.85 \times 10^{13}$  Hz. Calculate the (i) Debye temperature ; and (ii) specific heat capacity at 20 K. (Given  $k_B = 1.38 \times 10^{-23}$  JK<sup>-1</sup>,  $N = 6.02 \times 10^{23}$  atoms/mole)
19. Na metal has a typical electron density of  $10^{28}$  m<sup>-3</sup>. If Na has a room temperature conductivity of  $2 \times 10^7$  Ω<sup>-1</sup> m<sup>-1</sup>, calculate electron mean free path in this metal.
20. Using Hund's rule, obtain the quantum numbers S, L and J of the ground state of V<sup>3+</sup> and Fe<sup>2+</sup> ions (V: [Ar]3d<sup>3</sup>4s<sup>2</sup> and Fe : [Ar]3d<sup>6</sup>4s<sup>2</sup>).
21. The critical fields for a superconducting specimen are  $1.4 \times 10^5$  and  $4.2 \times 10^5$  A/m for 14 K and 13 K respectively. Calculate the (i) transition temperature ; and (ii) critical field at 5K.
22. If the electron concentration in a superconducting material at 0 K is  $10^{29}$  m<sup>-3</sup>, calculate London penetration depth assuming all electrons in the sample are superconducting electrons at 0 K.

(4 × 3 = 12 weightage)

**D 91053**

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.A./M.Sc./M.Com. DEGREE (REGULAR) EXAMINATION  
NOVEMBER 2020**

(CBCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Syllabus Year)

Time : Three Hours

Maximum : 30 Weightage

**General Instructions**

1. *In cases where choices are provided, students can attend all questions in each Section / Part.*
2. *The minimum number of questions to be attended from the Section / Part shall remain same.*
3. *There will be an overall ceiling for each Section / Part that is equivalent to maximum weightage of the Section / Part.*

**Section A**

**Eight Short questions answerable within 7½ minutes.**

**Answer all questions, each carry weightage 1.**

1. Explain the concept of Miller Indices and mention important features of Miller Indices.
2. Discuss the crystal structure of NaCl.
3. What are the basic assumptions on which the Debye theory is based ?
4. What are the limitations of free electron model in explaining Hall coefficient of metals ?
5. Distinguish between direct and indirect bandgap semiconductors. Give examples.
6. Briefly explain the concept of magnons in ferromagnetic materials.
7. What is superconductivity ? Discuss the type I and type II superconductors.
8. What is isotopic effect in superconductivity ?

(8 × 1 = 8 weightage)

**Section B**

**Four essay questions answerable within 30 minutes.**

**Answer any two questions, each carry weightage 5.**

9. Discuss the vibrations of a linear diatomic lattice. Obtain the dispersion relation and differentiate between the optical and acoustical branches.

**Turn over**

10. Explain how bands are formed in solids. Discuss the essential features of the behavior of electrons in a periodic potential using Kroning-Penny model.
11. Discuss Landau theory of ferroelectric phase transitions.
12. Discuss DC and AC Josephson effect and explain their importance.

(2 × 5 = 10 weightage)

### Section C

*Seven problems answerable within 15 minutes.*

*Answer any four questions, each carry weightage 3.*

13. Find the inter-planar spacing for (321) plane in a simple cubic lattice with lattice constant  $4.2 \times 10^{-8}$  cm.
14. Compute the cut-off frequency for a linear monoatomic lattice of interatomic distance  $3 \times 10^{-10}$  m, if the velocity of sound is  $3 \times 10^3$  m/s.
15. Calculate the Fermi energy at absolute zero of sodium metal if its atomic radius 1.86 Å.
16. A solid dielectric has electronic polarizability of  $10^{-40}$  Fm<sup>2</sup>. If the internal electric field be a Lorentz field. Find the dielectric constant of the material [Given density =  $3 \times 10^{28}$  atoms/m<sup>3</sup>.]
17. Copper has an FCC structure and the atomic radius is 0.1278 nm. Calculate the inter planar spacing for (111)-planes.
18. Find the order of magnitude of the exchange integral of a ferromagnet having curie temperature 727° C. What is the internal field ? [Given  $\mu_B = 9.3 \times 10^{-21}$  ergs/gauss].
19. For a superconductor the critical field at 0 K is  $6.39 \times 10^4$  A/m and the critical temperature for zero magnetic field is 7.18 K. What is the critical field for the material at 4 K ?

(4 × 3 = 12 weightage)

D 11690

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY)  
EXAMINATION, NOVEMBER 2021**

(CBCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

**General Instructions**

1. *In cases where choices are provided, students can attend **all** questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

**Section A**

8 Short questions answerable within 7.5 minutes.

Answer **all** questions, each question carries weightage 1.

1. What are symmetry operations ? Name the symmetry elements of a crystal.
2. What are the different types of bonding in the crystal and mention its characteristics ?
3. The one-dimensional monoatomic lattice acts as a low-pass filter. Explain.
4. What is Wiedemann -Franz law ?
5. What is Hall effect ? Give the expression for Hall co-efficient as predicted by free electron theory.
6. Explain the origin of the diamagnetism.
7. Distinguish between pyroelectric and piezoelectric materials.
8. What is the importance of high temperature superconductors ? Give one example with transition temperature.

(8 × 1 = 8 weightage)

**Turn over**

**Section B**

*4 essay questions answerable within 30 minutes.  
Answer any **two** questions, each carry weightage 5.*

9. What are the shortcomings of Einstein's theory of lattice specific heat? Explain Debye's theory of lattice specific heat.
10. Discuss with necessary theory the Kronig-Penny model and show how energy bands are formed in solids.
11. Distinguish between ferromagnetism and anti-ferromagnetisms. Describe the Neel model of anti-ferromagnetism.
12. Explain Meissner effect. Describe London equations and discuss how do they help in explaining superconducting state.

(2 × 5 = 10 weightage)

**Section C**

*7 problems answerable within 15 minutes.  
(Answer any **four** questions, each carry weightage 3.*

13. Silicon crystallizes in the diamond cubic structure. The radius of silicon atom is 0.1176 nm. The atomic weight and density of silicon are 28.09 and  $2.3 \times 10^3 \text{ kg/m}^3$ . Give me the number of atoms present in a unit cell.
14. If Einstein's temperature of a material is 157 K, find the value of  $C_v$  for the material at 100 K in cal/mol/K using Einstein's formula. Also calculate Einstein's frequency.
15. Find the relaxation time and mean free path of conduction electron in copper. For copper density of the free electron  $8.5 \times 10^{28}/\text{m}^3$ , resistivity  $1.69 \times 10^{-8} \text{ ohm-m}$  and average velocity of electron  $1.154 \times 10^5 \text{ m/s}$ .
16. Helium gas contains  $2.7 \times 10^{25} \text{ atoms/m}^3$  and dielectric constant of He atom NTD is 1.0000684. Calculate the electric polarizability of He atom.
17. A paramagnetic material has  $1028 \text{ atoms/m}^3$ . Its susceptibility at 350 K is  $2.8 \times 10^{-4}$ . Calculate susceptibility at 300 K.
18. A superconducting tin has a critical temperature of 3.7 K at zero magnetic field and a critical field of 0.0306 T at 0K. What is the critical field at 2K?
19. A beam of X-rays of wavelength  $0.842 \text{ \AA}$  is incident on a crystal at a glancing angle of  $8^\circ 35'$  when the first order Bragg reflection occurs. Calculate the glancing angle of the third order reflection.

(4 × 3 = 12 weightage)

D 31199

(Pages : 2)

Name.....

Reg. No.....

**THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY)  
EXAMINATION, NOVEMBER 2022**

(CBCSS)

Physics

PHY 3C 11—SOLID STATE PHYSICS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

**Section A**

*8 Short questions, answerable within 7.5 minutes  
Answer **all** questions, Each question carries weightage 1.*

1. What is the difference between a metallic bond and a covalent bond ?
2. Explain the concept of Phonons.
3. What is Dulong and Petti's law ? Why does Dulong and Petti's law fails at low temperature ?
4. What are Brillouin Zones ? Construct first Brillouin Zone for a two-dimensional square lattice.
5. What is effective mass of a charge carrier ? What is its importance ?
6. Explain Neel's theory of anti-ferromagnetism
7. Distinguish between hard and soft magnetic materials.
8. What is Meisner effect ?

(8 × 1 = 8 weightage)

**Section B**

*4 Essay questions, answerable within 30 minutes  
Answer any **two** questions, Each question carries weightage 5.*

9. Describe macroscopically the origin of static dielectric constant of a substance and discuss the classical theory of electronic polarization.
10. Obtain the expressions for the carrier concentrations in intrinsic semiconductor.

**Turn over**

11. What are reciprocal lattices ? Show the reciprocal lattice to BCC lattice is an FCC lattice and reciprocal lattice FCC lattice is BCC lattice.
12. Discuss BCS theory of superconductivity and briefly explain BCS ground state.

(2 × 5 = 10 weightage)

### Section C

*7 Problem answerable within 15 minutes*

*Answer any **four** questions, Each question carries weightage 3.*

13. The distance  $d_{100}$  between (100) plane s in BCC structure is 0.32 nm. What is the size of the unit cell ? What is the radius of the atom ?
14. Find the cut off frequency for a one-dimensional monoatomic chain given that the interatomic spacing is  $3\text{\AA}$  and velocity of sound 3000 m/s.
15. Find the Fermi velocity of the electrons if the number density of electrons in sodium is  $2.52 \times 10^{28} \text{ m}^{-3}$  at room temperature.
16. An electric field of 100 V/m is applied to a n-type semiconductor having hall co-efficient  $0.0125 \text{ m}^3/\text{C}$ . Determine the current density in the sample if the electron mobility is  $0.36 \text{ m}^2 \text{ v}^{-1} \text{ s}^{-1}$ .
17. If the magnetization and flux density of a magnetic material be 3200 A/m and  $0.005 \text{ Wb/m}^2$ . Calculate the relative permeability of the material.
18. The critical temperature for  $\text{H}_g$  with isotopic mass 199.5 is 4.18 K. Calculate the critical temperature for an isotopic mass 203.4
19. Copper has an FCC structure and the atomic radius is 0.1278 nm. Calculate the inter planar spacing for (110) and (212) -planes.

(4 × 3 = 12 weightage)