PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - Solid State Physics

All PYQs (2015-2025) with answer key

55 questions . Answer key included

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Q1. [Dec 2015] . 5.0 marks

Solid State Physics > Xray diffraction

CSIR NET	2015 Dec	5 M

The first order diffraction peak of a crystalline solid occurs at a scattering angle of 30^0 when the diffraction pattern is recorded using an x-ray beam of wavelength $0.15nm$. If the error in measurements of the wavelength and the angle are $0.01nm$ and 1^0 respectively, then the error in calculating the inter-planar spacing will approximately be

1. $1.1 \times 10^{-2}\ nm$
2. $1.3 \times 10^{-4} nm$
3. $2.5 \times 10^{-2} nm$
4. 2.0×10^{-3} nm

Q2. [Dec 2015] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2015 Dec	5 M

The dispersion relation of electrons in a 3 -dimensional lattice in the tight binding approximation is given by,

$$\varepsilon_k = \alpha \cos k_x a + \beta \cos k_y a + \gamma \cos k_z a$$

where a is the lattice constant and α, β, γ are constants with dimension of energy. The effective mass tensor at the corner of the first Brillouin zone $\left(\frac{\pi}{a}, \frac{\pi}{a}, \frac{\pi}{a}\right)$ is

1. $\frac{\hbar^2}{a^2}\begin{pmatrix} -\frac{1}{\alpha} & 0 & 0 \\ 0 & -\frac{1}{\beta} & 0 \\ 0 & 0 & \frac{1}{\gamma} \end{pmatrix}$

2. $\frac{\hbar^2}{a^2}\begin{pmatrix} -\frac{1}{\alpha} & 0 & 0 \\ 0 & -\frac{1}{\beta} & 0 \\ 0 & 0 & -\frac{1}{\gamma} \end{pmatrix}$

3. $\frac{\hbar^2}{a^2}\begin{pmatrix} \frac{1}{\alpha} & 0 & 0 \\ 0 & \frac{1}{\beta} & 0 \\ 0 & 0 & \frac{1}{\gamma} \end{pmatrix}$

4. $\frac{\hbar^2}{a^2}\begin{pmatrix} \frac{1}{\alpha} & 0 & 0 \\ 0 & \frac{1}{\beta} & 0 \\ 0 & 0 & -\frac{1}{\gamma} \end{pmatrix}$

Q3. [Dec 2015] . 5.0 marks
Solid State Physics > Free electron theory

CSIR NET	2015 Dec	5 M

A thin metal film of dimension $2mm \times 2mm$ contains 4×10^{12} electrons. The magnitude of the Fermi wavevector of the system, in the free electron approximation, is

1. $2\sqrt{\pi} \times 10^7 \text{ cm}^{-1}$
2. $\sqrt{2\pi} \times 10^7 \text{ cm}^{-1}$
3. $\sqrt{\pi} \times 10^7 \text{ cm}^{-1}$
4. $2\pi \times 10^7 \text{ cm}^{-1}$

Q4. [Dec 2015] . 5.0 marks
Solid State Physics > Tight binding model

CSIR NET	2015 Dec	5 M

For an electron moving through a one-dimensional periodic lattice of periodicity a, which of the following corresponds to an energy eigenfunction consistent with Bloch's theorem?

1. $\psi(x) = A \exp\left(i\left[\frac{\pi X}{a} + co\, s\left(\frac{\pi X}{2a}\right)\right]\right)$
2. $\psi(x) = A \exp\left(i\left[\frac{\pi x}{a} + co\, s\left(\frac{2\pi x}{a}\right)\right]\right)$
3. $\psi(x) = A \exp\left(i\left[\frac{2\pi x}{a} + i \cosh\left(\frac{2\pi x}{a}\right)\right]\right)$
4. $\psi(x) = A\exp\left(i\left[\frac{\pi x}{a} + i\left|\frac{\pi x}{2a}\right|\right]\right)$

Q5. [June 2015] . 3.5 marks

Solid State Physics > Semiconductor Physics

CSIR NET	2015 June	3.5 M

The concentration of electrons, n, and holes, p, for an intrinsic semiconductor at a temperature T can be expressed as $n = p = AT^{3/2}\exp\left(-\frac{E_g}{2k_BT}\right)$, where E_g is the band gap and A is a constant. If the mobility of both types of carriers is proportional to $T^{-3/2}$, then the log of the conductivity is a linear function of T^{-1}. with slope

1. $E_g/(2k_B)$
2. E_g/k_B
3. $-E_g/(2k_B)$
4. $-E_g/k_B$

Q6. [June 2015] . 5.0 marks
Solid State Physics > Xray diffraction

CSIR NET	2015 June	5 M

X-ray of wavelength $\lambda = a$ is reflected from the (111) plane of a simple cubic lattice. If the lattice constant is a, the corresponding Bragg angle (in radian) is

1. $\pi/6$
2. $\pi/4$
3. $\pi/3$
4. $\pi/8$

Q7. [June 2015] . 5.0 marks
Solid State Physics > Superconductivity

CSIR NET	2015 June	5 M

The critical magnetic fields of a superconductor at temperatures 4 K and 8 K are $11\ \mathrm{mA/m}$ and $5.5\ \mathrm{mA/m}$ respectively. The transition temperature is approximately

1. 8.4 K
2. 10.6 K
3. 12.9 K
4. 15.0 K

Q8. [Dec 2016] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2016 Dec	5M

Consider a one-dimensional chain of atoms with lattice constant a. The energy of an electron with wave-vector k is $\epsilon(k) = \mu - \gamma\cos(ka)$, where μ and γ are constants. If an electric field E is applied in the positive x-direction, the time dependent velocity of an electron is (In the following B is the constant)

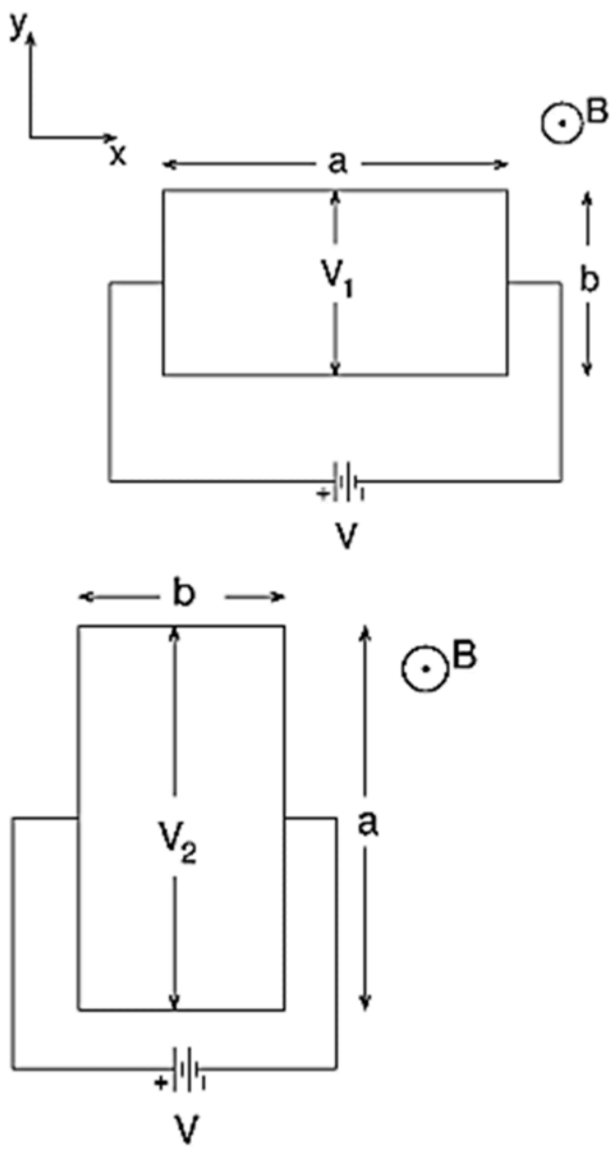
1. proportional to $\cos\left(B - \frac{eE}{\hbar}at\right)$
2. proportional to E
3. independent of E
4. proportional to $\sin\left(B - \frac{eE}{\hbar}at\right)$

Q9. [Dec 2016] . 5.0 marks
Solid State Physics > Hall effect

CSIR NET	2016 Dec	5M

A thin rectangular conducting plate of length a and width b is placed in the xy-plane in two different orientations, as shown in the figures below. In both cases a magnetic field B is applied in the z-direction and a current flows in the x direction due to the applied voltage V. If the Hall voltage across the y-direction in the two cases satisfy $V_2 = 2V_1$, the ratio a: b must be

1. 1: 2
2. 1: $\sqrt{2}$
3. 2:1
4. $\sqrt{2}$: 1

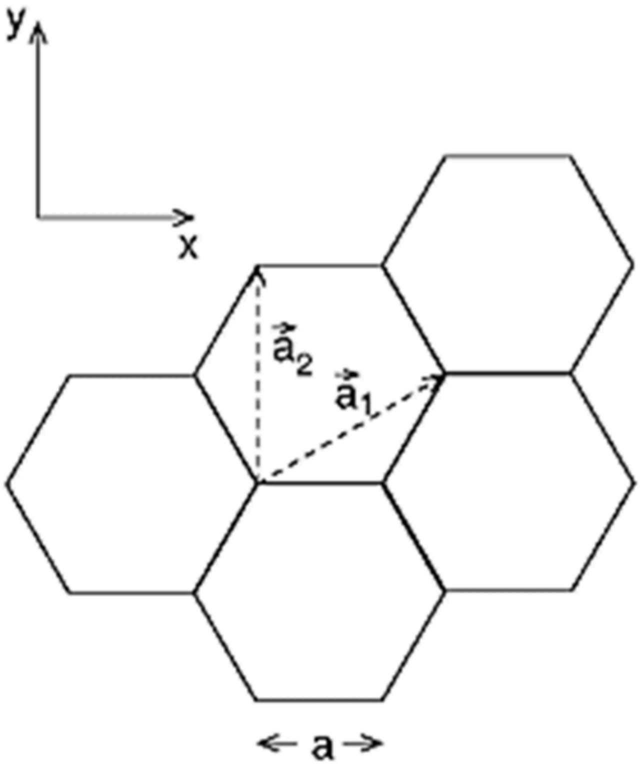


Q10. [Dec 2016] . 5.0 marks

Solid State Physics > Crystallography

CSIR NET	2016 Dec	5M

Consider a hexagonal lattice with basis vectors as shown in the figure below. If the lattice spacing is $a = 1$, the reciprocal lattice vectors are



1. $\left(\frac{4\pi}{3}, 0\right), \left(-\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right)$
2. $\left(\frac{4\pi}{3}, 0\right), \left(\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right)$
3. $\left(0, \frac{4\pi}{\sqrt{3}}\right), \left(\pi, \frac{2\pi}{\sqrt{3}}\right)$
4. $\left(\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right), \left(-2\pi, \frac{2\pi}{\sqrt{3}}\right)$

Q11. [June 2016] . 5.0 marks

Solid State Physics > Lattice vibrations

CSIR NET	2016 June	5M

Suppose the frequency of phonons in a onedimensional chain of atoms is proportional to the wavevector. If n is the number density of atoms and c is the speed of the phonons, then the Debye frequency is

1. $2\pi cn$
2. $\sqrt{2}\pi cn$
3. $\sqrt{3}\pi cn$
4. $\pi cn/2$

Q12. [June 2016] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2016 June	5M

The band energy of an electron in a crystal for a particular k-direction has the form

$\varepsilon(k) = A - B\cos 2ka$, where A and B are positive constants and $0 < ka < \pi$. The electron has a hole-like behaviour over the following range of k :

1. $\frac{\pi}{4} < ka < \frac{3\pi}{4}$
2. $\frac{\pi}{2} < ka < \pi$
3. $0 < ka < \frac{\pi}{4}$
4. $\frac{\pi}{2} < ka < \frac{3\pi}{4}$

Q13. [Dec 2017] . 5.0 marks
Solid State Physics > Xray diffraction

CSIR NET	2017 Dec	5M

A crystal of MnO has NaCl structure. It has a paramagnetic to anti- ferromagnetic transition at 120 K . Below 120 K , the spins within a single [111] planes are parallel but the spins in adjacent [111] planes are antiparallel. If neutron scattering is used to determine the lattice constants, respectively, d and d', below and above the transition temperature of MnO then

1. $d = \frac{d'}{2}$
2. $d = \frac{d'}{\sqrt{2}}$
3. $d = 2d'$
4. $d = \sqrt{2}d'$

Q14. [Dec 2017] . 5.0 marks
Solid State Physics > Tight binding model

CSIR NET	2017 Dec	5M

A metallic nanowire of length l is approximated as a one-dimensional lattice of N atoms with lattice spacing a. If the dispersion of electrons in the lattice is given as $E(k) = E_0 - 2t\cos ka$, where E_0 and t are constants, then the density of states inside the nanowire depends on E as

1. $N^3\sqrt{\frac{t^2}{E-E_0}}$
2. $\sqrt{\left(\frac{E-E_0}{2t}\right)^2 - 1}$
3. $N^3\sqrt{\frac{E-E_0}{t^2}}$
4. $\frac{N}{\sqrt{(2t)^2-(E-E_0)^2}}$

Q15. [Dec 2017] . 5.0 marks

Solid State Physics > Hall effect

CSIR NET	2017 Dec	5M

Consider a two-dimensional material of length l and width w subjected to a constant magnetic field B applied perpendicular to it. The number of change carries per unit area may be expressed as $n = k|q|\frac{B}{(2\pi\hbar)}$, where k is appositive real number and q is the carrier charge. Then the Hall resistivity ρ_{xy} is

1. $\frac{2\pi\hbar k}{q^2}\sqrt{\frac{l}{w}}$
2. $\frac{2\pi\hbar}{kq^2}\sqrt{\frac{w}{l}}$
3. $\frac{2\pi\hbar}{kq^2}$
4. $\frac{2\pi\hbar k}{q^2}$

Q16. [June 2017] . 5.0 marks

Solid State Physics > Semiconductor Physics

CSIR NET	2017 June	5M

The energy gap and lattice constant of an indirect band gap semiconductor are1.875 eV and $0.52nm$, respectively. For simplicity take the dielectric constant of the material to be unity. When it is excited by broadband radiation, an electron initially in the valence band at $k = 0$ makes a transition to the conduction band. The wavevector of the electron in the conduction band, in terms of the wavevector k_{max} at the edge of the Brillouin zone, after the transition is closest to

1. $k_{\text{max}}/10$
2. $k_{\text{max}}/100$
3. $k_{\text{max}}/1000$
4. 0

Q17. [June 2017] . 5.0 marks
Solid State Physics > Semiconductor Physics

CSIR NET	2017 June	5M

The electrical conductivity of copper is approximately 95% of the electrical conductivity of silver, while the electron density in silver is approximately 70% of the electron density in copper. In Drude's model, the approximate ratio τ_{Cu}/τ_{Ag} of the mean collision time in copper (τ_{Cu}) to the mean collision time in silver (τ_{Ag}) is

1. 0.44
2. 1.50
3. 0.33
4. 0.66

Q18. [Dec 2018] . 5.0 marks
Solid State Physics > Lattice vibrations

CSIR NET	2018 Dec	5M

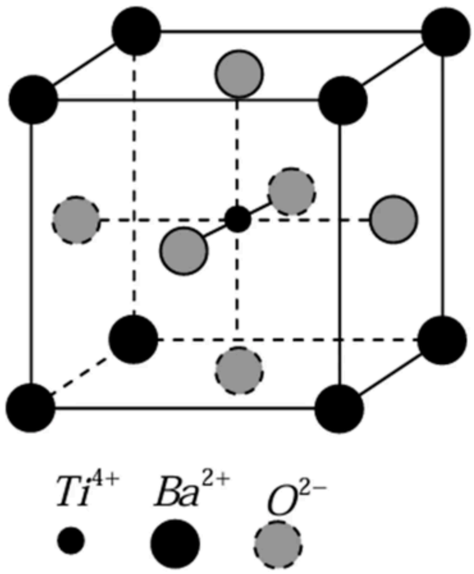
At low temperatures, in the Debye approximation, the contribution of the phonons to the heat capacity of a two dimensional solid is proportional to

1. T^2
2. T^3
3. $T^{1/2}$
4. $T^{3/2}$

Q19. [Dec 2018] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2018 Dec	5M

Barium Titanate ($\mathrm{BaTiO_3}$) crystal has a cubic perovskite structure, where the Ba^{2+} ions are at the vertices of a unit cube, the O^{2-} ions are at the centers of the faces while the Ti^{2+} is at the center. The number of optical phonon modes of the crystal is



1. 12
2. 15
3. 5
4. 18

Q20. [Dec 2018] . 5.0 marks
Solid State Physics > Tight binding model

CSIR NET	2018 Dec	5M

The dispersion relation of optical phonons in a cubic crystal is given by $\omega(k) = \omega_0 - ak^2$ where ω_0 and a are positive constants. The contribution to the density of states due to these phonons with frequencies just below ω_0 is proportional to

1. $(\omega_0 - \omega)^{1/2}$
2. $(\omega_0 - \omega)^{3/2}$
3. $(\omega_0 - \omega)^2$
4. $(\omega_0 - \omega)$

Q21. [Dec 2018] . 5.0 marks

Solid State Physics > Semiconductor Physics

CSIR NET	2018 Dec	5M

A silicon crystal is doped with phosphorus atoms. (The binding energy of a H atom is $13.6eV$, the dielectric constant of silicon is 12 and the effective mass of electrons in the crystal is $0.4m_e$). The gap between the donor energy level and the bottom of the conduction band is nearest to

1. 0.01 eV
2. 0.08 eV
3. 0.02 eV
4. 0.04 eV

Q22. [June 2018] . 5.0 marks

Solid State Physics > Xray diffraction

CSIR NET	2018 June	5M

Sodium Chloride (NaCl) crystal is a face-centered cubic lattice with a basis consisting of $\mathrm{Na}^{+}$and Cl^{-}ions separated by half the body diagonal of a unit cube. Which of the planes corresponding to the Miller indices given below will not give rise to Bragg reflection of X-rays?

1. (220)
2. (242)
3. (221)
4. (311)

Q23. [June 2018] . 5.0 marks
Solid State Physics > Semiconductor Physics

CSIR NET	2018 June	5M

The dispersion relation for the electrons in the conduction band of a semiconductor is given by $E = E_0 + \alpha k^2$ where α and E_0 are constants. If ω_c is the cyclotron resonance frequency of the conduction band electrons in a magnetic field B, the value of α is

1. $\frac{\hbar\omega_c}{4eB}$
2. $\frac{2\hbar^2\omega_c}{eB}$
3. $\frac{\hbar^2\omega_c}{eB}$
4. $\frac{\hbar^2\omega_c}{2eB}$

Q24. [June 2018] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2018 June	5M

Hard discs of radius R are arranged in a two-dimensional triangular lattice. What is the fractional area occupied by the discs in the closest possible packing?

1. $\frac{\pi\sqrt{3}}{6}$
2. $\frac{\pi}{3\sqrt{2}}$
3. $\frac{\pi\sqrt{2}}{5}$
4. $\frac{2\pi}{7}$

Q25. [Dec 2019] . 5.0 marks

Solid State Physics > Hall effect

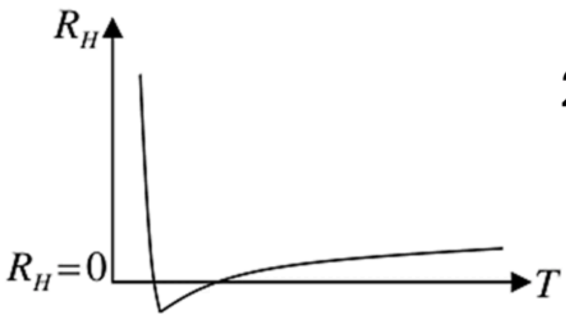
CSIR NET	2019 Dec	5M

The Hall coefficient for a semiconductor having both types of carriers is given as

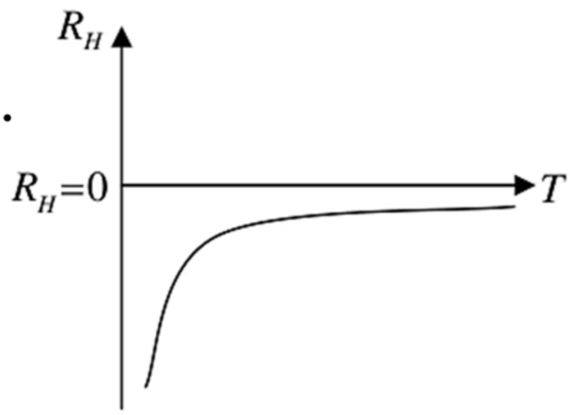
$$R_H = \frac{p\mu_p^2 - n\mu_n^2}{|e|\left(p\mu_p + n\mu_n\right)^2}$$

where p and n are the carrier densities of the holes and electrons, μ_p and μ_n are their respective mobilities. For a p-type semiconductor in which the mobility of holes is less than that of electrons, which of the following graphs best describes the variation of the Hall coefficient with temperature?

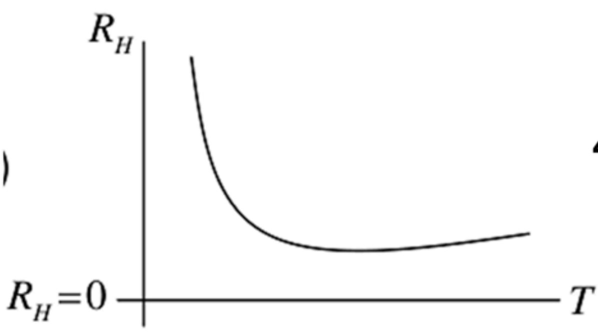
1.)



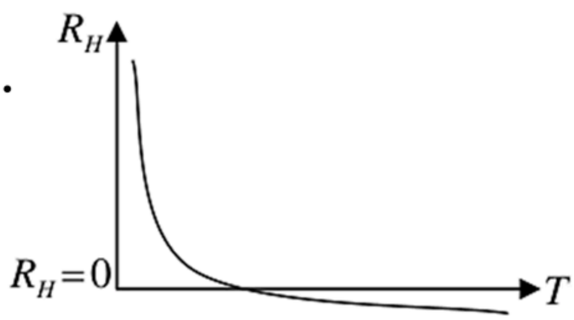
2.



3.)



4.



Q26. [Dec 2019] . 5.0 marks
Solid State Physics > Superconductivity

CSIR NET	2019 Dec	5M

In the AC Josephson effect, a supercurrent flows across two superconductors separated by a thin insulating layer and kept at an electric potential difference ΔV. The angular frequency of the resultant supercurrent is given by

1. $\frac{2e\Delta V}{\hbar}$
2. $\frac{e\Delta V}{\hbar}$
3. $\frac{e\Delta V}{\pi\hbar}$
4. $\frac{e\Delta V}{2\pi\hbar}$

Q27. [Dec 2019] . 5.0 marks
Solid State Physics > Lattice vibrations

CSIR NET	2019 Dec	5M

For T much less than the Debye temperature of copper, the temperature dependence of the specific heat at constant volume of copper, is given by (in the following a and b are positive constants)

1. aT^3
2. $aT + bT^3$
3. $aT^2 + bT^3$
4. $\exp\left(-\frac{a}{k_B T}\right)$

Q28. [June 2019] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2019 June	5M

The third-nearest neighbor distance in a BCC (Body Centered Cubic) crystal with lattice constant a_0 is

1. a_0
2. $\frac{3a_0}{2}$
3. $\sqrt{3}a_0$
4. $\sqrt{2}a_0$

Q29. [June 2019] . 5.0 marks
Solid State Physics > Semiconductor Physics

CSIR NET	2019 June	5M

A bound electron and hole pair interacting via Coulomb interaction in a semiconductor is called an exciton. The effective masses of an electron and a hole are about $0.1m_e$ and $0.5m_e$ respectively, where m_e is the rest mass of the electron. The dielectric constant of the semiconductor is 10 . Assuming that the energy levels of the excitons are hydrogen- like, the binding energy of an exciton (in units of the Rydberg constant) is closest to

1. 2×10^{-3}
2. 2×10^{-4}
3. 8×10^{-4}
4. 3×10^{-3}

Q30. [June 2019] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2019 June	5M

Consider an array of atoms in one dimension with an ensemble averaged periodic density distribution as shown in the figure.

If k is the wave number and $S(k,\Delta)$ denotes the Fourier transform of the density-density correlation function, the ratio $\frac{S(k,\Delta)}{S(k,0)}$ is

1. $\cos\left(\frac{k\Delta}{2}\right)$
2. $\cos^2\left(\frac{k\Delta}{2}\right)$
3. $\frac{2}{k\Delta}\sin\left(\frac{k\Delta}{2}\right)$
4. $\frac{4}{k^2\Delta^2}\sin^2\left(\frac{k\Delta}{2}\right)$

Q31. [June 2020] . 5.0 marks

Solid State Physics > Free electron theory

CSIR NET	2020 June	5M

A certain two-dimensional solid crystallises to a square monoatomic lattice with lattice constant a. Each atom can contribute an integer number of free conduction electrons. The minimum number of electrons each atom must contribute such that the free electron Fermi circle at zero temperature encloses the first Brillouin zone completely, is

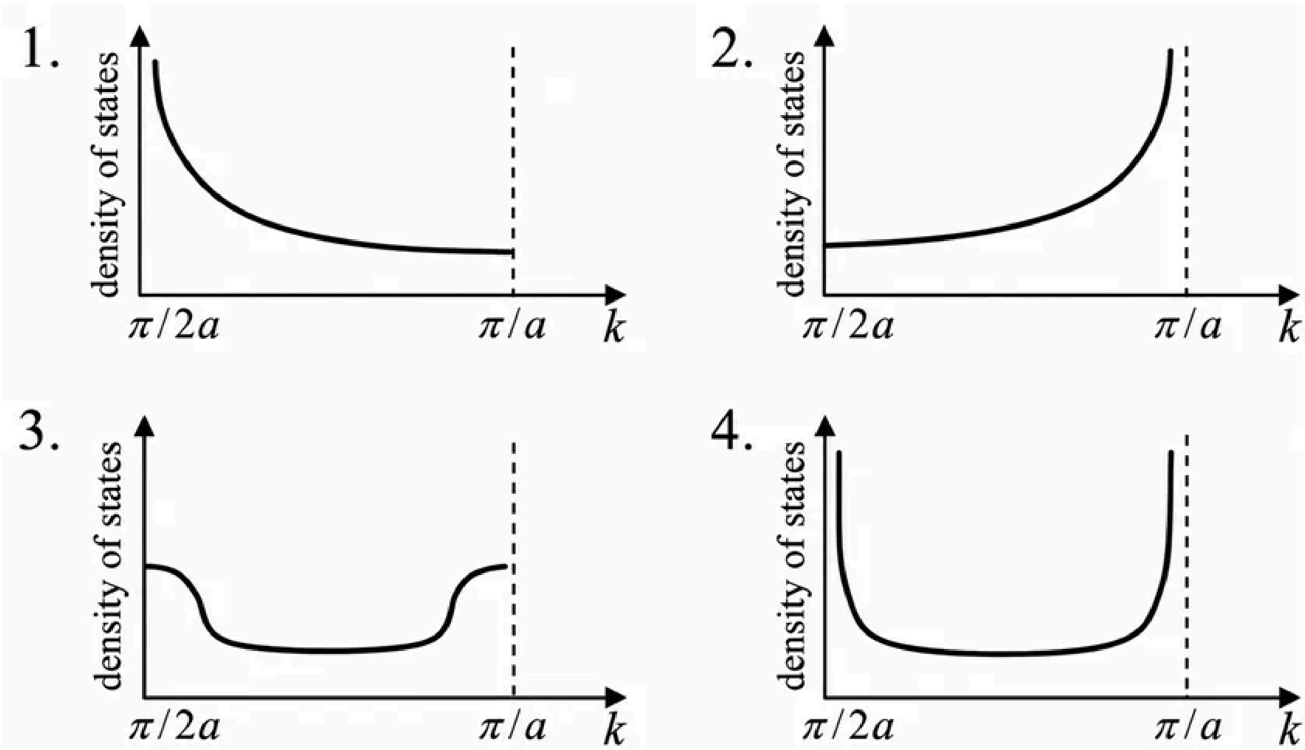
1. 3
2. 1
3. 4
4. 2

Q32. [June 2020] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2020 June	5M

A tight binding model of electrons in one dimension has the dispersion relation $\varepsilon(k) = -2t(1 - \cos ka)$, where $t > 0$, a is the lattice constant and $-\frac{\pi}{a} < k < \frac{\pi}{a}$. Which of the following figures best represents the density of states over the range $\frac{\pi}{2a} \leq k < \frac{\pi}{a}$?



Q33. [June 2020] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2020 June	5M

A lattice is defined by the unit vectors $\vec{a}_1 = a\hat{i}, \vec{a}_2 = -\frac{a}{2}\hat{i} + \frac{a\sqrt{3}}{2}\hat{j}$ and $\vec{a}_3 = a\hat{k}$, where $a > 0$ is a constant. The spacing between the (100) planes of the lattice is

1. $\sqrt{3}a/2$
2. $a/2$
3. a
4. $\sqrt{2}a$

Q34. [June 2021] . 3.5 marks

Solid State Physics > Lattice vibrations

CSIR NET	2021 June	3.5M

The total number of phonon modes in a solid of volume V is $\int_0^{\omega_D} g(\omega)d\omega = 3N$, is the number of primitive cells, ω_D is the Debye frequency and density of photon modes is $g(\omega) = AV\omega^2$ (with $A > 0$ a constant). If the density of the solid doubles in a phase transition, the Debye temperature θ_D will

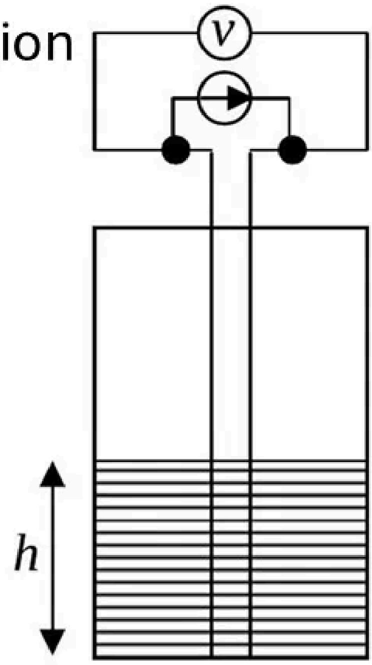
1. increase by a factor of $2^{2/3}$
2. increase by a factor of $2^{1/3}$
3. decrease by a factor of $2^{2/3}$
4. decrease by a factor of $2^{1/3}$

Q35. [June 2021] . 5.0 marks

Solid State Physics > Superconductivity

CSIR NET	2021 June	5M

To measure the height h of a column of liquid helium in a container, a constant current I is sent through an NbTi wire of length l, as shown in the figure. The normal state resistance of the NbTi wire is R. If the superconducting transition temperature of NbTi is $\approx 10K$, then the measured voltage $V(h)$ is best described by the expression



1. $IR\left(\frac{1}{2}-\frac{2h}{l}\right)$
2. $IR\left(1-\frac{h}{l}\right)$
3. $IR\left(\frac{1}{2}-\frac{h}{l}\right)$
4. $IR\left(1-\frac{2h}{l}\right)$

Q36. [June 2021] . 5.0 marks

Solid State Physics > Superconductivity

CSIR NET	2021 June	5M

Lead is superconducting below 7 K and has a critical magnetic field 800×10^{-4} tesla close to 0 K. At 2 K the critical current that flows through a long lead wire of radius 5 mm is closest to

1. 1760 A
2. 1670 A
3. 1950 A
4. 1840 A

Q37. [June 2021] . 5.0 marks

Solid State Physics > Xray diffraction

CSIR NET	2021 June	5M

Potassium chloride forms an FCC lattice, in which K and Cl occupy alternating sites. The density of KCl is $1.98\ \mathrm{g/cm^3}$ and the atomic weights of K and Cl are 39.1 and 35.5, respectively. The angles of incidence (in degrees) for which Bragg peaks will appear when X ray of wavelength 0.4 nm is shone on a KCl crystal are

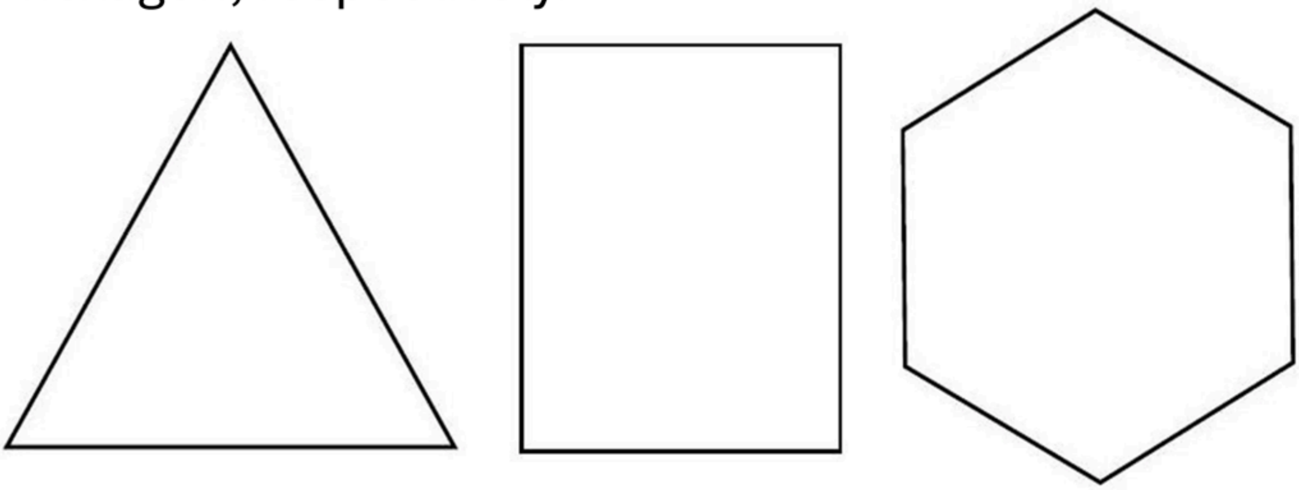
1. 18.5,39.4 and 72.2
2. 19.5 and 41.9
3. 12.5, 25.7, 40.5 and 60.0
4. 13.5, 27.8, 44.5 and 69.0

Q38. [June 2022] . 5.0 marks

Solid State Physics > Crystallography

CSIR NET	2022 June	5M

The Figures (i), (ii) and (iii) below represent an equilateral triangle, a rectangle and a regular hexagon, respectively.



(i) (ii) (iii)

Which of these can be primitive unit cells of a Bravais lattice in two dimensions?

1. only (i) and (iii) but not (ii)
2. only (i) and (ii) but not (iii)
3. only (ii) and (iii) but not (i)
4. All of them

Q39. [Dec 2023] . 5.0 marks
Solid State Physics > Free electron theory

CSIR NET	2023 Dec	5 M

The lattice constant of the bcc structure of sodium metal is 4.22Å. Assuming the mass of the electron inside the metal to be the same as free electron mass, the free electron Fermi energy is closest to

1. 3.2 eV
2. 2.9 eV
3. 3.5 eV
4. 2.5 eV

Q40. [Dec 2023] . 5.0 marks
Solid State Physics > Free electron theory

CSIR NET	2023 Dec	5 M

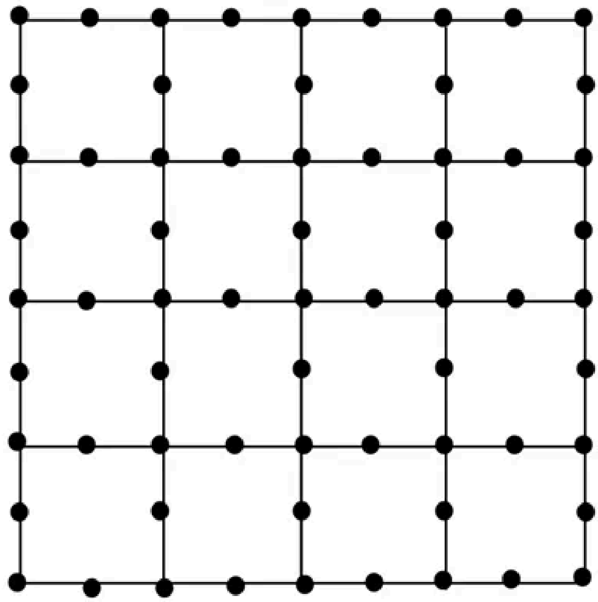
The collision time of the electrons in a metal in the Drude model is τ and their plasma frequency is ω_p. If this metal is placed between the plates of a capacitor, the time constant associated with the decay of the electric field inside the metal is

1. $\tau + \frac{1}{\omega_p}$
2. $\omega_p \tau^2$
3. $\frac{1}{\omega_p^2 \tau}$
4. $\frac{\tau}{1+\omega_p \tau}$

Q41. [Dec 2023] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2023 Dec	5 M

In the section of an infinite lattice shown in the figure below, all sites are occupied by identical hard circular discs so that the resulting structure is tightly packed.



The packing fraction is

1. $\frac{3\pi}{4}$
2. $\frac{\pi}{4}$
3. $\frac{3\pi}{16}$
4. $\frac{9\pi}{16}$

Q42. [June 2023] . 5.0 marks
Solid State Physics > Hall effect

CSIR NET	2023 June	5M

The Hall coefficient R_H of a sample can be determined from the measured Hall voltage $V_H = \frac{1}{d} R_H BI + RI$, where d is the thickness of the sample, B is the applied magnetic field, I is the current passing through the sample and R is an unwanted offset resistance. A lock-in detection technique is used by keeping I constant with the applied magnetic field being modulated as $B = B_0 \sin \Omega t$, where B_0 is the amplitude of the magnetic field and Ω is frequency of the reference signal. The measured V_H is

1. $B_0 \left(\frac{R_H I}{d}\right)$
2. $\frac{B_0}{\sqrt{2}} \left(\frac{R_H I}{d}\right)$
3. $\frac{I}{\sqrt{2}} \left(\frac{R_H B_0}{d} + R\right)$
4. $I \left(\frac{R_H B_0}{d} + R\right)$

Q43. [June 2023] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2023 June	5M

A lattice A consists of all points in three-dimensional space with coordinates (n_x, n_y, n_z) where n_x, n_y and n_z are integers with $n_x + n_y + n_z$ being odd integers. In another lattice B, $n_x + n_y + n_z$ are even integers. The lattices A and B are

1. both BCC
2. both FCC
3. BCC and FCC, respectively
4. FCC and BCC, respectively

Q44. [Dec 2024] . 5.0 marks
Solid State Physics > Superconductivity

CSIR NET	2024 Dec	5M

Magnetization M as a function of applied magnetic field H for two different solid samples at temperature T are shown below. These samples are known to be superconducting below their respective critical temperatures (T_C).

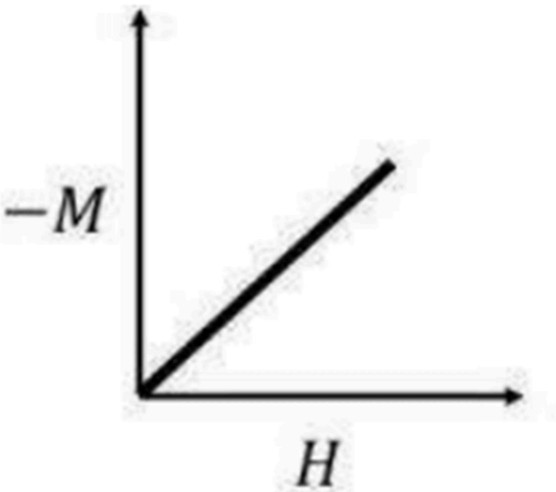


Fig. 1

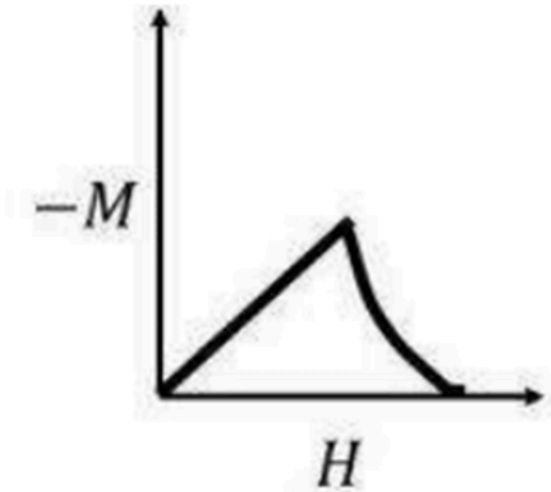


Fig. 2

The correct set of statements is

1. Fig. 1: Type I superconductor above T_C;

   Fig. 2: Type II superconductor below T_C and upto upper critical field;
2. Fig. 1: Type II superconductor below T_C and upto upper critical field;

   Fig. 2: Type II superconductor below T_C and upto lower critical field.
3. Fig. 1: Type I superconductor below T_C and below critical field;

   Fig. 2: Type II superconductor below T_C upto upper critical field;
4. Fig. 1: Type I superconductor below T_C and below critical

Q45. [Dec 2024] . 5.0 marks
Solid State Physics > Tight binding model

CSIR NET	2024 Dec	5M

Consider N mutually non-interacting electrons moving in a crystal where the ionic potential seen by an electron satisfies the condition $V(\vec{r}) = V(\vec{r} + \vec{R})$, where $\vec{R}$ is one of the lattice translation vectors. The energy eigenstates of the electrons are labelled as $\psi_{\vec{k}}(\vec{r})$ where $\vec{k}$ is a vector in the first Brillouin zone. Which of the following is true?

1. $\left|\psi_{\vec{k}}(\vec{r})\right|$ is constant.
2. $\psi_{\vec{k}}(\vec{r})$ is also an eigenstate of the momentum operator.
3. $\psi_{\vec{k}}(\vec{r}) = \psi_{\vec{k}}(\vec{r} + \vec{R})$
4. $\left|\psi_{\vec{k}}(\vec{r})\right| = \left|\psi_{\vec{k}}(\vec{r} + \vec{R})\right|$

Q46. [Dec 2024] . 5.0 marks

Solid State Physics > Free electron theory

CSIR NET	2024 Dec	5M

Consider a free fermion gas in a hypercubic infinite potential well in hypothetical 4-dimensional space. What will be the expression for ground state energy per particle in term of the Fermi energy E_F ? (Ignore spin degeneracy of the fermions)

1. $\frac{4}{5}E_F$
2. $\frac{2}{3}E_F$
3. $\frac{1}{3}E_F$
4. $\frac{2}{5}E_F$

Q47. [Dec 2024] . 5.0 marks
Solid State Physics > Crystallography

CSIR NET	2024 Dec	5M

The lattice spacing in a simple cubic lattice is given to be 5Å. The number of lattice points per square nanometer in the lattice plane with Miller index (212) is closest to

1. 7.5
2. 3
3. 1.33
4. 0.66

Q48. [June 2024] . 5.0 marks
Solid State Physics > Lattice vibrations

CSIR NET	2024 June	5M

The Debye temperature of a two-dimensional insulator is 150 K . The ratio of the heat required to raise its temperature from 1 K to 2 K and from 2 K to 3 K is

1. 7: 19
2. 3: 13
3. 1: 1
4. 3: 5

Q49. [June 2024] . 5.0 marks

Solid State Physics > Crystallography

CSIR NET	2024 June	5M

Consider a body-centered tetragonal lattice with lattice constants $a = b = a_0$ and $C = \frac{a_0}{2}$. The number of nearest neighbours, the nearest neighbour distance, the number of next nearest neighbours and the next nearest neighbour distance, respectively, are

1. $6, \frac{1}{2}a_0, 8\frac{\sqrt{3}}{2}a_0$
2. $8, \frac{\sqrt{3}}{2}a_0, 6, a_0$
3. $2, \frac{1}{2}a_0, 8, \frac{3}{4}a_0$
4. $8, a_0, 6, \frac{4}{3}a_0$

Q50. [June 2024] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2024 June	5M

The band dispersion of electrons in a two-dimensional square lattice (lattice constant a) is given by,

$$E(k_x, k_y) = -2(t_x \cos k_x a + t_y \cos k_y a)$$

where $t_x, t_y > 0$. The effective mass tensor $m^* = \begin{pmatrix} m_{xx} & m_{xy} \\ m_{yx} & m_{yy} \end{pmatrix}$ of electrons at $\vec{k} = \left(\frac{\pi}{a}, \frac{\pi}{a}\right)$ is

1. $\begin{pmatrix} 0 & \frac{\hbar^2}{2a^2\sqrt{t_x t_y}} \\ \frac{\hbar^2}{2a^2\sqrt{t_x t_y}} & 0 \end{pmatrix}$

2. $\begin{pmatrix} \frac{\hbar^2}{2a^2 t_x} & 0 \\ 0 & \frac{\hbar^2}{2a^2 t_y} \end{pmatrix}$

3. $\begin{pmatrix} -\frac{\hbar^2}{2a^2 t_x} & 0 \\ 0 & -\frac{\hbar^2}{2a^2 t_y} \end{pmatrix}$

4. $\begin{pmatrix} 0 & -\frac{\hbar^2}{2a^2(t_x + t_y)} \\ -\frac{\hbar^2}{2a^2(t_x + t_y)} & 0 \end{pmatrix}$

Q51. [Dec 2025] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2025 Dec	5M	SSP

In a one-dimensional chain of atoms, the phonon energy dispersion is given by $E = A|\sin(ka)|$. Here, A is a constant, k is a vector in the reciprocal space and a is lattice spacing. The density of states is proportional to

1. $\frac{1}{\sqrt{A^2-E^2}}$
2. $\frac{1}{\sqrt{A^2+E^2}}$
3. $\frac{1}{\sqrt{A-E}}$
4. $\frac{1}{\sqrt{A+E}}$

Q52. [Dec 2025] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2025 Dec	5M	SSP

Consider a one-dimensional chain of atoms with lattice constant a. The energy of an electron with wave-vector k is $\epsilon(k) = \mu - 2\gamma\cos(ka)$, where μ and γ are constants. If an electric field $\vec{E}$ is applied along the chain, the time dependent velocity of the electron is proportional to (assume initial wave vector $k = k_0$ at $t = 0$)

1. $\sin^2\left(k_0 a - \frac{eEa}{\hbar} t\right)$.
2. $\cos\left(k_0 a - \frac{eEa}{\hbar} t\right)$.
3. $\sin\left(k_0 a - \frac{eEa}{\hbar} t\right)$.
4. $\cos^2\left(k_0 a - \frac{eEa}{\hbar} t\right)$.

Q53. [Dec 2025] . 5.0 marks

Solid State Physics > Lattice vibrations

CSIR NET	2025 Dec	5M	SSP

A cubic sample of edge length L is maintained at a temperature of 4 K . The speed of sound in the material of the sample is 5×10^3 m/s. The minimum value of L required to excite the lowest frequency phonon mode is closest to

1. 10 nm
2. 30 nm
3. 20 nm
4. 5 nm

Q54. [June 2025] . 5.0 marks

Solid State Physics > Superconductivity

CSIR NET	2025 June	5M	SSP

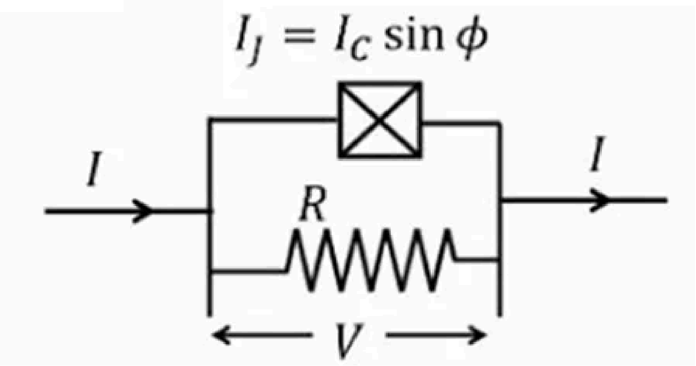
The current $I_J(t)$ through a Josephson junction (shown by the crossed box in the figure) and the voltage $V(t)$ across it, are given by

$$I_J(t) = I_C \sin\phi(t)$$
$$\frac{d\phi(t)}{dt} = \frac{2eV(t)}{\hbar}$$

where I_C is the critical current of the junction and $\phi(t)$ is the phase difference across the junction. A resistor R is connected in parallel to the junction and a constant current $I > I_C$ flows through the combination as shown.

The energy dissipated in R in the time ϕ changes by 2π is

1. $\frac{h}{2e} I$
2. $\frac{h}{2e} I_C$
3. $\frac{h}{2e}(I - I_C)$
4. $\frac{h}{2e}(I + I_C)$



Q55. [June 2025] . 5.0 marks
Solid State Physics > Semiconductor Physics

CSIR NET	2025 June	5M	SSP

A semiconductor has the dispersion relation $E = E_0 - A\cos(\alpha k_x)$, where A and α are positive constants. The effective electron mass close to the minimum energy is

1. $\frac{\hbar^2}{A^2\alpha}$
2. $\frac{1}{4}\frac{\hbar^2}{A^2\alpha}$
3. $\frac{\hbar^2}{A\alpha^2}$
4. $\frac{1}{2}\frac{\hbar^2}{A\alpha^2}$

Answer Key

55 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Solid State Physics	Xray diffraction	**1**
Q2	Solid State Physics	Tight binding model	**3**
Q3	Solid State Physics	Free electron theory	**2**
Q4	Solid State Physics	Tight binding model	**2**
Q5	Solid State Physics	Semiconductor Physics	**3**
Q6	Solid State Physics	Xray diffraction	**3**
Q7	Solid State Physics	Superconductivity	**2**
Q8	Solid State Physics	Tight binding model	**1 or 4**
Q9	Solid State Physics	Hall effect	**4**
Q10	Solid State Physics	Crystallography	**1**
Q11	Solid State Physics	Lattice vibrations	**1**
Q12	Solid State Physics	Tight binding model	**1**
Q13	Solid State Physics	Xray diffraction	**3**
Q14	Solid State Physics	Tight binding model	**4**
Q15	Solid State Physics	Hall effect	**3**
Q16	Solid State Physics	Semiconductor Physics	**3**
Q17	Solid State Physics	Semiconductor Physics	**4**
Q18	Solid State Physics	Lattice vibrations	**1**
Q19	Solid State Physics	Crystallography	**1**
Q20	Solid State Physics	Tight binding model	**1**
Q21	Solid State Physics	Semiconductor Physics	**4**
Q22	Solid State Physics	Xray diffraction	**3**
Q23	Solid State Physics	Semiconductor Physics	**4**
Q24	Solid State Physics	Crystallography	**1**
Q25	Solid State Physics	Hall effect	**4**
Q26	Solid State Physics	Superconductivity	**1**
Q27	Solid State Physics	Lattice vibrations	**2**
Q28	Solid State Physics	Crystallography	**4**
Q29	Solid State Physics	Semiconductor Physics	**3**
Q30	Solid State Physics	Tight binding model	**3**
Q31	Solid State Physics	Free electron theory	**3**
Q32	Solid State Physics	Tight binding model	**2**
Q33	Solid State Physics	Crystallography	**1**
Q34	Solid State Physics	Lattice vibrations	**2**
Q35	Solid State Physics	Superconductivity	**4**
Q36	Solid State Physics	Superconductivity	**4**
Q37	Solid State Physics	Xray diffraction	**1**
Q38	Solid State Physics	Crystallography	**3**
Q39	Solid State Physics	Free electron theory	**1**
Q40	Solid State Physics	Free electron theory	**3**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Solid State Physics	Crystallography	**3**
Q42	Solid State Physics	Hall effect	**2**
Q43	Solid State Physics	Crystallography	**2**
Q44	Solid State Physics	Superconductivity	**3**
Q45	Solid State Physics	Tight binding model	**4**
Q46	Solid State Physics	Free electron theory	**2**
Q47	Solid State Physics	Crystallography	**3**
Q48	Solid State Physics	Lattice vibrations	**1**
Q49	Solid State Physics	Crystallography	**3**
Q50	Solid State Physics	Tight binding model	**3**
Q51	Solid State Physics	Tight binding model	**1**
Q52	Solid State Physics	Tight binding model	**3**
Q53	Solid State Physics	Lattice vibrations	**2**
Q54	Solid State Physics	Superconductivity	**1**
Q55	Solid State Physics	Semiconductor Physics	**3**

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