Roll No. ....

O. M. R. Serial No.

Question Booklet Number

M. Sc. (Second Semester)

(NEP) EXAMINATION, 2025-26

PHYSICS

(Solid State Physics)

Paper Code							
B	0	1	0	8	0	2	T

Questions Booklet Series

B

Time : 1:30 Hours]

[*Maximum Marks : 75*

Instructions to the Examinee :

1. Do not open the booklet unless you are asked to do so.
2. The booklet contains 100 questions. Examinee is required to answer 75 questions in the OMR Answer-Sheet provided and not in the question booklet. All questions carry equal marks.
3. Examine the Booklet and the OMR Answer-Sheet very carefully before you proceed. Faulty question booklet due to missing or duplicate pages/questions or having any other discrepancy should be got immediately replaced.

(Remaining instructions on the last page)

परीक्षार्थियों के लिए निर्देश :

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।
2. प्रश्न-पुस्तिका में 100 प्रश्न हैं। परीक्षार्थी को 75 प्रश्नों को केवल दी गई OMR आन्सर-शीट पर ही हल करना है, प्रश्न-पुस्तिका पर नहीं। सभी प्रश्नों के अंक समान हैं।
3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR आन्सर-शीट को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका जिसमें कुछ भाग छपने से छूट गए हों या प्रश्न एक से अधिक बार छप गए हों या उसमें किसी अन्य प्रकार की कमी हो, तो उसे तुरन्त बदल लें।

(शेष निर्देश अन्तिम पृष्ठ पर)

(Only for Rough Work)

1. Energy quanta of mechanical or elastic wave is known as :

   (A) Photon

   (B) Phonon

   (C) Magnon

   (D) Polaron

2. If K_P and G are phonon and reciprocal wave vectors, then change in wave vectors ΔK of incident and scattered waves under inelastic scattering is equal to :

   (A) $\Delta K = G + K_P$

   (B) $\Delta K = G - K_P$

   (C) $\Delta K = G \pm K_P$

   (D) $\Delta K = G \,.\, K_P$

3. If the longitudinal, transverse and Debye average velocities are V_L, V_T and V_D, then the relation among them is :

   (A) $\frac{3}{V_D^3} = \frac{1}{V_L^3} + \frac{2}{V_T^3}$

   (B) $\frac{3}{V_D^2} = \frac{1}{V_L^2} + \frac{2}{V_T^2}$

   (C) $V_D = \frac{V_L + V_T}{2}$

   (D) $V_D = \frac{V_L + 2V_T}{3}$

4. The molar specific heat capacity of a solid at high temperatures as per Dulong-Petit law is equal to :

   (A) 3R

   (B) 2R

   (C) R

   (D) 1.5R

5. Which statement is incorrect according to Einstein theory of specific heat of solids ?

   (A) Atoms in a solid behave as independent quantum harmonic oscillators and have same frequency (ω_0).

   (B) The energy of an atomic oscillator is $\hbar\omega_0(n+1/2)$.

   (C) Einstein temperature (θ_E) for solid is $\hbar\omega_0 / k_B$.

   (D) Molar specific heat of solid at $T > \theta_E$ is equal to 3R/2.

6. If θ_E is Einstein temperature, then which one is correct for specific heat of solid at $T << \theta_E$?

   (A) $C_V \propto (\theta_E T)^2 \exp(+\theta_E / T)$

   (B) $C_V \propto (\theta_E T)^{-2} \exp(+\theta_E / T)$

   (C) $C_V \propto (\theta_E / T)^2 \exp(-\theta_E / T)$

   (D) $C_V \propto (\theta_E / T)^{-2} \exp(-\theta_E / T)$

7. If V_D is Debye average velocity and n is atomic concentration in solid, then the value for angular Debye frequency ω_D is :

(A) $V_D\left(6\pi^2 n\right)^{1/3}$

(B) $V_D\left(6\pi^2 n\right)^{-1/3}$

(C) $\sqrt{V_D}\left(6\pi^2 n\right)^{1/3}$

(D) $\sqrt{V_D}\left(6\pi^2 n\right)^{-1/3}$

8. Which statement is not true under the Debye theory of specific heat ?

(A) Atoms in a solid have variable range oscillation frequency. The maximum frequency is called Debye frequency (ω_D).

(B) Temperature corresponding to Debye frequency is called as Debye temperature $\left(\theta_D = \hbar\omega_D / k_B\right)$

(C) For $T >> \theta_D, C_V = 3R$ and for $T << \theta_D, C_V \propto T^3$.

(D) The average energy is proportional to T^2 for $T << \theta_D$.

9. Which one correctly defines the Bloch potential for a linear lattice ?

(A) $V(x+a) = V(x)$

(B) $V(x+a) = e^{+ika}V(x)$

(C) $V(x+a) = e^{-ika}V(a)$

(D) $V(x+a) = e^{\pm ika}V(a)$

10. Which is correct for the Bloch wave function (ψ) associated with electron in linear lattice having 'a' lattice parameter ?

(A) $\psi(x+a) = e^{\pm ika}\psi(x)$

(B) $|\psi(x+a)| = |\psi(x)|$

(C) Both (A) and (B)

(D) None of the above

11. Which statement is incorrect under Kronig-Penney model for Band theory of solids ?

(A) It assumes the motion of electron under periodic square or well potential.

(B) Bragg reflection of electron waves causes formation of energy band gaps.

(C) Wider bands results with decreases in lattice parameter.

(D) Band gap decreases with increase in the height of potential barrier.

12. The energy becomes discontinuous within E-K diagram when wave vector of electron becomes equals to :

(A) $\pm\frac{2n\pi}{a}; n = 1, 2, 3, \ldots$

(B) $\pm\frac{n\pi}{a}; n = 1, 2, 3, \ldots$

(C) $+\frac{n\pi}{a}; n = 1, 2, 3, \ldots$

(D) $-\frac{n\pi}{a}; n = 1, 2, 3, \ldots$

13. The range of first Brillouin zone for crystalline solid having '*a*' lattice parameter is :

(A) $0 \to \frac{2\pi}{a}$

(B) $-\frac{\pi}{a} \to +\frac{\pi}{a}$

(C) $\pm\frac{\pi}{a} \to \pm\frac{2\pi}{a}$

(D) $\pm\frac{\pi}{2a} \to \pm\frac{\pi}{a}$

14. The incorrect statement for velocity of an electron within crystalline solid is :

(A) It is equal to $(1/\hbar)\,(dE/dK)$.

(B) It has finite value at K = 0.

(C) It is zero at boundary of first Brillouin zone.

(D) It is maximum at point of inflection in E-K diagram.

15. Which statement is invalid for the effective mass of electron within crystalline solid ?

(A) It is equal to $\hbar^2\left(d^2E/dK^2\right)$.

(B) It is equal to rest mass at K = 0 in E-K diagram.

(C) It increases with K and is maximum near point of inflection in E-K diagram.

(D) It is negative after point of inflection in E-K diagram.

16. Which techniques are used for measuring effective mass and Fermi energy of electron ?

(A) Nuclear magnetic resonance and Meissner effect

(B) Cyclotron resonance and De Hass-Van Alphen effect

(C) Electron spin resonance and Nuclear magnetic resonance techniques

(D) Electron spin resonance and Cyclotron resonance techniques

17. Under Tight Binding Approximation of band theory of solids, which one is not true ?

(A) Electronic wavefunction is primarily constructed from linear combination of atomic orbitals.

(B) Energy bands in a crystal arise due to the overlap of atomic orbitals of adjacent atoms.

(C) Bandwidth is determined by the strength of the overlap integral.

(D) The number of energy bands is ratio of number of orbitals for each atom and number of atom in primitive cell.

18. If γ is strength of the overlap integral under Tight Binding Approximation, then bandwidth for SC, BCC and FCC crystals is equal to :

(A) 6γ, 10γ and 18γ

(B) 8γ, 12γ and 20γ

(C) 10γ, 14γ and 22γ

(D) 12γ, 16γ and 24γ

19. If n, ρ, σ and E_g is carrier concentration, resistivity, conductivity and energy band gap of intrinsic semiconductor, then which is correct relation at temperature T for intrinsic semiconductor ?

(A) $n \propto T^{3/2} \exp\left(-E_g / 2KT\right)$

(B) $\sigma = \sigma_0 \exp\left(-E_g / 2KT\right)$

(C) $\rho = \rho_0 \exp\left(E_g / 2KT\right)$

(D) All of the above

20. If the quantity σ represents electrical conductivity, then which statement is not true for graph between log σ and 1/T for semiconductor ?

(A) Its slope provides Eg/2K.

(B) Its slope is dynamic and variable.

(C) Its slope is large for intrinsic semiconductor.

(D) Its slope is small for extrinsic semiconductor.

21. The doping of impurities in semiconductor causes :

(A) Reduction in energy band gap and resistivity while enhancement in conductivity.

(B) Shift of fermi level towards conduction band for N-type semiconductor.

(C) Shift of fermi level towards valence band for P-type semiconductor.

(D) All of the above.

22. If E_A and E_V are accepter level and valance band energies, then Fermi energy for P-type semiconductor at T = 0 temperature is :

(A) $E_F = (E_A + E_V)/2$

(B) $E_F = (E_A - E_V)/2$

(C) $E_F = (E_A.E_V)^{1/2}$

(D) $E_F = (E_A.E_V)/(E_A + E_V)$

23. The expression of total current density for electron in intrisic semiconductor is :

(A) $J_n = en\mu_n E + eD_n \frac{dn}{dx}$

(B) $J_n = en\mu_n E - eD_n \frac{dn}{dx}$

(C) $J_n = -en\mu_n E - eD_n \frac{dn}{dx}$

(D) $J_n = en\mu_n E$

24. If the top of valance band and bottom of conduction band does not lie at same wave vector, then band gap is termed as :

(A) Coherent band gap

(B) Indirect band gap

(C) Direct band gap

(D) Incoherent band gap

25. If n_i and N_A are intrinsic and accepter concentration, then hole (p) and electron (n) concentration in P-type semiconductor is :

(A) $p = N_A + n_i^2 / N_A;\ n = n_i^2 / N_A$

(B) $p = N_A - n_i^2 / N_A;\ n = n_i^2 / N_A$

(C) $p = n_i^2 / N_A;\ n = N_A + n_i^2 / N_A$

(D) $p = n_i^2 / N_A;\ n = N_A - n_i^2 / N_A$

26. If carrier concentration and energy of donor level and conduction band are N_D, E_D and N_C, E_C respectively, then expression for Fermi energy of N-type semiconductor is :

(A) $E_F = (E_D + E_C)/2$ at T = 0

(B) $E_F = \frac{E_D + E_C}{2} + \frac{KT}{2} \log(N_D / N_C)$ at low T

(C) $E_F = E_c - kT \log(N_c / N_D)$ at high T

(D) All of the above

27. Which is not true for mobility ?

(A) It is equal to product of Hall resistance and conductivity.

(B) It is equal to $e\tau/m$ (τ : relaxation time, m : mass of electron).

(C) Its value is low for metals in comparison to semiconductors.

(D) Its value is high for N-type semiconductor in comparison to P-type semiconductor.

28. If n and p are hole and electron concentrations while μ_n and μ_p are mobility of hole and electron, then Hall resistance of semiconductor is :

(A) $\frac{p\mu_p^2 + n\mu_n^2}{e(p\mu_p - n\mu_n)^2}$

(B) $\frac{p\mu_p^2 - n\mu_n^2}{e(p\mu_p - n\mu_n)^2}$

(C) $\frac{p\mu_p^2 + n\mu_n^2}{e(p\mu_p + n\mu_n)^2}$

(D) $\frac{p\mu_p^2 - n\mu_n^2}{e(p\mu_p + n\mu_n)^2}$

29. The nature of Hall resistance for N-type semiconductor, P-type semiconductor and metals are :

(A) negative, positive, positive

(B) negative, positive, negative

(C) positive, negative, positive/negative

(D) negative, positive, negative/positive

30. Which statement is incorrect for superconductors ?

(A) It follows Meissner effect.

(B) The electrical resistance is zero.

(C) The magnetic susceptibility is negative.

(D) It is formed by first order phase transition.

31. Which property is not resembled for type-I superconductor ?

(A) It has one critical magnetic field.

(B) It is also known as soft superconductor.

(C) Quantization of magnetic flux through it is possible.

(D) The ratio of penetration depth and coherence length is less than $1/\sqrt{2}$.

32. If 't' is ratio of temperature and critical temperature H_c (0) represents critical magnetic field at 0 K for superconductor, then critical magnetic field H_c (T) at temperature T for type-I superconductor is :

(A) $H_c(T) = H_c(0)\left(1 - t^2\right)$

(B) $H_c(T) = H_c(0)\left(1 + t^2\right)$

(C) $H_c(T) = H_c(0)\left(1 - t^{-2}\right)$

(D) $H_c(T) = H_c(0)\left(1 + t^{-2}\right)$

33. If λ is penetration depth, then which one is London equation related to superconductivity ?

(A) $\nabla^2 \dot{\vec{B}} = \dfrac{\dot{\vec{B}}}{\lambda^2}$

(B) $\nabla^2 \vec{B} = \dfrac{\vec{B}}{\lambda^2}$

(C) $\vec{J} = -\dfrac{1}{\mu_0 \lambda^2} \vec{A}$

(D) All of the above

34. If λ is penetration depth for Type I superconductor, then which of the expressions explains the variation of magnetic field strength below critical temperature ?

(A) $B(x) \propto \exp(+x/\lambda)$

(B) $B(x) \propto \exp(-x/\lambda)$

(C) $B(x) \propto \left[1 - \exp(-x/\lambda)\right]$

(D) $B(x) \propto \left[1 + \exp(+x/\lambda)\right]$

35. Which one is incorrect statement for London's penetration depth ?

(A) It is distance to which an external magnetic field decays to $1/e$ times of its surface value.

(B) Its temperature dependence is given by $\lambda = \lambda_0 / \sqrt{1 - \left(T/T_C\right)^4}$.

(C) Its zero value represents the loss of superconductivity.

(D) Its magnitude is equal to $\sqrt{m/\left(\mu_0 n_s e^2\right)}$.

36. Which one is correct dependence of carrier concentration in superconductor with temperature ?

(A) $n_s = n_0 \left\{1 + \left(\mathrm{T/T}_c\right)^4\right\}$

(B) $n_s = n_0 \left\{1 - \left(\mathrm{T/T}_c\right)^4\right\}$

(C) $n_s = n_0 \sqrt{1 + \left(\mathrm{T}_c / \mathrm{T}\right)^4}$

(D) $n_s = n_0 \sqrt{1 - \left(\mathrm{T}_c / \mathrm{T}\right)^4}$

37. If C_s and C_n are superconducting specific heat and normal specific heat respectively, then the incorrect statement is :

(A) C_s is greater than C_n at $\mathrm{T} = \mathrm{T}_\mathrm{C}$.

(B) $\mathrm{C}_s - \mathrm{C}_n = -\mu_0 \mathrm{T}_\mathrm{C} \left(d\mathrm{H}_\mathrm{C} / d\mathrm{T}\right)^2$.

(C) Specific heat decreases exponentially at $\mathrm{T} < \mathrm{T}_\mathrm{C}$.

(D) Specific heat is independent of energy gap at $\mathrm{T} < \mathrm{T}_\mathrm{C}$.

38. If S_s and S_n are entropies in superconducting and normal conducting states, then the incorrect statement is :

(A) S_s is greater than S_n at $\mathrm{T} = \mathrm{T}_\mathrm{C}$.

(B) S_s is less than S_n at $\mathrm{T} < \mathrm{T}_\mathrm{C}$.

(C) S_s decays non-linearly at $\mathrm{T} < \mathrm{T}_\mathrm{C}$.

(D) $\mathrm{S}_s - \mathrm{S}_n = \mu_0 \mathrm{H}_c (d\mathrm{H}_\mathrm{C}/d\mathrm{T})$.

39. If λ, ξ and ϕ_0 are penetration depth, coherence length and fluxoid respectively, then which is not true for type II superconductor ?

(A) It has two critical magnetic fields.

(B) Ratio of lower and upper critical magnetic fields is equal to $\xi : \lambda$.

(C) Threshold critical magnetic field is equal to $\phi_0 / (\pi\lambda\xi)$.

(D) Ratio λ and ξ is greater than $1/\sqrt{2}$.

40. If H_{c1} and H_{c2} are lower and upper critical magnetic fields for superconductor, then threshold critical magnetic field is equal to :

(A) $\sqrt{\mathrm{H}_{c1}.\mathrm{H}_{c2}}$

(B) $\sqrt{\left(\mathrm{H}_{c1}.\mathrm{H}_{c2}\right)/2}$

(C) $\left(\mathrm{H}_{c2} - \mathrm{H}_{c1}\right)/2$

(D) $\left(\mathrm{H}_{c2} + \mathrm{H}_{c1}\right)/2$

41. Which does not support the Silsbee rule of superconductivity ?

(A) Superconductivity is destroyed when magnetic field at surface is equal to critical field.

(B) The value of critical current for superconducting wire is $2\pi r H_c$.

(C) In presence of external field, the critical current is $2\pi r\left(H_c - H\right)$.

(D) Difference of external magnetic field and self magnetic field must be equal to critical field.

42. What is a Cooper pair ?

(A) It is a pair of two electrons having opposite spins.

(B) It is a pair of two electrons having same spins.

(C) It is a pair of one electron and one proton.

(D) It is a pair of two protons having same spins.

43. If V_f is electron velocity at Fermi level and E_g is energy gap under BCS theory, the expression of intrinsic coherence length is :

(A) $\xi = \frac{\hbar V_f}{2E_g}$

(B) $\xi = \frac{\hbar V_f}{\pi E_g}$

(C) $\xi = \frac{2\hbar V_f}{\pi E_g}$

(D) $\xi = \frac{\pi E_g}{h V_f}$

44. Which statement is true for the critical temperature (T_C) of superconductor ?

(A) It is inversely proportional to the square root of isotopic mass and is proportional to Debye temperature.

(B) It depends on strength of electron phonon interaction.

(C) It is related to energy gap of superconductor.

(D) All of the above

45. What is the minimum value of magnetic flux that can be associated with superconducting ring ?

(A) $\pi hc / e$

(B) $\pi \hbar c / e$

(C) $e / \left(\pi hc\right)$

(D) $e / \left(\pi \hbar c\right)$

46. In which arrangement, a constant current flows under DC Josephson's effect ?

(A) Two superconductors are separated by thin layer of metal.

(B) Two superconductors are separated by thin layer of insulator.

(C) Two insulators are separated by thin layer of superconductor.

(D) Two metals are separated by thin layer of insulator.

47. If a potential difference V ($\geq E_g/2e$: E_g-energy gap for superconductor) is applied to the Josephson junction, then which statement is incorrect for current with it ?

(A) An alternating current flows through it whose angular frequency is equal to $2eV/\hbar$.

(B) The frequency of current through it is order 10^9 to 10^{12} Hz.

(C) Current density for it is $J = J_0 \sin\left\{\delta_0 - \left(\frac{2eV}{\hbar}t\right)\right\}$.

(D) Phases of cooper pairs do not affect the current.

48. Which effects are base for SQUIDS and Magnetic levitation respectively ?

(A) Meissner effect and Silsbee's rule

(B) Josephson's effect and Meissner effect

(C) Meissner effect and Josephson's effect

(D) Josephson's effect and Silsbee's rule

49. If δ_0 is phase difference of one side and another side of cooper pairs in Josephson junction, then the amplitude of current in Josephson ring is :

(A) $2J_0 \cos\delta_0$

(B) $2J_0 \sin\delta_0$

(C) $J_0 \cos\delta_0$

(D) $J_0 \sin\delta_0$

50. If β is spring constant and m is mass of atom for a monoatomic linear lattice, then Einstein temperature for it is :

(A) $(\hbar / k_B)\sqrt{4\beta/m}$

(B) $(\hbar / k_B)\sqrt{2\beta/m}$

(C) $(\hbar / k_B)\sqrt{\beta/m}$

(D) None of the above

51. Which statement is said to be incorrect about the crystallography ?

(A) Space group defines number of crystal systems while point group defines the number of Bravais lattices.

(B) The number of point groups for 2D and 3D crystal systems are 10 and 32 while space groups are 17 and 230 respectively.

(C) The number of 2D and 3D crystal systems are 4 and 7 respectively.

(D) The number of Bravais lattices for 2D and 3D crystal systems are 5 and 14 respectively.

52. Which types of operation are involved to form space group ?

(A) rotation, reflection

(B) rotation, inversion

(C) rotation, reflection, inversion

(D) rotation, reflection, inversion, translation

53. Which one is said not to be true about rotational symmetry of crystal systems ?

(A) A crystal can have 1, 2, 3, 4, 5 and 6 fold rotational symmetry.

(B) A crystal can have more than one type of rotational symmetry.

(C) The characteristic rotational symmetry for monoclinic crystal is single 2-fold symmetry.

(D) The characteristic rotational symmetry for cubic crystal is four 3-fold symmetry.

54. Which crystal systems do have base/end centered Bravais lattice ?

(A) Monoclinic, Triclinic

(B) Cubic, Orthorhombic

(C) Monoclinic and Orthorhombic

(D) Triginal, Tetragonal and Orthorhombic

55. The atomic packing fraction for SC, BCC, FCC and HCP crystals are :

(A) 0.52, 0.68, 0.74, 0.74

(B) 0.52, 0.68, 0.74, 0.68

(C) 0.52, 0.68, 0.74, 0.52

(D) 0.74, 0.74, 0.68, 0.52

56. The number of atoms per uint cell and coordination number for SC, BCC, FCC and HCP structures are :

(A) 1, 2, 4, 6 and 4, 8, 10, 12

(B) 1, 6, 4, 4 and 8, 4, 10, 10

(C) 1, 4, 6, 6 and 4, 8, 12, 12

(D) 1, 2, 4, 6 and 6, 8, 12, 12

57. If atomic weight, Avogadro's number and lattic parameter of a bcc structured material are M_A, N_A and a respectively, then the density is equal to :

(A) $\frac{M_A}{N_A a^3}$

(B) $\frac{2M_A}{N_A a^3}$

(C) $\frac{3M_A}{N_A a^3}$

(D) $\frac{4M_A}{N_A a^3}$

58. Which statement is not true for hcp structure ?

(A) It is characterised by two nested hexagonal lattices one at (0,0,0) and other at $\left(\frac{2}{3}a, \frac{1}{3}a, \frac{1}{2}c\right)$.

(B) Atomic packing fraction and axial ratio for it are 0.74 and 1.633.

(C) Number of atoms per unit cell for it is 6.

(D) Coordination number for it is 8.

59. NaCl type crystal structure is resultant lattice of :

(A) two fcc lattices which shifted by coordinates (1/2, 1/2, 1/2).

(B) two bcc lattices which shifted by coordinates (1/2, 1/2, 1/2).

(C) two fcc lattices which shifted by coordinates (1/4, 1/4, 1/4).

(D) two bcc lattices which shifted by coordinates (1/4, 1/4, 1/4).

60. If 'a' is lattice parameter, then the atomic radius for SC, BCC and FCC structures are respectively :

(A) $a, a\sqrt{3}/4$ and $a/2\sqrt{2}$

(A) $a/2, a\sqrt{3}/4$ and $a/2\sqrt{2}$

(B) $a/2, a/2\sqrt{2}$ and $a\sqrt{3}/4$

(C) $a, a/2\sqrt{2}$ and $a\sqrt{3}/4$

61. Which statement is invalid for CsCl structure ?

(A) It is combination of two SC structures shifted by coordinates (1/2, 1/2, 1/2).

(B) Number of atom per unit cell is 2 and is exactly BCC structure.

(C) Atomic paking fraction is approximately 68% and sum of radius of ions is $\sqrt{3}a/2$

(D) Number of ions per unit cell is 2 while coordination number is 8.

62. Which statement is incorrect for diamond structure ?

(A) It is formed by interpenetration of two FCC lattices along the body diagonal by 1/4th cube edge.

(B) Atomic packing fraction for it is 0.34 and stacking sequence is ABCAB(C)…....... .

(C) Atoms are arranged in octahedral configuration.

(D) Number of atoms per unit cell is 8 and coordination number is 4.

63. Which one is incorrect property of Wurtzite ZnS structure ?

(A) Each Zn atom is surrounded by 4 S atoms, and each S atom by 4 Zn atoms.

(B) It is based on HCP lattice structure and has tetrahedral coordination.

(C) It is stable at low temperature and has stacking sequence ABCABC….. .

(D) Its atomic packing fraction is 0.375.

64. If a lattice plane intercepts the three crystallographic axes by amount $3a$, $2b$ and c, then the Miller indices for the plane will be :

(A) (2, 3, 6)

(B) (1, 2, 3)

(C) (3, 2, 1)

(D) (6, 2, 3)

65. The ratio of interplanar spacing for [100], [110] and [111] planes of simple cubic crystal structure is :

(A) $1 : \sqrt{2} : \sqrt{3}$

(B) $1 : 1/\sqrt{2} : 1/\sqrt{3}$

(C) $1 : \sqrt{2} : 1/\sqrt{3}$

(D) $1 : 1/\sqrt{2} : 2\sqrt{3}$

66. Which is incorrect for reciprocal lattice ?

(A) The translation vector in reciprocal lattice is equal to reciprocal of interplanar spacing.

(B) The primitive cell volume of reciprocal lattice of SC structure in K-space is $(2\pi/a)^3$.

(C) The reciprocal lattice of BCC is FCC and vice-versa.

(D) Reciprocal lattice vector should not be equal to scattering vector for diffraction.

67. If $\vec{K}$ is wave propagation vector and $\vec{G}$ is reciprocal vector, then condition for elastic scattering is :

(A) $2\vec{K}.\vec{G}+\vec{G}^2=0$

(B) $\Delta\vec{K}=\vec{G}$

(C) $\vec{K}.\vec{G}/2=(G/2)^2$

(D) All of the above

68. Which statement is not true for diffraction through crystal ?

(A) It happens for X-ray and not for visible light and is based on scattering.

(B) It occurs when the incident wave vector is changed by reciprocal vector.

(C) It follows the Bragg's condition and also depends on refractive index of medium.

(D) It occurs at very large grazing angle.

69. Which X-ray diffraction technique does not use characteristic X-ray ?

(A) Laue Diffraction

(B) Powder X-ray Diffraction

(C) Thin film X-ray Diffraction

(D) Rotating single crystal X-ray Diffraction

70. Which statement is incorrect for the atomic scattering factor ?

(A) It is ratio of amplitudes of radiations scattered by atoms and electrons.

(B) It depends on atomic number and electron cloud distribution.

(C) It increases with increasing scattering angle.

(D) Its imaginary component shows absorption of X-ray by atom.

71. The invalid statement for geometrical structure factors is :

(A) It depends on lattice type, atomic positions, Miller indices and atomic scattering factor.

(B) It is not correlated with the diffraction intensity.

(C) Its zero value defines missing reflection in diffraction spectrum.

(D) It is equal to atomic scattering factor for SC structure.

72. If f is atomic scattering factor, then which statement is true for intensity (I) of diffraction peaks through crystal plane of cubic structures ?

(A) For SC, reflection from all plane is possible and $I_{hkl} \propto f^2$.

(B) For BCC, reflection from a plane is only possible if $h + k + l$ = even and $I_{hkl} \propto 4f^2$.

(C) For FCC, reflection from a plane is only possible if h, k, l = all even or all odd and $I_{hkl} \propto 16f^2$.

(D) All of the above

73. For which crystal plane, Bragg's reflection shall be missing in FCC crystal ?

(A) (1, 0, 0)

(B) (2, 0, 0)

(C) (1, 1, 1)

(D) (2, 2, 2)

74. If $\vec{b}_1$ is primitive vector in X direction for reciprocal lattice of bcc, then correct expression for $\vec{b}_1$ is :

(A) $\frac{2\pi}{a}\left(-\hat{x}+\hat{y}+\hat{z}\right)$

(B) $\frac{2\pi}{a}\left(\hat{x}+\hat{y}-\hat{z}\right)$

(C) $\frac{2\pi}{a}\left(\hat{x}+\hat{y}\right)$

(D) $\frac{2\pi}{a}\left(\hat{y}+\hat{z}\right)$

75. If n is electron density for metal, then expression of Fermi energy of electron gas at 0K is :

(A) $\mathrm{E}_f = \frac{\hbar^2}{2m}\left(3\pi^2 n\right)^{3/2}$

(B) $\mathrm{E}_f = \frac{\hbar^2}{2m}\left(3\pi^2 n\right)^{2/3}$

(C) $\mathrm{E}_f = \frac{2m}{\hbar^2}\left(\frac{3\pi^2}{n}\right)^{3/2}$

(D) $\mathrm{E}_f = \frac{2m}{\hbar^2}\left(\frac{3\pi^2}{n}\right)^{2/3}$

76. The incorrect statement related to Fermi energy level is :

(A) Occupancy of state above Fermi level is zero while is one below it at T = 0 K.

(B) Occupancy of state at Fermi level is half at $T \neq 0$ K.

(C) Wave vector of electron at Fermi level at T = 0 is $\left(3\pi^2 n\right)^3$. Here, n : electron density.

(D) Velocity of electron at Fermi level at T = 0 is $\hbar\left(3\pi^2 n\right)^{1/3} / m$ Here, m : mass of electron.

77. The ratio of mean energy of electron gas for 1-D and 3-D at 0 K under Sommerfeld quantum theory of free electron is :

(A) 5 : 3

(B) 3 : 5

(C) 9 : 5

(D) 5 : 9

78. If T_F and F_{fo} are Fermi temperature and Fermi energy electron gas at 0 K, then Fermi energy F_f at T under condition $T < T_F$ is :

(A) $E_f = E_{fo}\left[1 - \frac{5\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$

(B) $E_f = E_{fo}\left[1 + \frac{5\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$

(C) $E_f = E_{fo}\left[1 - \frac{\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$

(D) $E_f = E_{fo}\left[1 + \frac{\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$

79. If E_F and R are Fermi energy and gas constant, then electronic specific heat of monovalent metal for one mole at temperature T is :

(A) $\frac{\pi^2 R}{2}\left(\frac{k_B T}{E_F}\right)$

(B) $2\pi^2 R\left(\frac{k_B T}{E_F}\right)$

(C) $\frac{\pi^2 R}{2}\left(\frac{E_F}{k_B T}\right)$

(D) $\frac{2R}{\pi^2}\left(\frac{k_B T}{E_F}\right)^2$

80. If K and σ are thermal and electric conductivity of metals, then the values $K/\sigma T$ under Drude's classical and Sommerfeld quantum models are respectively :

(A) $\frac{2}{3}\left(\frac{k_B}{e}\right)^3, \frac{3}{\pi^2}\left(\frac{k_B}{e}\right)^3$

(B) $\frac{3}{2}\left(\frac{k_B}{e}\right)^2, \frac{\pi^2}{3}\left(\frac{k_B}{e}\right)^2$

(C) $\frac{3}{\pi^2}\left(\frac{k_B}{e}\right)^2, \frac{2}{3}\left(\frac{k_B}{e}\right)^3$

(D) $\frac{\pi^2}{3}\left(\frac{k_B}{e}\right)^3, \frac{3}{2}\left(\frac{k_B}{e}\right)^3$

81. If R_0 is interatomic separation for a metal, then under Drude model, the expression of electrical conductivity for metals at temperature T is :

(A) $\frac{ne^2 R_0}{\sqrt{3mk_B T}}$

(B) $\frac{ne^2 R_0}{m\sqrt{3k_B T}}$

(C) $\frac{ne^2\sqrt{3k_B T}}{mR_0}$

(D) $\frac{ne^2\sqrt{3mk_B T}}{R_0}$

82. Which statement is incorrect under Drude-Lorentz model of metals at temperature T ?

(A) Drift velocity of electron decreases exponentially with time.

(B) Relaxation time is proportional to $T^{1/2}$.

(C) Electrical conductivity is proportional to $T^{-1/2}$.

(D) Resistivity is proportional to $T^{1/2}$.

83. If θ_D is Debye temperature, then the electrical resistivity of metals under conditions $T >> \theta_D$ and $T << \theta_D$ are respectively proportional to :

(A) T and T^5

(B) T and T^3

(C) T^3 and T

(D) T^3 and T^5

84. If T and ϕ are temperature and work function of metal, then Richardson Dushman equation for thermionic emission is :

(A) $J = AT\exp(\phi / k_B T)$

(B) $J = AT^2\exp(-\phi / k_B T)$

(C) $J = AT^{-2}\exp(\phi / k_B T)$

(D) $J = AT^3\exp(-\phi / k_B T)$

85. The electric and lattice part of specific heat at constant volume for metals is respectively proportional to :

(A) T and T^2

(B) T^2 and T^3

(C) T and T^3

(D) T^3 and T^5

86. The incorrect statement for Magneto-resistance is :

(A) It is ratio of change in resistance on applying magnetic field and resistance without field.

(B) It is proportional to B^2 for low magnetic field (B).

(C) It tends to saturate for normal metals and is proportional to B for metal or semimetal at high B.

(D) It is not influenced by impurity and temperature.

87. Which one is not correlated with thermoelectric effect ?

(A) Thomson effect

(B) Josephson effect

(C) Seebeck effect

(D) Peltier effect

88. If S, Π and σ are Seebeck, Peltier and Thomson coefficients respectively, then which relation is incorrect ?

(A) $\Pi = TS$

(B) $\sigma = T\left(\frac{dS}{dT}\right)$

(C) $S = \left(\frac{d\sigma}{dT}\right) + \Pi$

(D) $\sigma = \left(\frac{d\Pi}{dT}\right) - S$

89. If E_Y, J_x and B_Z are Hall field, current density and magnetic field while w and t are width and thickness along y and z direction, then Hall resistance (R_H) and voltage is equal to :

(A) $E_Y / (J_x B_z)$ and $R_H I_x B_Z / t$

(B) $E_Y / (J_x B_z)$ and $R_H I_x B_Z / w$

(C) $(E_Y J_x) / B_z$ and $R_H I_x / B_Z w$

(D) $(E_Y J_x) / B_z$ and $R_H I_x / B_Z t$

90. Hall effect can be used to determine :

(A) Nature of charge carrier and charge concentration

(B) Mobitlity of charge carriers and Magnetic field

(C) Non-contact current sensing

(D) All of the above

91. If β and m are spring constant and mass of atom for a monoatomic linear lattice, then maximum possible angular frequency for it at boundary of first Brillouin zone is :

(A) $\sqrt{\frac{4\beta}{m}}$

(B) $\sqrt{\frac{3\beta}{m}}$

(C) $\sqrt{\frac{2\beta}{m}}$

(D) $\sqrt{\frac{\beta}{m}}$

92. Which one is incorrect for monoatomic linear lattice having atomic separation 'a' ?

(A) It is dispersive medium as angular frequency is not linear function of wave vector.

(B) Wavelength and group velocity of wave at wave vector $\pm\pi/a$ are $2a$ and zero.

(C) Range of first Brillouin zone for it is $-\pi/a$ to $+\pi/a$.

(D) It behaves as high pass filter.

93. If a, C and ρ is lattice parameter, longitudinal stress and linear mass density for the monoatomic linear lattice, then the velocity of wave travelling through it having low frequency will be :

(A) $\sqrt{C/\rho}$

(B) $a\sqrt{C/\rho}$

(C) $2a\sqrt{(\rho/C)}$

(D) $4a\sqrt{\rho/C}$

94. A diatomic linear lattice has spring constant β and atomic masses m and M (m < M). What is the highest frequency in acoustical and lowest frequency in optical regions ?

(A) $\sqrt{\frac{\beta}{M}}$ and $\sqrt{\frac{\beta}{m}}$

(B) $\sqrt{\frac{\beta}{m}}$ and $\sqrt{\frac{2\beta}{M}}$

(C) $\sqrt{\frac{2\beta}{M}}$ and $\sqrt{\frac{2\beta}{m}}$

(D) $\sqrt{\frac{4\beta}{M}}$ and $\sqrt{\frac{4\beta}{m}}$

95. A diatomic linear lattice has 'a' atomic separation, 'β' spring constant, atomic masses m and M (m < M). Then which statement is not true for it ?

(A) It possesses both acoustical and optical mode of vibrations.

(B) First Brillouin zone for it is $-(\pi/2a) \rightarrow +(\pi/2a)$.

(C) The forbidden frequency range is $\sqrt{2\beta/M}$ to $\sqrt{2\beta/m}$.

(D) Frequency in optical mode is minimum at $K \rightarrow 0$.

96. A diatomic linear lattice has spring constant β and atomic masses m and M (m < M). What will the angular frequency in acoustical and optical regions for it at zero wave vector ?

(A) 0 and $\sqrt{\frac{2\beta}{m+M}}$

(B) $\sqrt{\frac{2\beta}{M}}$ and $\sqrt{\frac{2\beta(m+M)}{mM}}$

(C) 0 and $\sqrt{\frac{2\beta(m+M)}{nM}}$

(D) $\sqrt{\frac{2\beta}{M}}$ and 0

97. A diatomic linear lattice has spring constant β and atomic masses m and M (m < M), then the correct statement is :

(A) The acoustical mode disappears and optical mode can have angular frequency only $\sqrt{2\beta/m}$ for $M \to \infty$.

(B) The optical mode disappears and acoustical mode is unaffected for $m \to 0$.

(C) In acoustical mode, atoms vibrate in same phase while for optical mode in opposite phase.

(D) All of the above

98. Which type of radiation can be absorbed by ionic crystal ?

(A) UV-radiation

(B) Visible radiation

(C) IR-radiation

(D) X-ray radiation

99. If a wave propagates in 3-D crystal, then how many mode of vibrations are possible in acoustical branch ?

(A) One longitudinal and two transverse modes

(B) Two longitudinal and one transverse mode

(C) One longitudinal and one transverse mode

(D) Two longitudinal and two transverse modes

100. The stiffness constants for cubic structured material having density ρ are C_{11}, C_{12} and C_{44}, then longitudinal and transverse wave velocities of elastic wave for wave propagation along [100] direction are :

(A) $\sqrt{C_{44}/\rho}$ and $\sqrt{C_{12}/\rho}$

(B) $\sqrt{C_{11}/\rho}$ and $\sqrt{C_{44}/\rho}$

(C) $\sqrt{C_{44}/\rho}$ and $\sqrt{C_{11}/\rho}$

(D) $\sqrt{C_{12}/\rho}$ and $\sqrt{C_{11}/\rho}$

(Only for Rough Work)

4. Four alternative answers are mentioned for each question as—A, B, C & D in the booklet. The candidate has to choose the correct answer and mark the same in the OMR Answer-Sheet as per the direction :

   Example :

   Question :

   Q. 1 Ⓐ ● Ⓒ Ⓓ
   Q. 2 Ⓐ Ⓑ ● Ⓓ
   Q. 3 Ⓐ ● Ⓒ Ⓓ

   Illegible answers with cutting and over-writing or half filled circle will be cancelled.

5. Each question carries equal marks. Marks will be awarded according to the number of correct answers you have.
6. All answers are to be given on OMR Answer Sheet only. Answers given anywhere other than the place specified in the answer sheet will not be considered valid.
7. Before writing anything on the OMR Answer Sheet, all the instructions given in it should be read carefully.
8. After the completion of the examination candidates should leave the examination hall only after providing their OMR Answer Sheet to the invigilator. Candidate can carry their Question Booklet.
9. There will be no negative marking.
10. Rough work, if any, should be done on the blank pages provided for the purpose in the booklet.
11. To bring and use of log-book, calculator, pager and cellular phone in examination hall is prohibited.
12. In case of any difference found in English and Hindi version of the question, the English version of the question will be held authentic.

Impt. : On opening the question booklet, first check that all the pages of the question booklet are printed properly. If there is any discrepancy in the question Booklet, then after showing it to the invigilator, get another question Booklet of the same series.

4. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार सम्भावित उत्तर—A, B, C एवं D हैं। परीक्षार्थी को उन चारों विकल्पों में से सही उत्तर छाँटना है। उत्तर को OMR आन्सर-शीट में सम्बन्धित प्रश्न संख्या में निम्न प्रकार भरना है :

   उदाहरण :

   प्रश्न :

   प्रश्न 1 Ⓐ ● Ⓒ Ⓓ
   प्रश्न 2 Ⓐ Ⓑ ● Ⓓ
   प्रश्न 3 Ⓐ ● Ⓒ Ⓓ

   अपठनीय उत्तर या ऐसे उत्तर जिन्हें काटा या बदला गया है, या गोले में आधा भरकर दिया गया, उन्हें निरस्त कर दिया जाएगा।

5. प्रत्येक प्रश्न के अंक समान हैं। आपके जितने उत्तर सही होंगे, उन्हीं के अनुसार अंक प्रदान किये जायेंगे।
6. सभी उत्तर केवल ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर ही दिये जाने हैं। उत्तर-पत्रक में निर्धारित स्थान के अलावा अन्यत्र कहीं पर दिया गया उत्तर मान्य नहीं होगा।
7. ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर कुछ भी लिखने से पूर्व उसमें दिये गये सभी अनुदेशों को सावधानीपूर्वक पढ़ लिया जाये।
8. परीक्षा समाप्ति के उपरान्त परीक्षार्थी कक्ष निरीक्षक को अपनी OMR Answer Sheet उपलब्ध कराने के बाद ही परीक्षा कक्ष से प्रस्थान करें। परीक्षार्थी अपने साथ प्रश्न-पुस्तिका ले जा सकते हैं।
9. निगेटिव मार्किंग नहीं है।
10. कोई भी रफ कार्य, प्रश्न-पुस्तिका के अन्त में, रफ-कार्य के लिए दिए खाली पेज पर ही किया जाना चाहिए।
11. परीक्षा-कक्ष में लॉग-बुक, कैलकुलेटर, पेजर तथा सेल्युलर फोन ले जाना तथा उसका उपयोग करना वर्जित है।
12. प्रश्न के हिन्दी एवं अंग्रेजी रूपान्तरण में भिन्नता होने की दशा में प्रश्न का अंग्रेजी रूपान्तरण ही मान्य होगा।

महत्वपूर्ण : प्रश्नपुस्तिका खोलने पर प्रथमत: जाँच कर देख लें कि प्रश्न-पुस्तिका के सभी पृष्ठ भलीभाँति छपे हुए हैं। यदि प्रश्नपुस्तिका में कोई कमी हो, तो कक्षनिरीक्षक को दिखाकर उसी सिरीज की दूसरी प्रश्न-पुस्तिका प्राप्त कर लें।