

Assignment 25

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14. The atomic number of an atom is 6. What is the spectroscopic notation of its ground state, according to Hund's rules?
- (A) 3P_0
 (B) 3P_1
 (C) 3D_3
 (D) 3S_1
15. H is the Hamiltonian, \vec{H} the orbital angular momentum and L_Z is the z-component of \vec{L} . The 1s state of the hydrogen atom in the non-relativistic formalism is an eigenfunction of which one of the following sets of operators?
- (A) H, L^2, L_Z
 (B) H, \vec{L}, L^2, L_Z
 (C) L^2, L_Z only
 (D) H and L_Z only
16. The Hall experiment is carried out with a non-magnetic semiconductor. The current I is along the x -axis and the magnetic field B is along the z -axis. Which one of the following is the CORRECT representation of the variation of the magnitude of the Hall resistivity ρ_{xy} as a function of the magnetic field?

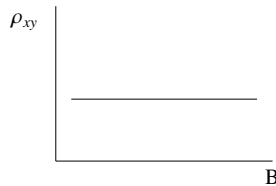


Fig. 0.1: option1

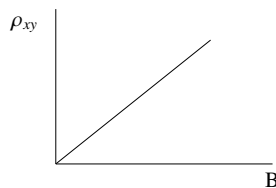


Fig. 0.2: option2

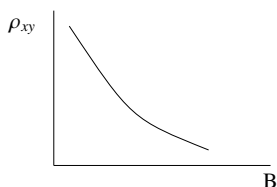


Fig. 0.3: option23

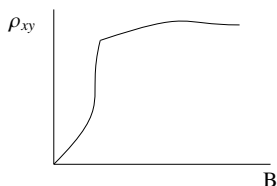


Fig. 0.4: option4

17. Consider a two dimensional Cartesian coordinate system in which a rank 2 contravariant tensor is represented by the matrix $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$. The coordinate system is rotated anticlockwise by an acute angle θ with the origin fixed. Which one of the following matrices represents the tensor in the new coordinate system?

- (A) $\begin{bmatrix} 0 & \cos 2\theta \\ -\sin 2\theta & 0 \end{bmatrix}$
 (B) $\begin{bmatrix} \sin 2\theta & \cos 2\theta \\ \cos 2\theta & -\sin 2\theta \end{bmatrix}$
 (C) $\begin{bmatrix} \sin 2\theta & -\cos 2\theta \\ \cos 2\theta & \sin 2\theta \end{bmatrix}$
 (D) $\begin{bmatrix} \sin 2\theta & 0 \\ 0 & -\cos 2\theta \end{bmatrix}$

18. A compound consists of three ions X, Y and Z. The Z ions are arranged in an FCC arrangement. The X ions occupy $\frac{1}{6}$ of the tetrahedral voids and the Y ions occupy $\frac{1}{3}$ of the octahedral voids. Which one of the following is the CORRECT chemical formula of the compound?

- (A) XY_2Z_4
 (B) XYZ_3
 (C) XYZ_2
 (D) XYZ_4

19. For a non-magnetic metal, which one of the following graphs best represents the behaviour of $\frac{C}{T}$ vs. T^2 where C is the heat capacity and T is the temperature?

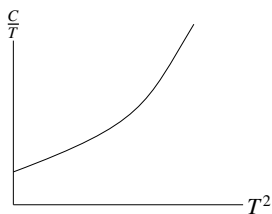


Fig. 0.5: option1

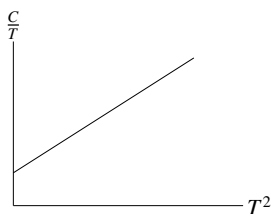


Fig. 0.6: option2

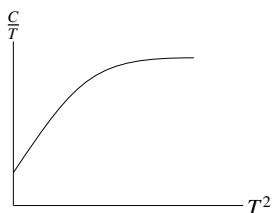


Fig. 0.7: option3

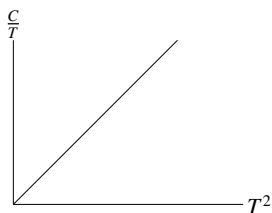


Fig. 0.8: option4

20. For nonrelativistic electrons in solid, different energy dispersion relations (with effective masses m_a^*, m_b^*, m_c^*) are schematically shown in the plots. Which one of the following options is correct?

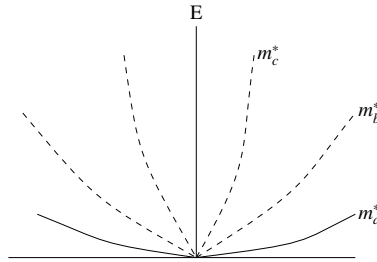


Fig. 0.9

- (A) $m_a^* = m_b^* = m_c^*$
 (B) $m_b^* > m_c^* > m_a^*$
 (C) $m_c^* > m_b^* > m_a^*$
 (D) $m_a^* > m_b^* > m_c^*$
21. The figure schematically shows the M (magnetization) - H (magnetic field) plots for certain types of materials. Here M and H are plotted in the same scale and units. Which one of the following is the most appropriate combination?

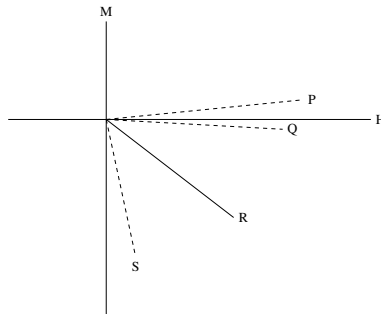


Fig. 0.10

- (A) (Q) - Paramagnet; (R) - Type-I Superconductor; (S) - Antiferromagnet
 (B) (P) - Paramagnet; (Q) - Diamagnet; (R) - Type-I Superconductor
 (C) (P) - Paramagnet; (Q) - Antiferromagnet; (R) - Type-I Superconductor
 (D) (P) - Diamagnet; (R) - Paramagnet; (S) - Type-I Superconductor
22. Graphene is a two dimensional material, in which carbon atoms are arranged in a honeycomb lattice with lattice constant a . As shown in the figure, \vec{a}_1 and \vec{a}_2 are two lattice vectors. Which one of the following is the area of the first Brillouin zone for this lattice?

- (A) $\frac{8\pi^2}{3\sqrt{3}a^2}$

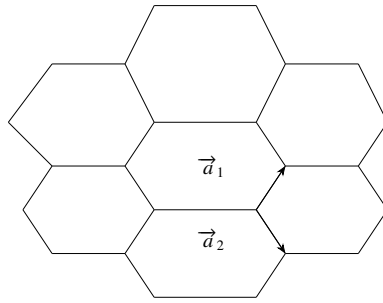


Fig. 0.11

- (B) $\frac{4\pi^2}{3\sqrt{3}a^2}$
 (C) $\frac{8\pi^2}{\sqrt{3}a^2}$
 (D) $\frac{4\pi^2}{\sqrt{3}a^2}$

23. A ^{60}Co nucleus emits a β particle and is converted to $^{60}\text{Ni}^*$ with $J^P = 4^+$, which in turn decays to the ^{60}Ni ground state with $J^P = 0^+$ by emitting two photons in succession, as shown in the figure. Which one of the following statements is correct?

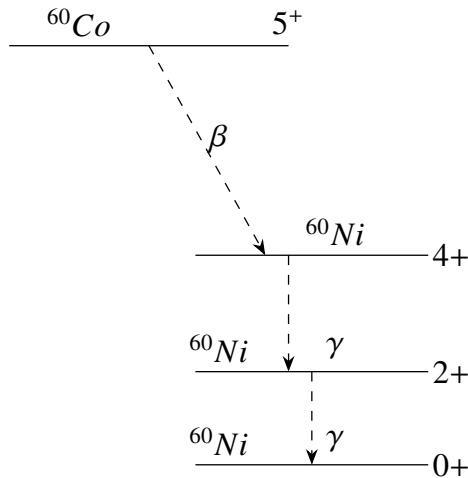


Fig. 0.12

- (A) $4^+ \rightarrow 2^+$ is an electric octupole transition
 (B) $4^+ \rightarrow 2^+$ is a magnetic quadrupole transition
 (C) $2^+ \rightarrow 0^+$ is an electric quadrupole transition
 (D) $2^+ \rightarrow 0^+$ is a magnetic quadrupole transition

24. Which one of the following options is CORRECT for the given logic circuit?

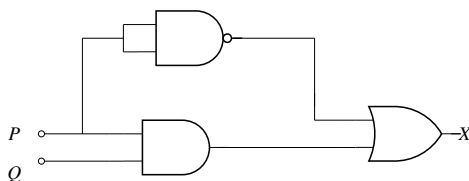


Fig. 0.13

- (A) $P = 1, Q = 1; X = 0$
 (B) $P = 1, Q = 0; X = 1$
 (C) $P = 0, Q = 1; X = 0$
 (D) $P = 0, Q = 0; X = 1$
25. An atom with non-zero magnetic moment has an angular momentum of magnitude $\sqrt{12}\hbar$. When a beam of such atoms is passed through a Stern-Gerlach apparatus, how many beams does it split into?
- (A) 3
 (B) 7
 (C) 9
 (D) 25
26. A 4×4 matrix M has the property $M^\dagger = -M$ and $M^4 = \mathbf{1}$, where $\mathbf{1}$ is the 4×4 identity matrix. Which one of the following is the CORRECT set of eigen values of the matrix M ?
- (A) $(1, 1, -1, -1)$
 (B) $(i, i, -i, -i)$
 (C) $(i, i, i, -i)$
 (D) $(1, 1, -i, -i)$