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, $\overrightarrow{H}$ the orbital angular momentum and L_Z is the z-component of $\overrightarrow{L}$. The 1s state of the hydrogen atom in the non-relativistic formalism is an eigen function of which one of the following sets of operators?
    (A) H, L^2, L_Z
    (B) $H, \overrightarrow{L}, L^2, L_Z$
    (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?

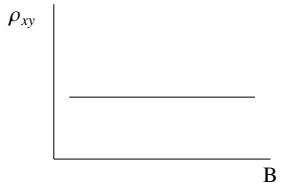

Fig. 0.1: option1

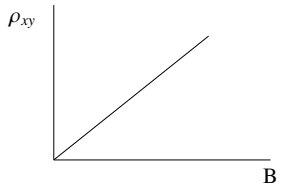

Fig. 0.2: option2

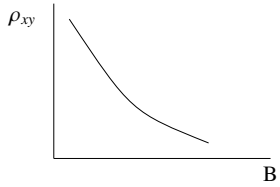

Fig. 0.3: option23

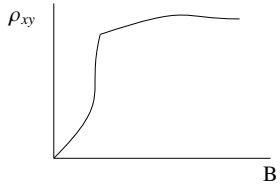

Fig. 0.4: option4

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) $\begin{bmatrix} 0 & cos2\theta \\ -sin2\theta & 0 \end{bmatrix}$

(B) $\begin{bmatrix} sin2\theta & cos2\theta \\ cos2\theta & -sin2\theta \end{bmatrix}$

(C) $\begin{bmatrix} sin2\theta & -cos2\theta \\ cos2\theta & sin2\theta \end{bmatrix}$

(D) $\begin{bmatrix} sin2\theta & 0 \\ 0 & -cos2\theta \end{bmatrix}$

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?

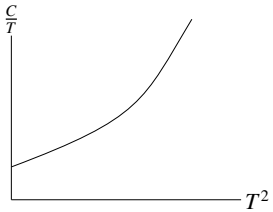

Fig. 0.5: option1

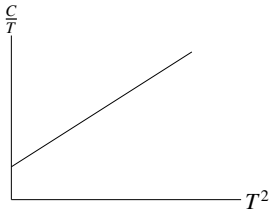

Fig. 0.6: option2

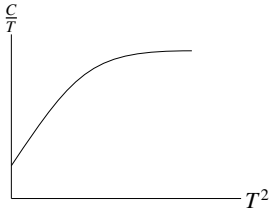

Fig. 0.7: option3

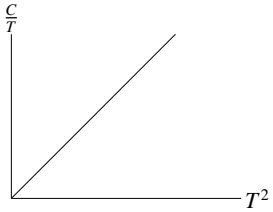

Fig. 0.8: option4

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?

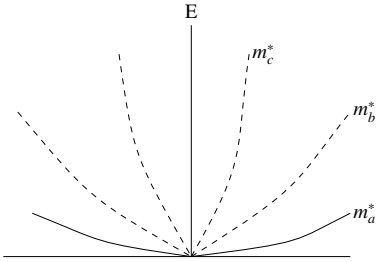

Fig. 0.9

(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?

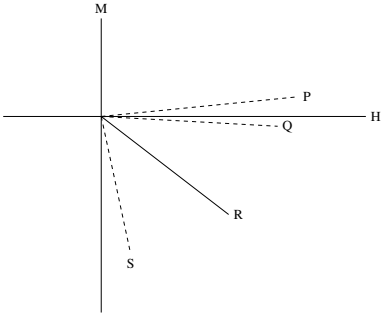

Fig. 0.10

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

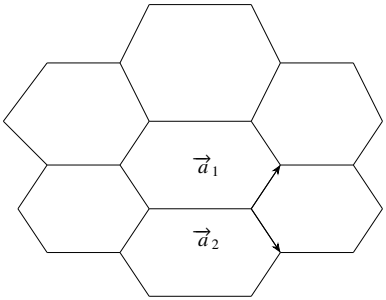

Fig. 0.11

(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 $^{60}Ni^*$ with $J^P = 4^+$, which in turn decays ot the $^{60}Ni^*$ ground state with $J^P = 0+$ by emitting two photons in succession, as shown in the figure. Which one of the folowing statements is correct?

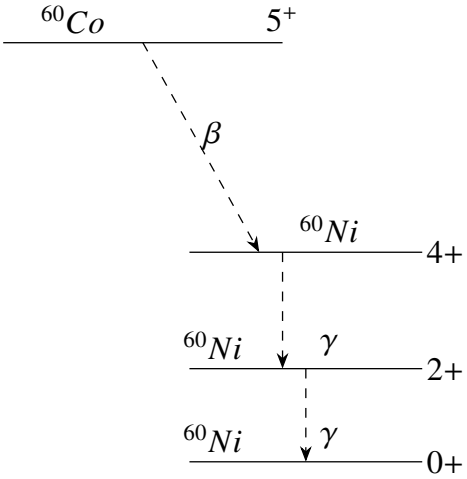

Fig. 0.12

(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?

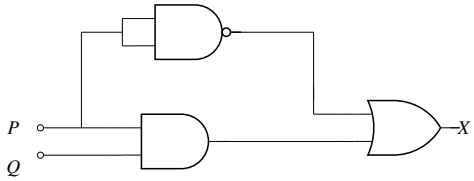

Fig. 0.13

(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 = 1, where **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) $(1, 1, -i, -i)$