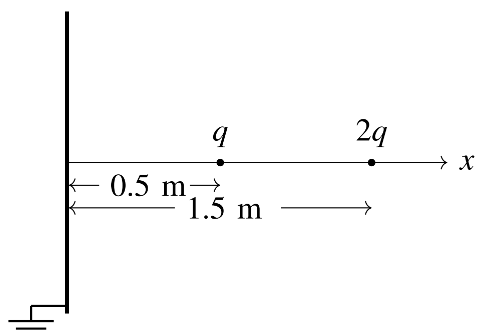
ph-2011-14 to 26

AI24BTECH11020 - Rishika

14) If L_x, L_y and L_z are respectively the x, y and z components of angular momentum operator L, the commutator $\left[L_x L_y, L_z\right]$ is equal to
   a) $\iota\hbar\left(L_x^2 + L_y^2\right)$
   b) $2\iota\hbar L_z$
   c) $\iota\hbar\left(L_x^2 - L_y^2\right)$
   d) 0
15) The normalized ground state wavefunction of a hydrogen atom is given by $\psi(r) = \frac{1}{\sqrt{4\pi}} \frac{2}{a^{\frac{3}{2}}} e^{\frac{-r}{a}}$, where a is the Bohr radius and r is the distance of the electron from the nucleus, located at the origin. The expectation value $\left\langle \frac{1}{r^2} \right\rangle$ is
   a) $\frac{8\pi}{a^2}$
   b) $\frac{4\pi}{a^2}$
   c) $\frac{4}{a^2}$
   d) $\frac{2}{a^2}$
16) Two charges q and $2q$ are placed along the x-axis in front of a grounded, infinite conducting plane, as shown in the figure. They are located respectively at a distance of $0.5m$ and $1.5m$ from the plane. The force acting on the charge q is



   a) $\frac{1}{4\pi\varepsilon} \frac{7q^2}{2}$
   b) $\frac{1}{4\pi\varepsilon} 2q^2$
   c) $\frac{1}{4\pi\varepsilon} q^2$
   d) $\frac{1}{4\pi\varepsilon} \frac{q^2}{2}$
17) A uniform surface current is flowing in the positive y-direction over an infinite sheet lying in $x - y$ plane. The direction of the magnetic field is
   a) along $\hat{i}$ for $z > 0$ and along $-\hat{i}$ for $z < 0$
   b) along $\hat{k}$ for $z > 0$ and along $-\hat{k}$ for $z < 0$
   c) along $-\hat{i}$ for $z > 0$ and along $\hat{i}$ for $z < 0$
   d) along $-\hat{k}$ for $z > 0$ and along $\hat{k}$ for $z < 0$
18) A magnetic dipole of dipole moment $\mathbf{m}$ is placed in a non-uniform magnetic field $\mathbf{B}$. If the position vector of the dipole is $\mathbf{r}$, the torque acting on the dipole about the origin is
   a) $\mathbf{r} \times (\mathbf{m} \times \mathbf{B})$
   b) $\mathbf{r} \times \nabla (\mathbf{m} \cdot \mathbf{B})$

c) $\mathbf{m} \times \mathbf{B}$
d) $\mathbf{m} \times \mathbf{B} + \mathbf{r} \times \nabla(\mathbf{m} \cdot \mathbf{B})$

19) Which of the following expressions for a vector potential **A** DOES NOT represent a uniform magnetic field of magnitude B_0 along the z-direction ?
a) $\mathbf{A} = (0, B_0 x, 0)$
b) $\mathbf{A} = (-B_0 y, 0, 0)$
c) $\mathbf{A} = \left(\frac{B_0 x}{2}, \frac{B_0 y}{2}, 0\right)$
d) $\mathbf{A} = \left(-\frac{B_0 y}{2}, \frac{B_0 x}{2}, 0\right)$

20) A neutron passing through a detector is detected because of
a) the ionization it produces
b) the scintillation light it produces
c) the electron - hole pairs it produces
d) the secondary particles produced in a nuclear reaction in the detector medium

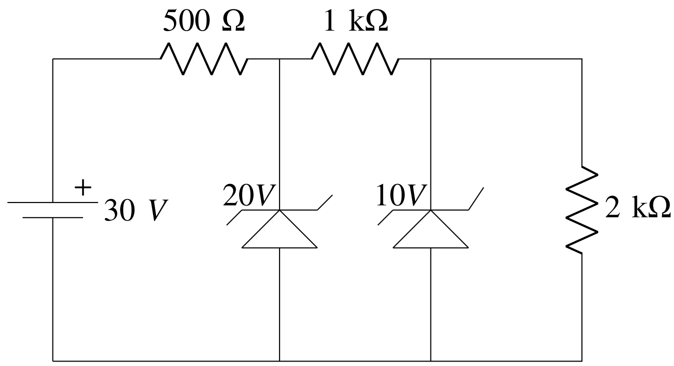
21) An atom with one outer electron having orbital angular momentum l is placed in a weak magnetic field. The number of energy levels into which the higher total angular momentum state splits, is
a) $2l + 2$
b) $2l + 1$
c) $2l$
d) $2l - 1$

22) For a multi-electron atom,l, L and S specify the one-electron orbital angular momentum,total orbital angular momentum and total spin angular momentum, respectively. The selection rules for electric dipole transition between the two electronic energy levels, specified by l, L and S are
a) $\Delta L = 0, \pm 1; \Delta S = 0; \Delta l = 0, \pm 1$
b) $\Delta L = 0, \pm 1; \Delta S = 0; \Delta l = \pm 1$
c) $\Delta L = 0, \pm 1; \Delta S = \pm 1; \Delta l = 0, \pm 1$
d) $\Delta L = 0, \pm 1; \Delta S = \pm 1; \Delta l = \pm 1$

23) For a three-dimensional crystal having N primitive unit cells with a basis of p atoms, the number of optical branches is
a) 3
b) $3p$
c) $3p - 3$
d) $3N - 3p$

24) For an intrinsic semiconductor, m_e^* and m_h^* are respectively the effective masses of electrons and holes near the corresponding band edges. At a finite temperature, the position of the Fermi level
a) depends on m_e^* but not on m_h^*
b) depends on m_h^* but not on m_e^*
c) depends on both m_e^* and m_h^*
d) depends neither on m_e^* nor on m_h^*

25) In the following circuit, the voltage across and the current through the $2K\Omega$ resistance are



a) $20V, 10mA$
b) $20V, 5mA$
c) $10V, 10mA$
d) $10V, 5mA$

I. $Q.26$ to $Q.55$ carry two marks each.

26) The unit vector normal to the surface $x^2 + y^2 - z = 1$ at the point $P(1, 1, 1)$ is

a) $\frac{\hat{i}+\hat{j}-\hat{k}}{\sqrt{3}}$
b) $\frac{2\hat{i}+\hat{j}-\hat{k}}{\sqrt{6}}$
c) $\frac{\hat{i}+2\hat{j}-\hat{k}}{\sqrt{6}}$
d) $\frac{2\hat{i}+2\hat{j}-\hat{k}}{3}$