GATE PH - 2021

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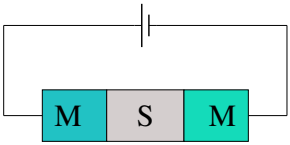
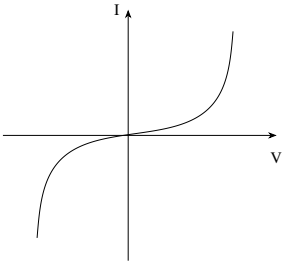
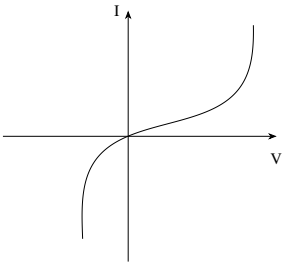
14) As shown in the figure, two metal-semiconductor junctions are formed between an n-type semiconductor S and metal M. The work functions of S and M are φ_s and φ_m, respectively with $\varphi_m > \varphi_s$.



The I-V characteristics (on linear scale) of the junctions is best represented by



a)



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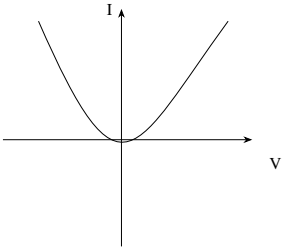

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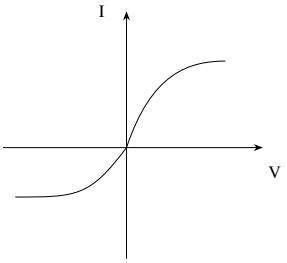


d)

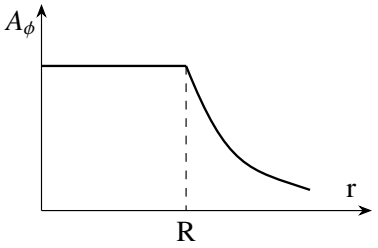
15) Consider a tiny current loop driven by a sinusoidal alternating current. If the surface integral of its time-averaged Poynting vector is constant, then the magnitude of the time-averaged magnetic field intensity, at any arbitrary position, $\overrightarrow{r}$, is proportional to

a) $\frac{1}{r^3}$
b) $\frac{1}{r^2}$
c) $\frac{1}{r}$
d) r

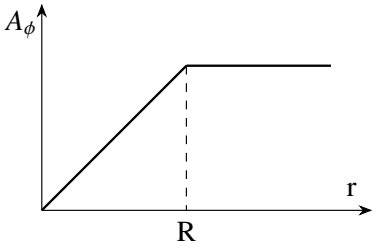
16) Consider a solenoid of length L and radius R, where $R << L$. A steady-current flows through the solenoid. The magnetic field is uniform inside the solenoid and zero outside. Among the given options, choose the one that best represents the variation in the magnitude of the vector potential, $\left(0, A_\varphi, 0\right)$ at $z = \frac{L}{2}$, as a function of the radial distance (r) in cylindrical coordinates.

Useful information: The curl of a vector $\overrightarrow{F}$, in cylindrical coordinates is

$$\overrightarrow{\nabla} \times \overrightarrow{F}(r, \varphi, z) = \hat{r}\left[\frac{1}{r}\frac{\partial F_z}{\partial \varphi} - \frac{\partial F_\varphi}{\partial z}\right] + \hat{\varphi}\left[\frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r}\right] + \hat{z}\frac{1}{r}\left[\frac{\partial (rF_\varphi)}{\partial r} - \frac{\partial F_r}{\partial \varphi}\right]$$



a)



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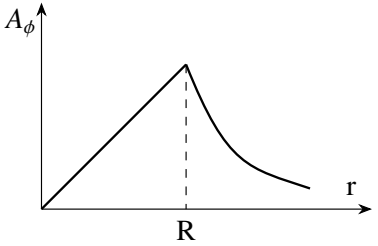

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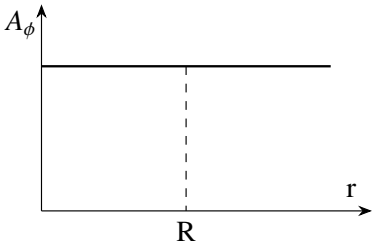


d)

17) Assume that ^{13}N ($z = 7$) undergoes first forbidden β^+ decay from its ground state with spin-parity J_i^π, to a final state with spin J_f^π. The possible values for J_i^π and J_f^π,

respectively, are

a) $\frac{1^-}{2}, \frac{5^+}{2}$
b) $\frac{1^+}{2}, \frac{5^+}{2}$
c) $\frac{1^-}{2}, \frac{1^-}{2}$
d) $\frac{1^+}{2}, \frac{1^-}{2}$

18) In an experiment, it is seen that an electric-dipole ($E1$) transition can connect an initial nuclear state of spin-parity $J_i^\pi = 2^+$ to a final state J_f^π . All possible values of J_f^π are

a) $1^+, 2^+$
b) $1^+, 2^+, 3^+$
c) $1^-, 2^-$
d) $1^-, 2^-, 3^-$

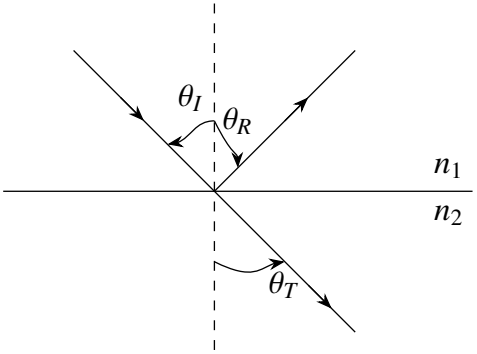
19) Choose the correct statement of the following

a) Silicon is a direct band gap semiconductor.
b) Conductivity of metals decreases with increase in temperature.
c) Conductivity of semiconductors decreases with increase in temperature.
d) Gallium Arsenide is an indirect band gap semiconductor.

20) A two-dimensional square lattice has lattice constant a. k represents the wavevector in reciprocal space. The coordinates $\left(k_x, k_y\right)$ of reciprocal space where band gap(s) can occur, are

a) $(0, 0)$
b) $\left(\pm\frac{\pi}{a}, \pm\frac{\pi}{a}\right)$
c) $\left(\pm\frac{\pi}{a}, \pm\frac{\pi}{1.3a}\right)$
d) $\left(\pm\frac{\pi}{3a}, \pm\frac{\pi}{a}\right)$

21) As shown in the figure, an electromagnetic wave with intensity I_I is incident at the interface of two media having refractive indices $n_1 = 1$ and $n_2 = \sqrt{3}$ The wave is reflected with intensity I_R and transmitted with intensity I_T Permeability of each medium is the same. (Reflection coefficient $R = \frac{I_R}{I_I}$ and Transmission coefficient $T = \frac{I_T}{I_I}$



Choose the correct statement(s)

a) $R = 0$ if $\theta_1 = 0°$ and polarization of incident light is parallel to the plane of incidence.
b) $T = 1$ if $\theta_1 = 60°$ and polarization of incident light is parallel to the plane of incidence.
c) $R = 0$ if $\theta_1 = 60°$ and polarization of incident light is perpendicular to the plane of incidence.
d) $T = 1$ if $\theta_1 = 60°$ and polarization of incident light is perpendicular to the plane of incidence.

22) A material is placed in a magnetic field intensity H. As a result, bound current density J_b is induced and magnetization of the material is M. The magnetic flux density is B. Choose the correct option(s) valid at the surface of the material.

a) $\nabla.M = 0$
b) $\nabla.B = 0$
c) $\nabla.h = 0$
d) $\nabla.J_b = 0$

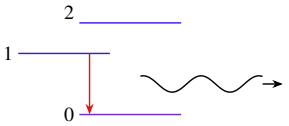
23) For a finite system of Fermions where the density of states increases with energy, the chemical potential

a) decreases with temperature
b) increases with temperature
c) does not vary with temperature
d) corresponds to the energy where the occupation probability is 0.5

24) Among the term symbols ${}^4S_1$, ${}^2D_{\frac{7}{2}}$, ${}^3S_1$ and ${}^2D_{\frac{5}{2}}$ choose the option(s) possible in the LS coupling notation.

a) ${}^4S_1$
b) ${}^2D_{\frac{7}{2}}$
c) ${}^3S_1$
d) ${}^2D_{\frac{5}{2}}$

25) To sustain lasing action in a three-level laser as shown in the figure, necessary condition(s) is (are)

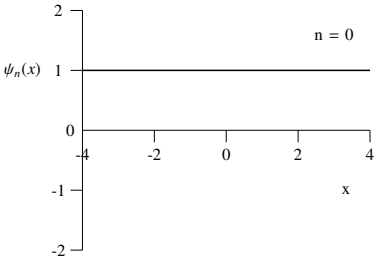


a) lifetime of the energy level 1 should be greater than that of energy level 2
b) population of the particles in level 1 should be greater than that of level 0
c) lifetime of the energy level 2 should be greater than that of energy level 0
d) population of the particles in level 2 should be greater than that of level 1

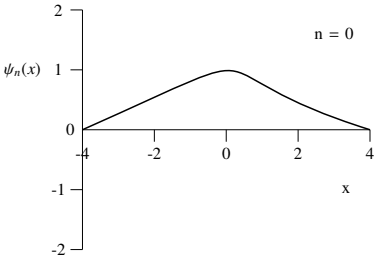
26) If $y_n(x)$ is a solution of the differential equation

$$y'' - 2xy' + 2ny = 0$$

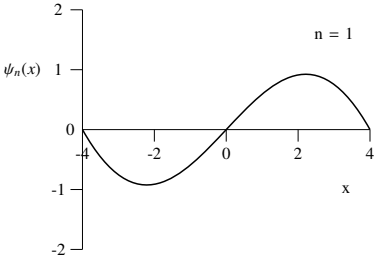
where n is an integer and the prime ($'$) denotes differentiation with respect to x, then acceptable plot(s) of $\psi_n(x) = e^{\frac{-x^2}{2}} y_n(x)$, is(are)



a)



b)



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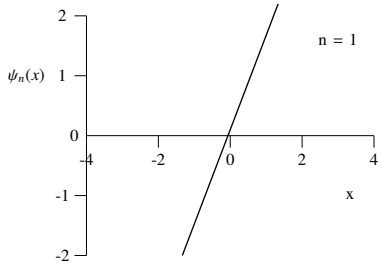

d)