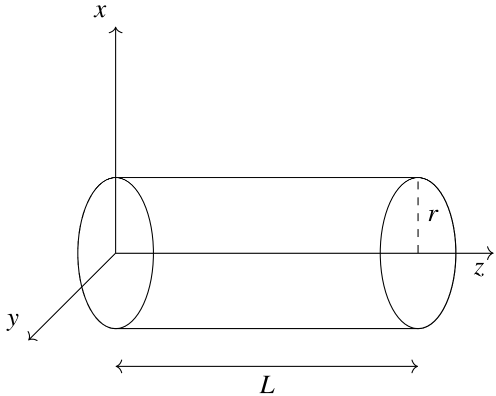
# GATE-2009-PH-25-36

EE24BTECH11047 - Niketh Prakash Achanta

25) A cylindrical rod of length $L$ and radius $r$, made of an inhomogeneous dielectric,is placed with its axis along the z direction with one end at the origin as shown below.



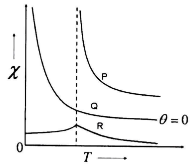

If the rod carries a polarization, $\mathbf{P} = \left(5z^2 + 7\right)\hat{k}$, the volume bound charge inside the dielectric is

a) Zero
b) $10\pi r^2 L$
c) $-5\pi r^2 L$
d) $-5\pi r^2 L^2$

26) Let $T_{ij} = \sum_k \varepsilon_{ijk} a_k$ and $\beta_k = \sum_{i,j} \varepsilon_{ijk} T_{ij}$, where $\varepsilon_{ijk}$, is the Levi-Civita density, defined to be zero if two of the indices coincide and +1 and -1 depending on whether ijk is even or odd permutation of 1,2,3. Then $\beta_3$ is equal to

a) $2a_3$
b) $-2a_3$
c) $a_3$
d) $-a_3$

27) The dependence of the magnetic susceptibility ($\chi$) of a material with temperature ($T$) can be represented by $\chi \propto \frac{1}{T-\theta}$, where $\theta$ is the Curie-Weiss Temperature. The plot of magnetic susceptibility versus temperature is sketched in the figure, as curves P,Q and R with curve Q having $\theta = 0$.




Which of the following statements is correct?

a) Curve R represents a paramagnet and Q a ferromagnet
b) Curve Q represents a ferromagnet and P an antiferromagnet
c) Curve R represent an antiferromagnet and Q a paramagnet
d) Curve R represents an antiferromagnet and Q a ferromagnet

28) The dielectric constant of a material at optical frequencies is mainly due to

a) ionic polarizability
b) electronic polarizability
c) dipolar polarizability
d) ionic and dipolar polarizability

29) An electron of wavevector $\mathbf{k_e}$, velocity $\mathbf{v_h}$, and effective mass $m_h$. Which one of the following statements is correct?

a) $\mathbf{k_h} = -\mathbf{k_e}; \mathbf{v_h} = -\mathbf{v_e}; m_h = -m_e$
b) $\mathbf{k_h} = \mathbf{k_e}; \mathbf{v_h} = \mathbf{v_e}; m_h = m_e$
c) $\mathbf{k_h} = \mathbf{k_e}; \mathbf{v_h} = -\mathbf{v_e}; m_h = -m_e$
d) $\mathbf{k_h} = -\mathbf{k_e}; \mathbf{v_h} = \mathbf{v_e}; m_h = -m_e$

30) In a diatomic molecule, the internuclear separation of the ground and first excited electronic state are the same as shown in the figure.

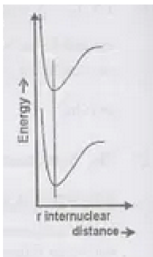
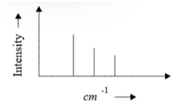
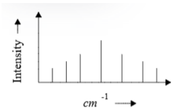



Fig. 30

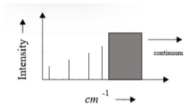
If the molecule is initially in the lowest vibrational state of the ground state, then the absorption spectrum will appear as



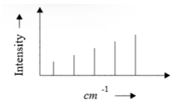

a)




b)

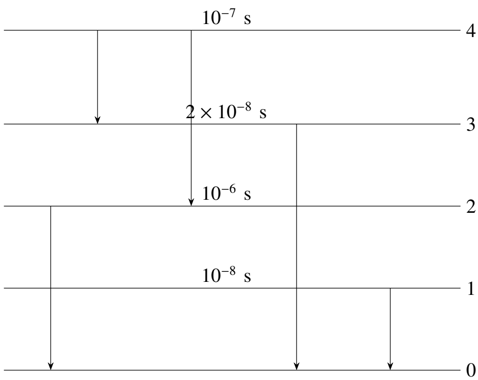



c)




d)

31) Five energy levels of a system including the ground state are shown below. Their lifetimes and the allowed electric dipole transitions are also marked.



Which one of the following transitions is the most suitable for a continuous wave ($CW$) laser?

a) $1 \to 0$
b) $2 \to 0$
c) $4 \to 2$
d) $4 \to 3$

32) Assuming the mean life time of a muon (in its rest frame) to be $2 \times 10^{-6} s$, its life time in the laboratory frame, when it is moving with a velocity $0.95c$ is

a) $6.4 \times 10^{-6} s$
b) $0.62 \times 10^{-6} s$
c) $2.16 \times 10^{-6} s$
d) $0.19 \times 10^{-6} s$

33) Cesium has a nuclear spin of 7/2. The hyperfine spectrum of the D lines of the cesium atom will consist of

a) 10 lines
b) 4 lines
c) 6 lines
d) 14 lines

34) The probability that an energy level $\varepsilon$ at a temperature $T$ is *unoccupied* by a fermion of chemical potential $\mu$ is given by

a) $\frac{1}{e^{(\varepsilon-\mu)/k_BT}+1}$
b) $\frac{1}{e^{(\varepsilon-\mu)/k_BT}-1}$
c) $\frac{1}{e^{(\mu-\varepsilon)/k_BT}+1}$
d) $\frac{1}{e^{(\mu-\varepsilon)/k_BT}-1}$

35) Consider the following expression for the mass of a nucleus with $Z$ protons and $A$ nucleons:
$M(A,Z) = \frac{1}{c^2}\left(f(A) + yZ + zZ^2\right)$ Here, $f(A)$ is a function of $A$,

$$y = -4a_A, \quad z = a_c A^{-1/3} + 4a_A A^{-1}$$

$a_A$ and $a_c$ are constants of suitable dimensions. For a fixed $A$, the expression of $Z$ for the most stable nucleus is

a) $Z = \frac{A/2}{1+\left(\frac{a_c}{a_A}\right)A^{2/3}}$
b) $Z = \frac{A/2}{1+\left(\frac{a_c}{4a_A}\right)A^{2/3}}$
c) $Z = \frac{A}{1+\left(\frac{a_c}{4a_A}\right)A^{2/3}}$
d) $Z = \frac{A}{1+A^{2/3}}$

36) The de Broglie wavelength of particles of mass $m$ with average momentum $p$ at a temperature $T$ in three dimensions is given by

a) $\lambda = \frac{h}{\sqrt{2mk_BT}}$
b) $\lambda = \frac{h}{\sqrt{3mk_BT}}$
c) $\lambda = \frac{h}{\sqrt{2k_BT}}$

d) $\lambda = \frac{h}{\sqrt{3m}}$