

Gate PH-2010

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27) The solution of the differential equation for $y(t)$: $\frac{d^2y}{dt^2} - y = 2 \cosh(t)$, subject to the initial conditions $y(0) = 0$ and $\frac{dy}{dt}|_{t=0} = 0$, is:

- a) $\frac{1}{2} \cosh(t) + t \sinh(t)$ c) $t \cosh(t)$
b) $-\sinh(t) + t \cosh(t)$ d) $t \sinh(t)$

28) Given the recurrence relation for the Legendre polynomials:

$$(2n+1)P_n(x) = (n+1)P_{n+1}(x) + nP_{n-1}(x)$$

which of the following integrals has a non-zero value?

- a) $\int_{-1}^1 x^2 P_n(x) P_{n+1}(x) dx$ c) $\int_{-1}^1 x [P_n(x)]^2 dx$
b) $\int_{-1}^1 x P_n(x) P_{n+2}(x) dx$ d) $\int_{-1}^1 x^2 P_n(x) P_{n+2}(x) dx$

29) For a two-dimensional free electron gas, the electronic density n and the Fermi energy E_f are related by:

- a) $n = \frac{(2mE_f)^{\frac{3}{2}}}{3\pi^2\hbar^3}$ c) $n = \frac{mE_f}{2\pi\hbar^2}$
b) $n = \frac{mE_f}{\pi\hbar^2}$ d) $n = \frac{2^{\frac{3}{2}}(mE_f)^{\frac{1}{2}}}{\pi\hbar}$

30) Far away from any of the resonance frequencies of a medium, the real part of the dielectric permittivity is

- a) Always independent of frequency
- b) Monotonically decreasing with frequency
- c) Monotonically increasing with frequency
- d) A non-monotonic function of frequency

31) The ground state wavefunction of a deuteron is in a superposition of s and d states. Which of the following is NOT true as a consequence?

- a) It has a non-zero quadrupole moment
- b) The neutron-proton potential is non-central
- c) The orbital wavefunction is not spherically symmetric
- d) The Hamiltonian does not conserve the total angular momentum

32) The first three energy levels of $^{228}\text{Th}_{90}$ are shown below:

Spin-Parity	Energy (keV)
4^+	187
2^+	57.5
0^+	0

a) $\frac{31}{10}\hbar\omega$

b) $\frac{25}{10}\hbar\omega$

c) $\frac{13}{10}\hbar\omega$

d) $\frac{11}{10}\hbar\omega$

36) Match the typical spectra of stable molecules with the corresponding wave-number range:

(A) Electronic spectra

(1) 10^6 cm^{-1} and above

(B) Rotational spectra

(2) $10^5 - 10^6 \text{ cm}^{-1}$

(C) Molecular dissociation

(3) $10^0 - 10^2 \text{ cm}^{-1}$

a) $A - 2, B - 1, C - 3$

c) $A - 3, B - 2, C - 1$

b) $A - 2, B - 3, C - 1$

d) $A - 1, B - 2, C - 3$

37) Consider the operations $P : \vec{r} \rightarrow -\vec{r}$ (parity) and $T : t \rightarrow -t$ (time-reversal). For the electric and magnetic fields \vec{E} and \vec{B} , which of the following set of transformations is correct?

a) $P : \vec{E} \rightarrow -\vec{E}, \vec{B} \rightarrow \vec{B};$

c) $P : \vec{E} \rightarrow -\vec{E}, \vec{B} \rightarrow \vec{B};$

$T : \vec{E} \rightarrow \vec{E}, \vec{B} \rightarrow -\vec{B}$

$T : \vec{E} \rightarrow -\vec{E}, \vec{B} \rightarrow -\vec{B}$

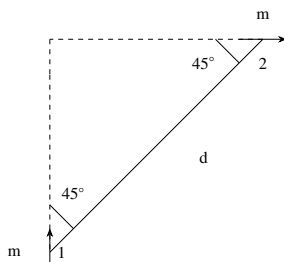
b) $P : \vec{E} \rightarrow \vec{E}, \vec{B} \rightarrow \vec{B};$

d) $P : \vec{E} \rightarrow \vec{E}, \vec{B} \rightarrow -\vec{B};$

$T : \vec{E} \rightarrow \vec{E}, \vec{B} \rightarrow \vec{B}$

$T : \vec{E} \rightarrow -\vec{E}, \vec{B} \rightarrow \vec{B}$

38) Two magnetic dipoles of magnitude m each are placed in a plane as shown.



The energy of interaction is given by:

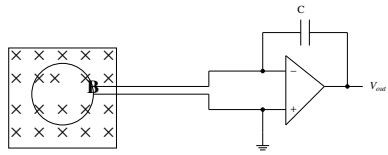
a) Zero

c) $\frac{3\mu_0 m^2}{2\pi d^3}$

b) $\frac{\mu_0 m^2}{4\pi d^3}$

d) $-\frac{3\mu_0 m^2}{8\pi d^3}$

39) Consider a conducting loop of radius a and total loop resistance R placed in a region with a magnetic field B , thereby enclosing a flux Φ_0 . The loop is connected to an electronic circuit as shown, the capacitor being initially uncharged.



If the loop is pulled out of the region of the magnetic field at a constant speed v , the final output voltage V_{out} is independent of:

- | | |
|-------------|--------|
| a) Φ_0 | c) u |
| b) R | d) C |