GATE PH-2012

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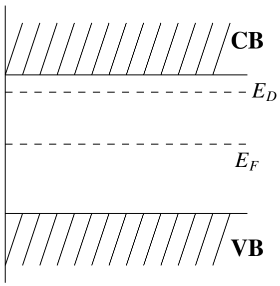
14) In a central force field, the trajectory of a particle of mass m and angular momentum L in plane polar coordinates is given by,

$$\frac{1}{r} = \frac{m}{L^2}(1 + \epsilon \cos\theta)$$

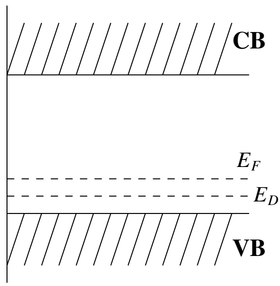
where ϵ is the eccentricity of the particle's motion. Which one of the following choices for ϵ gives rise to a parabolic trajectory?

a) $\epsilon > 0$ b) $\epsilon = 0$ c) $0 < \epsilon < 1$ d) $\epsilon > 1$

15) Identify the CORRECT energy band diagram for Silicon doped with Arsenic. Here CB, VB, E_D and E_F are conduction band, valence band, impurity level and Fermi level, respectively.



a)



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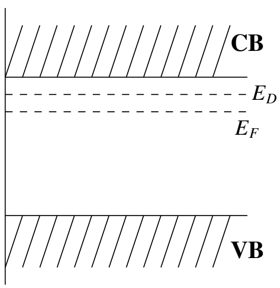

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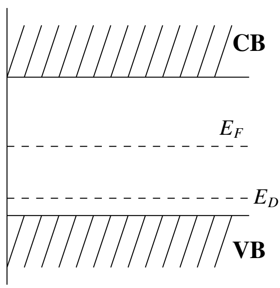


d)

16) The first Stokes line of a rotational Raman spectrum is observed at $12.96cm^{-1}$. Considering the rigid rotor approximation, the rotational constant is given by

a) $6.48cm^{-1}$ b) $3.24cm^{-1}$ c) $2.16cm^{-1}$ d) $1.62cm^{-1}$

17) The total energy, E of an ideal non-relativistic Fermi gas in three dimensions is given by $E \propto \frac{N^{\frac{5}{3}}}{V^{\frac{2}{3}}}$ where N is the number of particles and V is the volume of the gas. Identify the CORRECT equation of state (P being the pressure),

a) $PV = \frac{1}{3}E$ b) $PV = \frac{2}{3}E$ c) $PV = E$ d) $PV = \frac{5}{3}E$

18) Consider the wavefunction $\Psi = \psi\left(\overrightarrow{r_1}, \overrightarrow{r_2}\right)\chi_S$ for a fermionic system consisting of two spin-half particles. The spatial part of the wavefunction is given by.

$$\psi\left(\overrightarrow{r_1}, \overrightarrow{r_2}\right) = \frac{1}{\sqrt{2}}\left[\phi_1(\overrightarrow{r_1})\phi_2(\overrightarrow{r_2}) + \phi_2(\overrightarrow{r_1})\phi_1(\overrightarrow{r_2})\right]$$

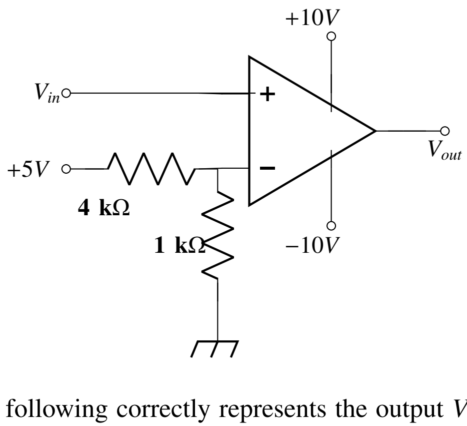
where ϕ_1 and ϕ_2 are single particle states. The spin part χ_s of the wavefunction with spin states $\alpha\left(\frac{+1}{2}\right)$ and $\alpha\left(\frac{-1}{2}\right)$ should be

a) $\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)$ b) $\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)$ c) $\alpha\alpha$ d) $\beta\beta$

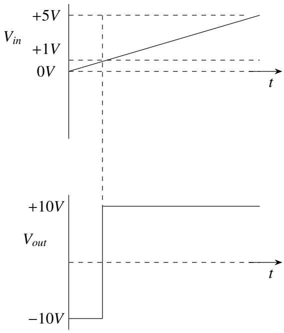
19) The electric and the magnetic fields, $\overrightarrow{E}(z,t)$ and $\overrightarrow{B}(z,t)$ respectively corresponding to the scalar potential $\phi(z,t) = 0$ and vector potential $\overrightarrow{A}(z,t) = \hat{i}tz$ are

a) $\overrightarrow{E} = \hat{i}z$ and $\overrightarrow{B} = -jt$
b) $\overrightarrow{E} = \hat{i}z$ and $\overrightarrow{B} = jt$
c) $\overrightarrow{E} = \widehat{-i}z$ and $\overrightarrow{B} = -jt$
d) $\overrightarrow{E} = \widehat{-i}z$ and $\overrightarrow{B} = jt$

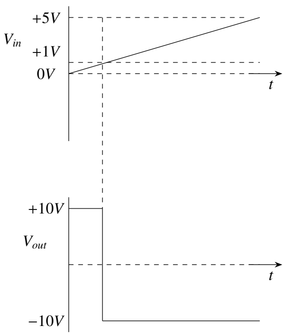
20) Consider the following OP-AMP circuit.



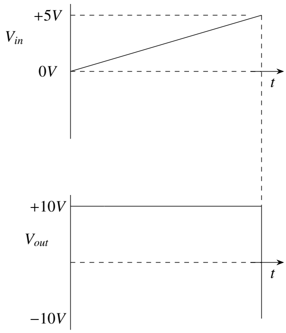
Which one of the following correctly represents the output V_{out} corresponding to the input V_{in}?



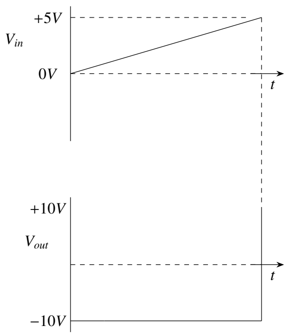
a)



b)



c)



d)

21) Deuteron has only one bound state with spin parity 1^+ isospin 0 and electric quadrupole moment $0.286efm^2$. These data suggest that the nuclear forces are having
   a) only spin and isospin dependence
   b) no spin dependence and no tensor components
   c) spin dependence but no tensor components
   d) spin dependence along with tensor components

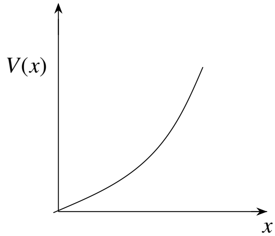
22) A particle of unit mass moves along the x-axis under the influence of a potential, $V(x) = x(x-2)^2$. The particle is found to be in stable equilibrium at the point $x = 2$. The time period of oscillation of the particle is

   a) $\frac{\pi}{2}$ b) π c) $\frac{3\pi}{2}$ d) 2π

23) Which one of the following CANNOT be explained by considering a harmonic approximation for the lattice vibrations in solids?

a) Debye's T^3 law
b) Dulong Petit's law
c) Optical branches in lattices
d) Thermal expansion

24) A particle is constrained to move in a truncated harmonic potential well ($x > 0$) as shown in the figure. Which one of the following statements is CORRECT?



a) The parity of the first excited state is even
b) The parity of the ground state is even
c) The ground state energy is $\frac{1}{2}\hbar\omega$
d) The first excited state energy is $\frac{7}{2}\hbar\omega$

25) The number of independent components of the symmetric tensor A_{ij} with indices $i, j = 1, 2, 3$ is

a) 1
b) 3
c) 6
d) 9

26) Consider a system in the unperturbed state described by the Hamiltonian $H_0 = \begin{pmatrix} 0 & 1 \\ 0 & 1 \end{pmatrix}$. The system is subjected to a perturbation of the form $H' = \begin{pmatrix} \delta & \delta \\ \delta & \delta \end{pmatrix}$, where $\delta << 1$. The energy eigenvalues of the perturbed system using the first order perturbation approximation are

a) 1 and $(1 + 2\delta)$
b) $(1 + \delta)$ and $(1 - \delta)$
c) $(1 + 2\delta)$ and $(1 - 2\delta)$
d) $(1 + \delta)$ and $(1 - 2\delta)$