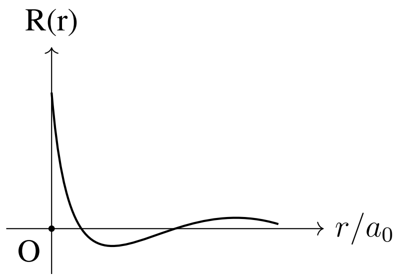
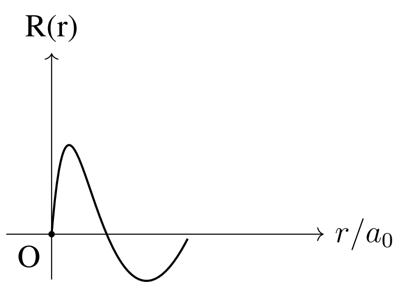
# 2018-PH-'1-13'

AI24BTECH11006 - Bugada Roopansha

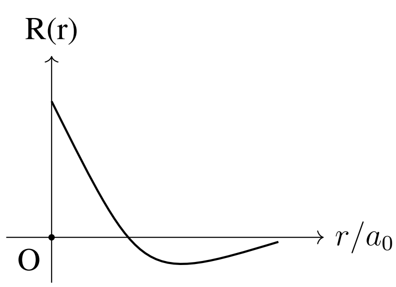
1) The eigenvalues of a Hermitian matrix are all
   a) real
   b) imaginary
   c) of modulus one
   d) real and positive
2) Which one of the following represents the $3p$ radial wave function of the hydrogen atom? ($a_0$ is the Bohr radius)



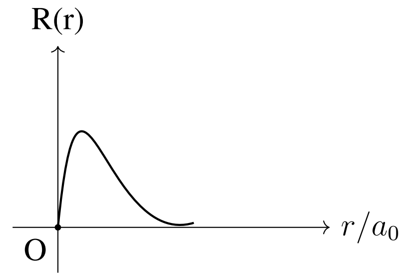

   a)




   b)




   c)



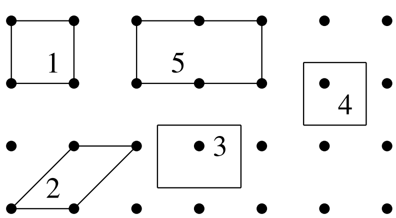

   d)
3) Given the following table,

| Group I | Group II |
|---|---|
| P: Stern-Gerlach experiment | 1: Wave nature of particles |
| Q: Zeeman effect | 2: Quantization of energy of electrons in the atoms |
| R: Frank-Hertz experiment | 3: Existence of electron spin |
| S: Davisson-Germer experiment | 4: Space quantization of angular momentum |

   Which one of the following correctly matches the experiments from Group I to their inferences in Group II?
   a) P-2, Q-3, R-4, S-1
   b) P-1, Q-3, R-2, S-4
   c) P-3, Q-4, R-2, S-1
   d) P-2, Q-1, R-4, S-3
4) In spherical polar coordinates $(r, \theta, \phi)$, the unit vector $\hat{\theta}$ at $\left(10, \frac{\pi}{4}, \frac{\pi}{2}\right)$ is
   a) $\hat{k}$
   b) $\frac{1}{\sqrt{2}}\left(\hat{j} + \hat{k}\right)$
   c) $\frac{1}{\sqrt{2}}\left(-\hat{j} + \hat{k}\right)$
   d) $\frac{1}{\sqrt{2}}\left(\hat{j} - \hat{k}\right)$
5) The scale factors corresponding to the covariant metric tensor $g$ in spherical polar coordinates are
   a) $1, r^2, r^2 \sin^2 \theta$
   b) $1, r^2, \sin^2 \theta$
   c) $1, 1, 1$
   d) $1, r, r \sin \theta$
6) In the context of small oscillations, which one of the following does NOT apply to the normal coordinates?

a) Each normal coordinate has an eigen-frequency associated with it
b) The normal coordinates are orthogonal to one another
c) The normal coordinates are all independent
d) The potential energy of the system is a sum of squares of the normal coordinates with constant coefficients

7) For the given unit cells of a two-dimensional square lattice, which option lists all the primitive cells?




a) 1 and 2
b) 1,2 and 3
c) 1,2,3 and 4
d) 1,2,3,4 and 5

8) Among electric field ($\mathbf{E}$), magnetic field ($\mathbf{B}$), angular momentum ($\mathbf{L}$), and vector potential ($\mathbf{A}$), which is/are odd under parity (space inversion) operation?
a) $\mathbf{E}$ only
b) $\mathbf{E}$ & $\mathbf{A}$ only
c) $\mathbf{E}$ & $\mathbf{B}$ only
d) $\mathbf{B}$ & $\mathbf{L}$ only

9) The expression for the second overtone frequency in the vibrational absorption spectra of a diatomic molecule in terms of the harmonic frequency $\omega$ and anharmonicity constant $x_e$, is
a) $2\omega_e\left(1 - x_e\right)$
b) $2\omega_e\left(1 - 3x_e\right)$
c) $3\omega_e\left(1 - 2x_e\right)$
d) $3\omega_e\left(1 - 4x_e\right)$

10) Match the physical effects and order of magnitude of their energy scales given below, where $\alpha = \frac{e^2}{4\pi\epsilon_o\hbar c}$ is the fine structure constant, $m_e$ and $m_p$ are the electron and proton masses, respectively.

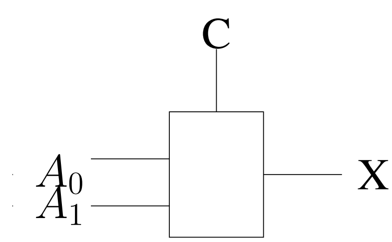
| Group I | Group II |
|---|---|
| P: Lamb shift | $1 :\sim 0\left(\alpha^2 m_e c^2\right)$ |
| Q: Fine structure | $2 :\sim 0\left(\alpha^4 m_e c^2\right)$ |
| R: Bohr energy | $3 :\sim 0\left(\frac{\alpha^4 m_e^2 c^2}{m_p}\right)$ |
| S: Hyperfine structure | $4 :\sim 0\left(\alpha^5 m_p c^2\right)$ |

a) $P-3, Q-1, R-2, S-4$
b) $P-2, Q-3, R-1, S-4$
c) $P-4, Q-2, R-1, S-3$
d) $P-2, Q-4, R-1, S-3$

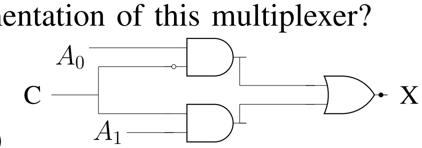
11) The logic expression $\bar{A}BC + \bar{A}\bar{B}C + AB\bar{C} + A\bar{B}\bar{C}$ can be simplified to
a) $AXORC$
b) $AANDC$
c) 0
d) 1

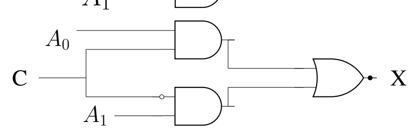
12) At low temperatures $(T)$, the specific heat of common metals is described by (with$\alpha$and$\beta$as constants)
a) $\alpha T + \beta T^3$
b) $\beta T^3$
c) $\exp\left(-\frac{\alpha}{T}\right)$
d) $\alpha T + \beta T^5$

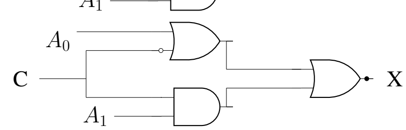
13) In a 2-to-1 multiplexer as shown below, the output $X = A_0$ if $C = 0$ and $X = A_1$ if $C = 1$.
Which one of the following is the correct




implementation of this multiplexer?

a) 


b) 


c) 


d)