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EE24BTECH11003 - Akshara Sarma Chennubhatla

1) If the half-life of an elementary particle moving with speed $0.9c$ in the laboratory frame is $5x10^{-8}$ s, then the proper half-life is _____$x10^{-8}$ s. $\left(c = 3x10^{8}\ \text{m/s}\right)$
2) An unpolarized light wave is incident from air on a glass surface at the Brewster angle. The angle between the reflected and the refracted wave is
   a) 0°
   b) 45°
   c) 90°
   d) 120°
3) Two masses m and $3m$ are attached to the two ends of a massless spring with force constant K. If $m = 100$ g and $K = 0.3$ N/m, then the natural angular frequency of oscillation is _____ Hz.
4) The electric field of a uniform plane wave propagating in a dielectric, non-conducting medium is given by,

$$\mathbf{E} = \mathbf{x}10\cos\left(6\pi x10^{7}t - 0.4\pi z\right) V/m.$$

   The phase velocity of the wave is _____$x10^{8}$ m/s.
5) The matrix $A = \frac{1}{\sqrt{3}}\begin{pmatrix} 1 & 1+i \\ 1-i & -1 \end{pmatrix}$ is
   a) orthogonal
   b) symmetric
   c) anti-symmetric
   d) unitary
6) The recoil momentum of an atom is p_A when it emits an infrared photon of wavelength 1500 nm, and it is p_B when it emits a photon of visible wavelength 500 nm. The ratio $\frac{p_A}{p_B}$ is
   a) 1 : 1
   b) 1 : $\sqrt{3}$
   c) 1 : 3
   d) 3 : 2
7) For a gas under isothermal conditions, its pressure P varies with volume V as $P \propto V^{-\frac{5}{3}}$. The bulk modulus B is proportional to
   a) $V^{-\frac{1}{2}}$
   b) $V^{-\frac{2}{3}}$
   c) $V^{-\frac{3}{5}}$
   d) $V^{-\frac{5}{3}}$
8) Which one of the following high energy processes is allowed by conservation laws?
   a) $p + \bar{p} \rightarrow \Lambda^0 + \Lambda^0$
   b) $\pi^- + p \rightarrow \pi^0 + n$
   c) $n \rightarrow p + e^- + \nu_e$
   d) $\mu^+ \rightarrow e^+ + \gamma$
9) The length element ds of an arc is given by, $(ds)^2 = 2\left(dx^2\right)^2 + \sqrt{3}dx^1dx^2$. The metric tensor g_g is
   a) $\begin{pmatrix} 2 & \sqrt{3} \\ \sqrt{3} & 1 \end{pmatrix}$

b) $\begin{pmatrix} 2 & \sqrt{\frac{3}{2}} \\ \sqrt{\frac{3}{2}} & 1 \end{pmatrix}$

c) $\begin{pmatrix} 2 & 1 \\ \sqrt{\frac{3}{2}} & \sqrt{\frac{3}{2}} \end{pmatrix}$

d) $\begin{pmatrix} 1 & \sqrt{\frac{3}{2}} \\ \sqrt{\frac{3}{2}} & 2 \end{pmatrix}$

10) The ground state and the first excited state wave functions of a one dimensional infinite potential well are ψ_1 and ψ_2, respectively. When two spin-up electrons are placed in this potential, which one of the following, with x1 and x2 denoting the position of the two electrons, correctly represents the space part of the ground state wave function of the system?
   a) $\frac{1}{\sqrt{2}}\left[\psi_1(x_1)\psi_2(x_1) - \psi_1(x_2)\psi_2(x_2)\right]$
   b) $\frac{1}{\sqrt{2}}\left[\psi_1(x_1)\psi_2(x_2) + \psi_1(x_2)\psi_2(x_1)\right]$
   c) $\frac{1}{\sqrt{2}}\left[\psi_1(x_1)\psi_2(x_1) + \psi_1(x_2)\psi_2(x_2)\right]$
   d) $\frac{1}{\sqrt{2}}\left[\psi_1(x_1)\psi_2(x_2) - \psi_1(x_2)\psi_2(x_1)\right]$
11) If the vector potential

$$\mathbf{A} = \alpha x\mathbf{x} + 2y\mathbf{y} - 3z\mathbf{z},$$

   satisfies the Colomb gauge, the value of the constant α is _____
12) At a given temperature, T, the average energy per particle of a non-interacting gas of two-dimensional classical harmonic oscillators is _____k_BT (k_B is the Boltzmann constant).
13) Which of the following is a fermion?
   a) α particle
   b) Be_4^7 nucleus
   c) Hydrogen atom
   d) Deuteron