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1) Let $\vec{L}$ and $\vec{p}$ be the angular and linear momentum operators, respectively, for a particle. The commutator $[L_z, p_y]$ gives
   a) $-i\hbar p_x$
   b) 0
   c) $i\hbar p_x$
   d) $i\hbar p_y$
2) The decay $\mu^+ \to e^+ + \gamma$ is forbidden, because it violates
   a) momentum and lepton number conservations
   b) baryon and lepton number conservations
   c) angular momentum conservation
   d) lepton number conservation
3) An operator for a spin-$\frac{1}{2}$ particle is given by $\hat{A} = \lambda \vec{\sigma} \cdot \vec{B}$, where $\vec{B} = \frac{B}{\sqrt{2}}\hat{x} + i\frac{B}{\sqrt{2}}\hat{y}$, $\vec{\sigma}$ denotes Pauli matrices and λ is a constant. The eigenvalues of $\hat{A}$ are
   a) $\pm\lambda B\sqrt{2}$
   b) $\pm\lambda B$
   c) $0, \lambda B$
   d) $0, -\lambda B$
4) In an inertial frame S, two events A and B take place at $(ct_A = 0, \vec{r}_A = 0)$ and $(ct_B = 0, \vec{r}_B = 2\hat{y})$, respectively. The times at which these events take place in a frame S' moving with a velocity $0.6cy$ with respect to S are given by
   a) $ct'_A = 0; ct'_B = -1.5$
   b) $ct'_A = 0; ct'_B = 0$
   c) $ct'_A = 0; ct'_B = 1.5$
   d) $ct'_A = 0; ct'_B = 0.5$
5) Given that the magnetic flux through the closed loop PQRSP is Φ. If $\int_P^R \vec{A} \cdot \vec{dl} = \phi_1$ along PQR, the value of $\int_P^R \vec{A} \cdot \vec{dl}$ along PSR is
   a) $\Phi - \phi_1$
   b) $\phi_1 - \Phi$
   c) $-\phi_1$
   d) ϕ_1
6) If $f(x) = e^{-x^2}$ and $g(x) = |x|e^{-x^2}$, then
   a) f and g are differentiable everywhere
   b) f is differentiable everywhere but g is not
   c) g is differentiable everywhere but f is not
   d) g is discontinuous at $x = 0$
7) In Bose-Einstein condensates, the particles

a) have strong interparticle attraction
b) condense in real space
c) have overlapping wavefunctions
d) have large and positive chemical potential

8) Consider a system of N non-interacting spin-$\frac{1}{2}$ particles, each having a magnetic moment μ, is in a magnetic field $\vec{B} = B\hat{z}$. If E is the total energy of the system, the number of accessible microstates Ω is given by

a) $\Omega = \dfrac{N!}{\frac{1}{2}\left(N - \frac{E}{\mu B}\right)! \frac{1}{2}\left(N + \frac{E}{\mu B}\right)!}$
b) $\Omega = \dfrac{\left(N - \frac{E}{\mu B}\right)!}{\left(N + \frac{E}{\mu B}\right)!}$
c) $\Omega = \frac{1}{2}\left(N - \frac{E}{\mu B}\right)! \frac{1}{2}\left(N + \frac{E}{\mu B}\right)!$
d) $\Omega = \dfrac{N!}{\left(N + \frac{E}{\mu B}\right)!}$

9) For a black body radiation in a cavity, photons are created and annihilated freely as a result of emission and absorption by the walls of the cavity. This is because

a) the chemical potential of the photons is zero
b) photons obey Pauli exclusion principle
c) photons are spin-1 particles
d) the entropy of the photons is very large

10) Consider $w = f(z) = u(x, y) + iv(x, y)$ to be an analytic function in a domain D. Which one of the following options is NOT correct?

a) $u(x, y)$ satisfies Laplace equation in D
b) $v(x, y)$ satisfies Laplace equation in D
c) $\int_{z_1}^{z_2} f(z)\, dz$ is dependent on the choice of the contour between z_1 and z_2 in D
d) $f(z)$ can be Taylor expanded in D

11) The value of $\int_0^3 t^3 \delta(3t - 6)\, dt$ is

12) Which one of the following DOES NOT represent an exclusive OR operation for inputs A and B?

a) $\left(A + \bar{B}\right) \bar{A}B$
b) $\bar{A}B + \bar{B}A$
c) $(A + B)\left(\bar{A} + \bar{B}\right)$
d) $(A + B)\, \bar{A}B$

13) Consider a complex function $f(z) = \frac{1}{z\left(z + \frac{1}{z}\right)\cos(z\pi)}$. Which one of the following statements is correct?

a) $f(z)$ has simple poles at $z = 0$ and $z = -\frac{1}{2}$
b) $f(z)$ has a second order pole at $z = -\frac{1}{2}$
c) $f(z)$ has infinite number of second order poles
d) $f(z)$ has all simple poles