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53) Let u^{μ} denote the 4-velocity of a relativistic particle whose square $u^{mu}u_{mu} = 1$. If $\epsilon_{\mu\nu\rho\sigma}$ is the Levi-Civita tensor then the value of $\epsilon_{\mu\nu\rho\sigma}u^{\mu}u^{\nu}u^{\rho}u^{\sigma}$ is __________.
54) Consider a simple cubic monoatomic Bravais lattice which has a basis with vectors $\overrightarrow{r_1} = 0, \overrightarrow{r_2} = \frac{a}{4}(\hat{x} + \hat{y} + \hat{z})$, a is the lattice parameter. The Bragg reflection is observed due to the change in the wave vector between the incident and the scatterd beami is given by $\overrightarrow{K} = n_1\overrightarrow{G_1} + n_2\overrightarrow{G_2} + n_3\overrightarrow{G_3}$, where $\overrightarrow{G_1}$,$\overrightarrow{G_2}$ and $\overrightarrow{G_3}$ are primitive reciprocal lattice vectors. For $n_1 = 3,\ n_2 = 3$ and $n_3 = 2$, the geometrical structure factor is __________.
55) A plane electromagnetic wave of wavelength λ is incident on a circular loop of conducting wore. The loop radius is $a\,(a << \lambda)$. THe angle (in degrees), made by the Poynting vector with the normal to the plane of the loop to generate a maximum induced electrical signal, is __________.
56) An electron in a hydrogen atom is in the state $n = 3,\ l = 2,\ m = -2$. Let $\hat{L_y}$ denote the y-component of the orbital angular momentum operator. If $\left(\Delta\hat{L_y}\right)^2 = \alpha\hbar^2$, the value of α is __________.
57) A sinusoidal voltage of the form $v(t) = V_o\cos(\omega t)$ is applied across a parallel plate capacitor placed in vacuum. Ignoring the edge effects, the induced emf within the region between the capacitor plates can be expressed as a power series in ω. The lowest non-vanishing exponent in ω is __________.
58) If $\sum_{k=1}^{\infty} a_k \sin(kx)$, for $-\pi \leq x \leq \pi$, the value of a_2 is __________.
59) Let $f_n(x) = \begin{cases} 0, & \text{if } x < -\frac{1}{2n} \\ n, & \text{if } -\frac{1}{2n} < x < \frac{1}{2n} \\ 0, & \text{if } x > \frac{1}{2n} \end{cases}$
    The value of $\lim_{n\to\infty}\int_{-\infty}^{\infty} f_n(x)\sin x dx$ is __________.
60) Consider the Hamiltonian $\hat{H} = \hat{H}_0 + \hat{H}'$ where
    $\hat{H}_0 = \begin{pmatrix} E & 0 & 0 \\ 0 & E & 0 \\ 0 & 0 & E \end{pmatrix}$ and $\hat{H}'$ is the time independent pertubation given by
    $\hat{H}' = \begin{pmatrix} 0 & k & 0 \\ k & 0 & k \\ 0 & k & 0 \end{pmatrix}$, where $k > 0$. If, the maximum energy eigenvalue of $\hat{H}$ is $3\ eV$ corresponding to $E = 2\ eV$, the value of k (rounded off to three decimal places) in eV is __________.
61) A hydrogen atom is in orbital angular momentum $|l, m = l\rangle$. If $\overrightarrow{L}$ lies on a cone which makes a half angle 30°with respect to z-axis, the value of l is __________.
62) In the center of mass frame, two protons having energy 7000 GeV, collide to produce protons and anti-protons. The maximum number of anti-protons produced is __________.
    $\left(\text{Assume the proton mass to be } 1\ \frac{GeV}{c^2}\right)$
63) Consider a gas of hydrogen atoms in the atmosphere of the Sun where the temperature is 5800 K. If a sample from this atmosphere contains 6.023×10^{23} of hydrogen atoms in the ground state, the number of hydrogen atoms in the first excited state is approximately 8×10^n, where n is an integer. The value of n is __________.
    $\left(\text{Boltzmann constant: } 8.617 \times 10^{-5}\frac{eV}{K}\right)$

64) For a gas of non-interacting particles, the probability that a particle has a speed v in the interval v to $v + dv$ is given by

$$f(v)\,dv = 4\pi v^2 dv \left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} e^{\frac{mv^2}{2k_B T}}$$

If E is the energy of a particle, then the maximum in the corresponding energy distributions in units of $\frac{E}{k_B T}$ occurs at __________ (rounded off to one decimal place).

65) The Planck's energy density distribution in given by $u(\omega) = \frac{\hbar\omega^3}{\pi^2 c^3\left(e^{\frac{\hbar\omega}{k_B T}} - 1\right)}$. At long wavelengths, the energy density of photons in thermal equilibrium with a cavity at temperature T varies as T^{α}, where α is __________.