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27) An infinite solenoid carries a time-varying current $I(t) = At^2$ with $A = 40$. The axis of the solenoid is along the z direction. $\hat{r}$, $\hat{\theta}$, and $\hat{z}$ are the usual radial, polar, and axial directions in cylindrical polar coordinates. $B = B_r\hat{r} + B_\theta\hat{\theta} + B_z\hat{z}$ is the magnetic field at a point outside the solenoid.
Which one of the following statements is true?
a) $B_r = 0, B_\theta = 0, B_z = 0$
b) $B_r \neq 0, B_\theta = 0, B_z = 0$
c) $B_r \neq 0, B_\theta \neq 0, B_z = 0$
d) $B_r = 0, B_\theta = 0, B_z \neq 0$

28) A uniform volume charge density is placed inside a conductor $(with resistivity 10^2\,\Omega\text{m})$. The charge density becomes $\frac{1}{(2.718)}$ of its original value after time t femtoseconds (up to two decimal places), with $\epsilon_0 = 8.854 \times 10^{-12}\,\frac{F}{m}$.

29) Water freezes at 0°C at atmospheric pressure $(1.01 \times 10^5\,\text{Pa})$. The densities of water and ice at this temperature and pressure are $1000\,\frac{kg}{m^3}$ and $934\,\frac{kg}{m^3}$ respectively. The latent heat of fusion is $3.34 \times 10^5\,\frac{J}{kg}$. The pressure required for depressing the melting temperature of ice by 1°C is GPa (up to two decimal places).

30) The minimum number of NAND gates required to construct an OR gate is:
a) 2
b) 4
c) 5
d) 3

31) Consider a 2-dimensional electron gas with a density of $10^{19}\,\text{m}^{-2}$. The Fermi energy of the system is eV (up to two decimal places).
Given: $m = 9.31 \times 10^{-31}\,\text{kg}$, $h = 6.626 \times 10^{-34}\,\text{Js}$, $e = 1.602 \times 10^{-19}\,\text{C}$

32) The total energy of an inert-gas crystal is given by $E(R) = \frac{0.5}{R^{12}} - \frac{1}{R^6}\ (ineV)$, where R is the inter-atomic spacing in Angstroms. The equilibrium separation between the atoms is Angstroms (up to two decimal places).

33) Consider N non-interacting, distinguishable particles in a two-level system at temperature T. The energies of the levels are 0 and ϵ, where $\epsilon > 0$. In the high temperature limit $(k_BT \gg \epsilon)$, what is the population of particles in the level with energy ϵ?
a) $\frac{N}{2}$
b) N
c) $\frac{N}{3}$
d) $\frac{3N}{4}$

34) A free electron of energy 1 eV is incident upon a one-dimensional finite potential step of height 0.75 eV. The probability of its reflection from the barrier is (up to two decimal places).

35) Consider a one-dimensional potential well of width 3 nm. Using the uncertainty principle $(\Delta x\,\Delta p \geq \hbar/2)$, an estimate of the minimum depth of the well such that it has at least one bound state for an electron is (up to two decimal places).
Given: $m_e = 9.31 \times 10^{-31}\,\text{kg}$, $h = 6.626 \times 10^{-34}\,\text{Js}$, $e = 1.602 \times 10^{-19}\,\text{C}$
a) 1 μeV
b) 1 meV
c) 1 eV
d) 1 MeV

36) Consider a metal with free electron density of $6 \times 10^{22}\,\text{cm}^{-3}$. The lowest frequency of electromagnetic radiation to which this metal is transparent is 1.38×10^{16} Hz. If this metal had a free electron density of $1.8 \times 10^{23}\,\text{cm}^{-3}$ instead, the lowest frequency of electromagnetic radiation to which it would be transparent is $\times 10^{16}$ Hz (up to two decimal places).

37) An object travels along the x-direction with velocity $\frac{c}{2}$ in a frame O. An observer in a frame $O\prime$ sees the same object travelling with velocity $\frac{c}{4}$. The relative velocity of $O\prime$ with respect to O in units of c is (up to two decimal places).

38) The integral $\int (x^2 - 1)^3\,dx$ is equal to (up to two decimal places).

39) The imaginary part of an analytic complex function is $v(x, y) = 2xy + 3y$. The real part

of the function is zero at the origin. The value of the real part of the function at $1 + i$ is (up to two decimal places).