2019-PH-27-39

EE24BTECH11066 - YERRA AKHILESH

27) Consider a three-dimensional crystal of N inert gas atoms. The total energy is given by $U(R) = 2N \in \left[p\left(\frac{\sigma}{R}\right)^{12} - q\left(\frac{\sigma}{R}\right)^{6}\right]$, where $p = 12.13, q = 14.45$, and R is the nearest neighbour distance between two atoms. The two constants, $\in$ and R, have the dimensions of energy and length, respectively. The equilibrium separation between two nearest neighbour atoms in units of σ (rounded off to two decimal places) is ______ [2019-PH]

28) The energy-wavevector $(E-k)$ dispersion relation for a particle in two dimensions is $E = Ck$, where C is a constant. If its density of states $D(E)$ is proportional to E^p then the value of p is ______ [2019-PH]

29) A circular loop made of a thin wire has radius 2 cm and resistance 2Ω. It is placed perpendicular to a uniform magnetic field of magnitude $\left|\overrightarrow{B}_0\right| = 0.01$ Tesla. At time $t = 0$ the field starts decaying as $\overrightarrow{B} = \overrightarrow{B}_0 e^{\frac{-t}{t_0}}$, where $t_0 = 1s$. The total charge that passes through a cross section of the wire during the decay is Q. The value of Q in μC (rounded off to two decimal places) is ______ [2019-PH]

30) The electric field of an electromagnetic wave in vacuum is given by

$$\overrightarrow{E} = E_0 \cos\left(3y + 4z - 1.5 \times 10^9 t\right)\hat{x}.$$

The wave is reflected from the $z = 0$ surface. If the pressure exerted on the surface is $\alpha \in_0 E_0^2$, the value of α (rounded off to one decimal place) is ______ [2019-PH]

31) The Hamiltonian for a quantum harmonic oscillator of mass m in three dimensions is

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 r^2$$

where ω is the angular frequency. The expectation value of r^2 in the first excited state of the oscillator in units of $\frac{\hbar}{m\omega}$ (rounded off to one decimal place) [2019-PH]

32) The Hamiltonian for a particle of mass m is $H = \frac{p^2}{2m} + kqt$ where q and p are the generalized coordinate and momentum, respectively, t is time and k is a constant. For the initial condition, $q = 0$ and $p = 0$ at $t = 0, q(t) \propto t^{\alpha}$. The value of α is ______ [2019-PH]

33) At temperature TKelvin (K), the value of the Fermi function at an energy $0.5eV$ above the Fermi energy is 0.01. Then T, to the nearest integer, is ______ $\left(k_B = 8.62 \times 10^{-5} \frac{eV}{K}\right)$ [2019-PH]

34) Let $|\psi_1\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, |\psi_2\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ represent two possible states of a two-level quantum system. The state obtained by the incoherent superposition of $|\psi_1\rangle$ and $|\psi_2\rangle$ is given by a density matrix that is defined as $\rho \equiv c_1|\psi_1\rangle\langle\psi_1| + c_2|\psi_2\rangle\langle\psi_2|$. If $c_1 = 0.4$ and $c_2 = 0.6$, the matrix element ρ_{22} (rounded off to one decimal place) is ______ [2019-PH]

35) A conventional type-I superconductor has a critical temperature of 4.7K at zero magnetic field and a critical magnetic field of 0.3 Tesla at 0 K. The critical field in Tesla at 2 K (rounded off to three decimal places) is ______ [2019-PH]

36) Consider the following Boolean expression:

$$\left(\overline{A} + \overline{B}\right)\left[\overline{A\,(B + C)}\right] + A\left(\overline{B} + \overline{C}\right)$$

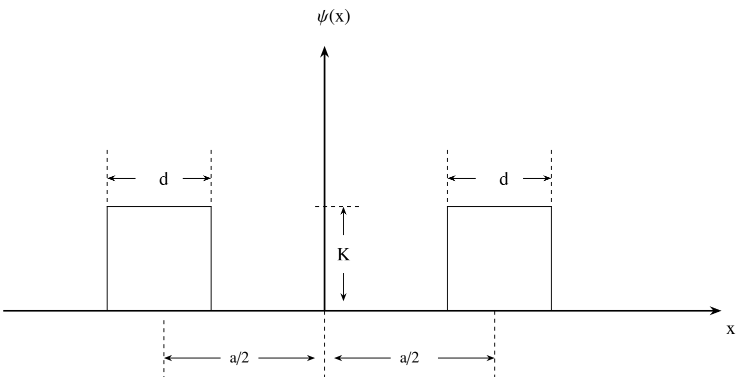
It can be represented by a single three-input logic gate. Identify the gate. [2019-PH]

a) AND b) OR c) XOR d) NAND

37) The value of the integral $\int_{-\infty}^{\infty} \frac{\cos(kx)}{x^2+a^2}\,\mathrm{d}x$, where $k > 0$ and $a > 0$, is [2019-PH]

a) $\frac{\pi}{a}e^{-ka}$ b) $\frac{2\pi}{a}e^{-ka}$ c) $\frac{\pi}{2a}e^{-ka}$ d) $\frac{3\pi}{2a}e^{-ka}$

38) The wave function $\psi(x)$ of a particle is as shown below



Here K is a constant, and $a > d$. The position uncertainty $\langle \Delta x \rangle$ of the particle is

a) $\sqrt{\frac{a^2+3d^2}{12}}$ b) $\sqrt{\frac{3a^2+d^2}{12}}$ c) $\sqrt{\frac{d^2}{6}}$ d) $\sqrt{\frac{d^2}{24}}$

39) A solid cylinder of radius R has total charge Q distributed uniformly over its volume. It is rotating about its axis with angular speed ω. The magnitude of the total magnetic moment of the cylinder is [2019-PH]

a) $QR^2\omega$
b) $\frac{1}{2}QR^2\omega$
c) $\frac{1}{4}QR^2\omega$
d) $\frac{1}{8}QR^2\omega$