A circular rod of length 1\,m and diameter 0.8\,cm is clamped rigidly at one of its end in a vertical position. A couple of magnitude \(N\ dynes/cm\) is applied at the open end resulting in deflecting a mirror fixed near this end to deflect the spot of light by 10\,cm on a scale kept at a distance of 1\,m. If the modulus of rigidity of the bar is \(\eta = 8.0 \times 10^{11}\ dynes/cm^2\), calculate \(N\)?

Options:
- \(1.6 \times 10^6\ dynes/cm\)
- \(1.6 \times 10^7\ dynes/cm\)
- \(2.56 \times 10^5\ dynes/cm\)
2.56 \times 10^7 \text{ dynes/cm}

Question Number : 2  Question Id : 827347302  Question Type : MCQ

A champion swimmer wants to cross a river spanning 2 km. The velocity of the flow of water in the river is 6 km/hr. The swimmer desires to go exactly to the opposite end. His maximum speed in still water is 10 km/hr. Find the time he would take to cross the river?
Options :
10 min.
15 min.
20 min.
25 min.

Question Number : 3  Question Id : 827347303  Question Type : MCQ

A car of mass $M$ has a simple pendulum suspended from its ceiling. If at any instant the pendulum makes an angle $\theta$ with the vertical, the acceleration, $a$, of the car is given by
Options :
$a = \tan \theta$
$a = \cos \theta$
$a = M \tan \theta$
$a = M \cos \theta$

Question Number : 4  Question Id : 827347304  Question Type : MCQ

Consider a fixed sphere of radius $R$ and a particle of mass $M$ slides on its surface from the topmost point and leaves the contact with the sphere at an angle $\theta$. The angle $\theta$ is given by
Options :
$\cos^{-1} \left( \frac{1}{3} \right)$
$\sin^{-1} \left( \frac{1}{3} \right)$
$\cos^{-1} \left( \frac{2}{3} \right)$
$\sin^{-1} \left( \frac{2}{3} \right)$

Question Number : 5  Question Id : 827347305  Question Type : MCQ

A central force $\vec{F} = -k \frac{\vec{r}}{r^3}$ acts on a particle of mass $M$. If the total energy of the particle is $E$, then its speed $V$ is given by
Options :
\[
\sqrt{\frac{k}{Mr^2} - \frac{E}{M}}
\]
\[
\sqrt{\frac{k}{2Mr^2} + \frac{2E}{M}}
\]

Question Number : 6  Question Id : 827347306  Question Type : MCQ

Liquid drops of water, each of radius \( r \), combines to form a drop of radius \( R \). If \( T \) is the surface tension then the rise in temperature of the resulting droplet will be

Options :

2T \left[ \frac{\frac{1}{r} - \frac{1}{R}}{r} \right]

3T \left[ \frac{\frac{1}{r} - \frac{1}{R}}{r} \right]

2T \left[ \frac{\frac{1}{r} + \frac{1}{R}}{r} \right]

3T \left[ \frac{\frac{1}{r} + \frac{1}{R}}{r} \right]

Question Number : 7  Question Id : 827347307  Question Type : MCQ

Two masses \( M_1 \) and \( M_2 \) are connected by a massless spring of force constant \( k \). If at any instant, the displacement of the two masses are respectively \( x_1 \) and \( x_2 \), then the Lagrangian \( L \) and eigen frequency of small oscillation \( \omega \) are given by

Options :

\[
L = \frac{1}{2} M_1 \dot{x}_1^2 + \frac{1}{2} M_2 \dot{x}_2^2 - \frac{1}{2} k (x_2 - x_1)^2 : \omega = \sqrt{\frac{k(M_1 + M_2)}{M_1 M_2}}
\]

\[
L = \frac{1}{2} M_1 \dot{x}_1^2 + \frac{1}{2} M_2 \dot{x}_2^2 + \frac{1}{2} k (x_2 - x_1)^2 : \omega = \sqrt{\frac{k(M_1 - M_2)}{M_1 M_2}}
\]

\[
L = \frac{1}{2} M_1 \dot{x}_1^2 - \frac{1}{2} M_2 \dot{x}_2^2 - \frac{1}{2} k (x_2 - x_1)^2 : \omega = \sqrt{\frac{k(M_1 + M_2)}{M_1 M_2}}
\]

\[
L = \frac{1}{2} M_1 \dot{x}_1^2 - \frac{1}{2} M_2 \dot{x}_2^2 + \frac{1}{2} k (x_2 - x_1)^2 : \omega = \sqrt{\frac{k(M_1 - M_2)}{M_1 M_2}}
\]
The Hamiltonian for a charge particle of mass $m$, momentum $\vec{p}$ and carrying a charge $q$ in an electromagnetic field $(\vec{A}, \varphi)$ with velocity $c$ may be written as:

Options:

$$H = \frac{1}{2} m \left( \frac{\vec{p}}{m} + \frac{q}{mc} \vec{A} \right)^2 + q\varphi$$

$$H = \frac{1}{2} m \left( \frac{\vec{p}}{m} - \frac{q}{mc} \vec{A} \right)^2 - q\varphi$$

$$H = \frac{1}{2} m \left( \frac{\vec{p}}{m} + \frac{q}{mc} \vec{A} \right)^2 - q\varphi$$

$$H = \frac{1}{2} m \left( \frac{\vec{p}}{m} - \frac{q}{mc} \vec{A} \right)^2 + q\varphi$$

Question Number : 9  Question Id : 827347309  Question Type : MCQ

The mean life of muon in its rest frame is $2 \times 10^{-6} \, s$. If it is moving with a speed of 0.93 times the speed of light $c$, then its life in laboratory frame will be

Options :

$2.44 \times 10^{-6} \, s$

$3.44 \times 10^{-6} \, s$

$4.44 \times 10^{-6} \, s$

$5.44 \times 10^{-6} \, s$

Question Number : 10  Question Id : 827347310  Question Type : MCQ

Calculate the relative velocity of an electron with respect to a photon when the electron is moving with a speed of 0.9 times the velocity of light, $c$, in a direction opposite to that of a moving photon.

Options :

$0.9c$

$c$

$c/2$

$c/4$

Question Number : 11  Question Id : 827347311  Question Type : MCQ

A space ship moves with certain velocity $V$ such that the every day corresponds to 4 days on earth’s surface. Calculate $V$?

Options :

$0.9 \times 10^8 \, m/s$

$1.9 \times 10^8 \, m/s$

$2.9 \times 10^8 \, m/s$
3.9 \times 10^8 \text{m/s}

Question Number : 12  Question Id : 827347312  Question Type : MCQ

If \( p \) and \( T \) denote the momentum and kinetic energy of a particle, then the rest mass of the particle is given by

Options :

\[
m_0 = \frac{p^2 c^2 - T^2}{2 T c^2}
\]

\[
m_0 = \frac{p^2 c^2 + T^2}{2 T c^2}
\]

\[
m_0 = \frac{p^2 c^2 - T^2}{T c^2}
\]

\[
m_0 = \frac{3 p^2 c^2 - T^2}{2 T c^2}
\]

Question Number : 13  Question Id : 827347313  Question Type : MCQ

An infinitely straight wire is charged uniformly. If charge per unit length of the wire is \( \mu \) and the permittivity of the free space is \( \varepsilon_0 \), then the electric field \( E \) at a perpendicular distance \( R \) from the wire is given by

Options :

\[
\frac{1}{4\pi \varepsilon_0} \frac{\mu}{r}
\]

\[
\frac{1}{2\pi \varepsilon_0} \frac{\mu}{r}
\]

\[
\frac{1}{2\pi \varepsilon_0} \ln \frac{\mu}{r}
\]

\[
\frac{1}{4\pi \varepsilon_0} \ln \frac{\mu}{r}
\]

Question Number : 14  Question Id : 827347314  Question Type : MCQ

A solid sphere of radius \( R \) has uniformly distributed charge \( Q \). The potential \( V \) at any point \( r < R \) is given by

Options :

\[
\frac{1}{4\pi \varepsilon_0} \frac{Q}{R}
\]

\[
\frac{1}{2\pi \varepsilon_0} \frac{Q}{R}
\]

\[
\frac{1}{4\pi \varepsilon_0} \frac{Q}{R} \left[ \frac{3 - \frac{r^2}{R^2}}{2} \right]
\]
\[ \frac{1}{4\pi \varepsilon_0} \frac{Q}{R} \left[ \frac{3}{2} - \frac{r^2}{2R^2} \right] \]

Question Number : 15  Question Id : 827347315  Question Type : MCQ

Find the charge distribution \( \rho \) of nucleus for which the Yukawa potential at a point \( r \) from the center is \( V(r) = \frac{Q}{4\pi \varepsilon_0} \frac{e^{-r/a}}{r} \)?

Options:

\[ \rho = -\frac{Q}{4\pi \varepsilon_0} \frac{e^{-r/a}}{r} \]
\[ \rho = -\frac{Q}{4\pi a^2} \frac{e^{-r/a}}{r} \]
\[ \rho = -\frac{Q}{4\pi a^3} \frac{e^{-r/a}}{r} \]
\[ \rho = -\frac{Q}{4\pi} \frac{e^{-r/a}}{r} \]

Question Number : 16  Question Id : 827347316  Question Type : MCQ

Certain space has uniform electric field \( E \) and magnetic field \( B \). The scalar and vector potentials at a position vector \( \vec{r} \) in such a space is

Options:

\[ \phi = \vec{E} \cdot \vec{r} ; \vec{A} = (\vec{B} \times \vec{r}) \]
\[ \phi = \vec{E} \cdot \vec{r} ; \vec{A} = \frac{1}{2} (\vec{B} \times \vec{r}) \]
\[ \phi = -\vec{E} \cdot \vec{r} ; \vec{A} = \frac{1}{2} (\vec{B} \times \vec{r}) \]
\[ \phi = -\vec{E} \cdot \vec{r} ; \vec{A} = \frac{1}{3} (\vec{B} \times \vec{r}) \]

Question Number : 17  Question Id : 827347317  Question Type : MCQ

The magnetic field \( \vec{B} \), when \( \vec{E} = E_0 \sin(\omega t - \alpha z)\vec{a}_y \), is given by

Options:

\[ \frac{E_0 \alpha}{\omega} \sin(\omega t - \alpha z)\vec{a}_x \]
\[ -\frac{E_0 \alpha}{\omega} \cos(\omega t + \alpha z)\vec{a}_y \]
\[ -\frac{E_0 \alpha}{\omega} \sin(\omega t - \alpha z)\vec{a}_z \]
\[- \frac{E_0}{\omega} \cos(\omega t + \alpha z) \vec{a}_x \]

Question Number : 18  Question Id : 827347318  Question Type : MCQ

In an isotropic, homogeneous and loss-less medium with \( \varepsilon_r = 8 \) and \( \mu_r = 2 \), the electric and magnetic fields are respectively \( \vec{E} = 60\pi \cos(10^6 t - \alpha x) \vec{a}_y \) (V/m) and \( \vec{H} = P \cos(10^6 t - \alpha x) \vec{a}_z \) (A/m). The values of \( P \) and \( \alpha \) respectively are:

Options :

2, 0.055
2, 0.065
1, 0.042
1, 0.055

Question Number : 19  Question Id : 827347319  Question Type : MCQ

The Laplace equation satisfied by the potential \( V \) at a point outside a cylindrical conductor of radius \( b \) is given by

\[ V = - \left( 1 - \frac{b^2}{r^2} \right) E_0 r \cos \theta. \]

Find the surface charge density \( \sigma \) (per unit area) of the conducting surface?

Options :

\( \varepsilon_0 E_0 \cos \theta \)
\( \varepsilon_0 E_0 \sin \theta \)
2 \( \varepsilon_0 E_0 \cos \theta \)
2 \( \varepsilon_0 E_0 \sin \theta \)

Question Number : 20  Question Id : 827347320  Question Type : MCQ

Find the amplitude of electric field \( (E_0) \) and magnetic field \( (H_0) \) of radiation if earth receives 2 \( \text{cal.min.}^{-1} \cdot \text{cm}^{-2} \) of solar radiation?

Options :

\( E_0 = 1027.12(V/m) ; H_0 = 2.72(A/m) \)
\( E_0 = 726.32(V/m) ; H_0 = 1.93(A/m) \)
\( E_0 = 363.16(V/m) ; H_0 = 1.93(A/m) \)
\( E_0 = 726.32(V/m) ; H_0 = 3.86(A/m) \)

Question Number : 21  Question Id : 827347321  Question Type : MCQ

If the magnetic vector potential is given by \( \vec{A} = (y^2 \hat{i} - x^2 \hat{j}) \), then the current density \( \vec{j} \) may be written as

Options :
\[ \frac{2}{\mu_0} [i - j] \]
\[ \frac{2}{\mu_0} [i + j] \]
\[ - \frac{2}{\mu_0} [i - j] \]
\[ - \frac{2}{\mu_0} [i + j] \]

Question Number : 22  Question Id : 827347322  Question Type : MCQ

If in vacuum the electric and magnetic field respectively are \( E = E_0 \sin(kx - \omega t) \) and \( B = B_0 \sin(kx - \omega t) \), then

Options :
\[ E_0 B_0 = \omega k \]
\[ E_0 \omega = B_0 k \]
\[ E_0 / \omega = B_0 k \]
\[ E_0 k = B_0 \omega \]

Question Number : 23  Question Id : 827347323  Question Type : MCQ

An interference fringe system is observed due to interference of two light beams of intensities \( I \) and \( 9I \). If the phase difference is \( \pi / 2 \) at a point \( A \) and \( \pi \) at point \( B \), then the difference of the intensities at \( A \) and \( B \) is

Options :
\[ 3I \]
\[ 4I \]
\[ 5I \]
\[ 6I \]

Question Number : 24  Question Id : 827347324  Question Type : MCQ

A first order diffraction image is observed using a lamp emitting electromagnetic waves of wavelength 6000 Å and a fabric with 200 threads/cm. Find the angle between the lamp filament and its first diffracted image.

Options :
\[ 31.25 \text{ min} \]
\[ 41.25 \text{ min} \]
\[ 51.25 \text{ min} \]
\[ 55.25 \text{ min} \]

Question Number : 25  Question Id : 827347325  Question Type : MCQ
The numerical aperture of a step index fibre is 0.15. If the core diameter and refractive index are 60 cm and 1.45 respectively, find the normalized frequency for the fibre when light of wavelength of 0.9 μm gets transmitted through it.

Options:
3.14 × 10^4
3.14 × 10^5
3.14 × 10^6
3.14 × 10^7

Question Number : 26  Question Id : 827347326  Question Type : MCQ

In an experiment 1 gm helium at S.T.P is compressed adiabatically such that its pressure is doubled. If $\frac{dW}{dT} = 8.3 \times 10^7 \text{ergs/}^\circ \text{C/mole}$, find the work done in compressing the gas?

Options:
310.2 × 10^7 \text{ergs}
-310.2 × 10^7 \text{ergs}
350.2 × 10^6 \text{ergs}
-350.2 × 10^7 \text{ergs}

Question Number : 27  Question Id : 827347327  Question Type : MCQ

What is the difference between 1 gm of ice at 0°C and 1 gm of steam at 100°C. Given that latent heat of fusion of ice is 80cals. And latent heat of steam at 100°C is 540cals.

Options:
3.12 cal/°C
0.312 cal/°C
0.0312 cal/°C
0.00312 cal/°C

Question Number : 28  Question Id : 827347328  Question Type : MCQ

Which of the following relation hold true? All symbols have their usual meaning.

Options:
\[ TdS = C_v dT + T \left( \frac{\partial p}{\partial T} \right)_v dV \]
\[ TdS = C_v dT + T \left( \frac{\partial S}{\partial T} \right)_v dV \]
\[ TdS = C_v dT - T \left( \frac{\partial p}{\partial T} \right)_v dV \]
\[ TdS = C_v dT - T \left( \frac{\partial S}{\partial T} \right)_v dV \]
The Gibb’s function, $G$, in thermodynamics is given by $G = H - TS$, where $H, T$ and $S$ respectively refers to enthalpy, temperature and entropy. For an isothermal, isobaric reversible process $G$

Options:
- varies non-linearly with $P$
- is less than zero
- remains constant
- varies non-linearly with volume

Thermodynamical relation that express the change in temperature with change in volume at constant entropy is given by

Options:

\[
\left( \frac{\partial T}{\partial V} \right)_s = \left( \frac{\partial p}{\partial Q} \right)_v \\
\left( \frac{\partial T}{\partial V} \right)_s = T \left( \frac{\partial p}{\partial Q} \right)_v \\
\left( \frac{\partial T}{\partial V} \right)_s = -T \left( \frac{\partial p}{\partial Q} \right)_v \\
\left( \frac{\partial T}{\partial V} \right)_s = -V \left( \frac{\partial p}{\partial Q} \right)_v
\]

The value of the integral $\oint \frac{dq}{T}$ for a reversible cycle is

Options:
- zero
- greater than zero
- less than zero
- $T$, the temperature

For non-interacting particles of spin $\frac{1}{2}$, the total number of accessible states is

Options:
- $2N$
- $N$
- $2^N$
- $N^2$
Question Number : 33  Question Id : 827347333  Question Type : MCQ

For a single particle, the number of coordinates in phase space equals
Options:
6
4
3
2

Question Number : 34  Question Id : 827347334  Question Type : MCQ

The thermodynamic probability for a system in equilibrium is
Options:
zero
one
maximum
minimum

Question Number : 35  Question Id : 827347335  Question Type : MCQ

The translational partition function, \( Z \), for a gas molecule is
Options:
proportional to \( T^{1/2} \)
proportional to \( T^{1/3} \)
proportional to \( T^{3/2} \)
proportional to \( T^{2/3} \)

Question Number : 36  Question Id : 827347336  Question Type : MCQ

If \( E_F \) is the Fermi energy and \( f(E) \) is the fermi distribution at temperature \( T \), then
\( f(E_F) \) is
Options:
\( \frac{1}{2} \)
a step function
\( E < E_F \)
\( E > E_F \)

Question Number : 37  Question Id : 827347337  Question Type : MCQ

The average value of \( v_x \) for a system of particle obeying Maxwellian distribution is
Options:
\( \frac{1}{k_B T} \)
\( \frac{1}{2 k_B T} \)
\[
\sqrt{\frac{k_B T}{m}}
\]

zero

Question Number : 38  Question Id : 827347338  Question Type : MCQ

Find the most probable position of the particle if the wave function is

\[
\psi(x) = \frac{1 + i x}{1 + i x^2}
\]

Options :

\[x = \pm \sqrt{2} - 1\]

\[x = \pm \sqrt{2} + 1\]

\[x = \pm \sqrt{3} - 1\]

\[x = \pm \sqrt{3} + 1\]

Question Number : 39  Question Id : 827347339  Question Type : MCQ

If \(\psi(r) = \frac{1}{\pi a^2} e^{-r/a}\) corresponds to the ground state wave function of hydrogen atom, the average value \(<r>\) is

Options :

zero

\[\frac{a}{2}\]

\[3\frac{a}{2}\]

\[5\frac{a}{2}\]

Question Number : 40  Question Id : 827347340  Question Type : MCQ

The quantum mechanical operator representing the momentum of a particle is given by

Options :

\[-i\hbar \frac{\partial}{\partial x}\]

\[-i\hbar \frac{\partial}{\partial t}\]

\[\hbar \frac{d^2}{dx^2}\]

\[-i\hbar \frac{d^2}{dx^2}\]

Question Number : 41  Question Id : 827347341  Question Type : MCQ
The de-Broglie wavelength, $\lambda$, for a charge $Q$ accelerated through a potential $V$ volts is given by

Options:

$\lambda = \frac{\hbar}{\sqrt{2mQV}}$

$\lambda = \frac{\hbar}{\sqrt{mQV}}$

$\lambda = \frac{\hbar}{mQV}$

Question Number : 42  Question Id : 827347342  Question Type : MCQ

The Schrödinger time independent equation can be written as

Options:

$H\psi = (E - V)\psi$

$H\psi + E\psi = 0$

$H\psi = (E + V)\psi$

$H\psi = E\psi$

Question Number : 43  Question Id : 827347343  Question Type : MCQ

The uncertainty in the velocity of an electron when they are located within a distance of $2A^*$ is

Options:

$5.83 \times 10^5 m/s$

$5.83 \times 10^7 m/s$

$5.83 \times 10^9 m/s$

$5.83 \times 10^8 m/s$

Question Number : 44  Question Id : 827347344  Question Type : MCQ

The average momentum in the ground state of a particle of mass $m$ moving in a one-dimensional box of length $L$ is given by

Options:

$\frac{\hbar}{L}$

$\frac{\hbar}{2\pi L}$

$\frac{\hbar}{2L}$

$2\frac{\hbar}{L}$

Question Number : 45  Question Id : 827347345  Question Type : MCQ
If \( L_\pm = L_x \pm i L_y \), find the value of \( L^2 \)?

Options:
\[
\frac{1}{2} (2L_+L_- + L_-L_+)
\]
\[
\frac{1}{2} (L_+L_- + L_-L_+)L_z^2
\]
\[
(2L_+L_- + L_-L_+)
\]
\[
\frac{1}{2} (2L_+L_- + L_-L_+)L_z^2
\]

Question Number : 46  Question Id : 827347346  Question Type : MCQ

If \( \vec{L} = L_x \hat{j} + L_y \hat{j} + L_z \hat{k} \), the value of commutator \([L_x, L_y, L_z]\) is

Options:
\[i\hbar[L_x + L_y]
\]
\[i\hbar[L_x^2 + L_y^2]
\]
\[i\hbar[L_x^2 - L_y^2]
\]
\[i\hbar[L_x - L_y]
\]

Question Number : 47  Question Id : 827347347  Question Type : MCQ

What is the probability that a particle has \( L_z = 0 \), if its state is given by
\[
\frac{1}{\sqrt{14}} \begin{pmatrix} 3 \\ 2 \\ 1 \end{pmatrix}
\]

Options:
\[2/5
\]
\[2/7
\]
\[3/5
\]
\[3/7
\]

Question Number : 48  Question Id : 827347348  Question Type : MCQ

The wave function of hydrogen atom is given by
\[
\psi(r, \theta, \phi) = \frac{1}{\sqrt{2}} \left( \frac{1}{\alpha_0} \right)^{3/2} \left[ 1 - \frac{r}{2\alpha_0} \right] e^{-r/2\alpha_0} \cos \theta
\]

where \( \alpha_0 \) is a constant. The quantum number of the state are

Options:
\[n = 1, l = 0, m = 0
\]
\[n = 2, l = 1, m = 0
\]
\[ n = 2, l = 1, m = 1 \]
\[ n = 1, l = 2, m = 1 \]

Question Number : 49  Question Id : 827347349  Question Type : MCQ

The state \( S_{z} = \frac{\hbar}{2} \) refers to a spin half particle. The expectation value for \( S_{y}^{2} \) is

Options:
\[ \frac{\hbar}{2} \]
\[ \frac{\hbar^{2}}{4} \]
\[ \frac{\hbar^{2}}{3} \]
\[ \frac{\hbar}{3} \]

Question Number : 50  Question Id : 827347350  Question Type : MCQ

If
\[ V(\vec{r}) = \begin{cases} V_{0} & \text{if } r \leq a \\ 0 & \text{if } r > a \end{cases} \]

then the low energy scattering cross-section \( \sigma(\theta) \) is

Options:
\[ \left( \frac{2mV_{0}a^{3}}{3\hbar^{2}} \right)^{2} \]
\[ \left( \frac{2mV_{0}a^{3}}{3\hbar^{2}} \right)^{3} \]
\[ \left( \frac{2mV_{0}a^{3}}{\hbar^{2}} \right)^{2} \]
\[ \left( \frac{2mV_{0}a^{3}}{5\hbar^{2}} \right)^{3} \]

Question Number : 51  Question Id : 827347351  Question Type : MCQ

A transistor is put in a common base configuration such that the emitter current is 2mA. If the collector current in open emitter circuit is 50\mu A, what is the total collector current for \( \alpha = 0.90 \) is

Options:
1.80mA
1.70mA
1.75mA
1.85mA

Question Number : 52  Question Id : 827347352  Question Type : MCQ
When electromagnetic radiation shorter than 3000 nm is incident on a semiconductor, its conductivity increases. Find the band gap of the semiconductor.

Options:
0.415 eV
1.415 eV
0.750 eV
0.315 eV

Question Number: 53  Question Id: 827347353  Question Type: MCQ

If the band gap of pure silicon is 1.1 eV, then by doping with

Options:
\( n \)-type impurities, the band gap is less than 1.1 eV
\( p \)- or \( n \)-type impurities, the band gap is always 1.1 eV
\( p \)-type impurities, the band gap becomes 1.25 eV
\( p \)-type impurities, the band gap more than 1.1 eV

Question Number: 54  Question Id: 827347354  Question Type: MCQ

The maximum resistance \( R \) that can be used in series with a zener diode \((V_Z = 5V, I_Z = 10mA)\) when a 20 V supply is connected across the combination is

Options:
10 kΩ
1.0 kΩ
1.5 kΩ
15 kΩ

Question Number: 55  Question Id: 827347355  Question Type: MCQ

In an \( n - p - n \) transistor circuit if \( I_c = 2mA \) and \( \alpha = 0.98 \) then the base current \( I_b \) is

Options:
0.041 mA
4.10 mA
0.41 mA
0.0041 mA

Question Number: 56  Question Id: 827347356  Question Type: MCQ

A transistor amplifier has current gain 50. When connected with the input signal
\[ V_i = V_1 \sin(2\pi ft + \pi/2) \]

the output signal is found to be
\[ V_o = V_2 \sin(2\pi ft + 3\pi/2). \]
The transistor is connected as

Options:
a common base amplifier
a common collector amplifier
a common emitter amplifier
a push-pull amplifier

Question Number : 57 Question Id : 827347357 Question Type : MCQ

An operational amplifier has bias currents of $40 \mu A$ and $39.5 \mu A$. The input offset current is
Options :
250$nA$
500$nA$
750$nA$
150$nA$

Question Number : 58 Question Id : 827347358 Question Type : MCQ

An op-amp has 3 terminal amplifier stages with the following gains and critical frequencies
Stage-1: $A_{v1} = 40 dB, f_{c1} = 4 kHz$ ; Stage-2: $A_{v2} = 20 dB, f_{c2} = 40 kHz$ ; Stage-1: $A_{v3} = 10 dB, f_{c3} = 160 kHz$

The open-loop midrange gain and total phase lag between $f = f_{c1}$ respectively is
Options :
70$dB$, $-52.14^\circ$
30$dB$, $-52.14^\circ$
50$dB$, $+52.14^\circ$
70$dB$, $+52.14^\circ$

Question Number : 59 Question Id : 827347359 Question Type : MCQ

Using half adders and OR-gates a full adder can be implemented. Therefore a 4-bit parallel full adder without any initial carry needs
Options :
7 half adders and 4-OR gates
7 half adders and 3-OR gates
8 half adders and 2-OR gates
8 half adders and 4-OR gates

Question Number : 60 Question Id : 827347360 Question Type : MCQ

The clock frequency, required for having a delay of $32 \mu s$ in 8 bit serial register, is
Options :
275$kHz$
250kHz
300kHz
375kHz

Question Number : 61  Question Id : 827347361  Question Type : MCQ

If \( A \) and \( B \) are inputs to a logic gate and its output is \( X \), then for \( A = 1 \), \( B = 0 \) it is observed that \( X = 1 \). What type of gate it could be?

Options:
- OR gate or NAND gate
- AND gate or NOR gate
- AND gate only
- NOT gate or NOR gate

Question Number : 62  Question Id : 827347362  Question Type : MCQ

The JKFF, initially cleared and then clocked for 5 pulses. The output sequence \( Q \) will be

Options:
- 010000
- 010101
- 011101
- 010010

Question Number : 63  Question Id : 827347363  Question Type : MCQ

The characteristic table of an \( X-Y \) flip-flop is given below.

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>( Q_{n+1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>( Q_n )</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>( \overline{Q_n} )</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

It is needed to be implemented using J-K flip flop by making

Options:
- \( J = X, K = \overline{Y} \)
- \( J = Y, K = \overline{X} \)
- \( J = \overline{Y}, K = X \)
- \( J = \overline{X}, K = Y \)

Question Number : 64  Question Id : 827347364  Question Type : MCQ
If the radius of the $n$-th orbit of an electron in hydrogen atom is $r_n$, then its total energy is given by

\[ \frac{e^2}{2\pi \varepsilon_0 r_n^2} \]
\[ -\frac{e^2}{4\pi \varepsilon_0 r_n} \]
\[ \frac{e^2}{8\pi \varepsilon_0 r_n^2} \]
\[ -\frac{e^2}{8\pi \varepsilon_0 r_n} \]

Question Number: 65  Question Id: 827347365  Question Type: MCQ

In hydrogen atom, the $n$-th energy level is given by

\[ E_n = -\frac{1}{(4\pi \varepsilon_0)^2} \frac{m^4}{2n^2 \hbar^2} \]

The $n$-th energy levels $E_n^p$ of the positronium (it is a hydrogen like bound state of a positron and an electron) is

Options:

- $2E_n$
- $4E_n$
- $E_n$
- $E_n/2$
- $E_n/4$

Question Number: 66  Question Id: 827347366  Question Type: MCQ

What is the ratio of frequencies of first line of Balmer series to that in Lyman series?

Options:

- $5/27$
- $27/5$
- $5/9$
- $9/27$

Question Number: 67  Question Id: 827347367  Question Type: MCQ

If the wave function of hydrogen atom has $\varphi$-dependent part as $e^{i2\varphi}$, then the minimum principal quantum number $n$ and angular momentum quantum number $l$ are respectively

Options:

- 3 and 1
- 2 and 2
3 and 2
2 and 3

Question Number : 68  Question Id : 827347368  Question Type : MCQ

The possible values of total angular momentum $J$, in accordance with L-S coupling for a system of two electrons with $l_1 = 2$ and $l_2 = 1$, is

Options :
4,3,2
4,2,1
3,2,1,0
4,3,2,1,0

Question Number : 69  Question Id : 827347369  Question Type : MCQ

If the ionization energy for hydrogen atom is 13.6eV. Using Bohr’s model, the ionization energy of Li$^{2+}$ ion is

Options :
27.2eV
122.4 eV
40.8 eV
4.5 eV

Question Number : 70  Question Id : 827347370  Question Type : MCQ

An atom kept in a weak magnetic field shows Zeeman components for the transition $^2D_{3/2} \rightarrow ^2P_{3/2}$. How many components are observed?

Options :
14
12
10
8

Question Number : 71  Question Id : 827347371  Question Type : MCQ

Find the bond length of the CO molecule in which the first line of rotational spectra is 3.8423 cm$^{-1}$. Given that $M_C = 19.921 \times 10^{-27} kg$; $M_O = 26.561 \times 10^{-27} kg$.

Options :
0.0113 $\AA$
0.113 $\AA$
1.13 $\AA$
1.31 $\AA$

Question Number : 72  Question Id : 827347372  Question Type : MCQ
The short wavelength cut-off of the continuous X-ray spectrum for a certain target is 0.1250 nm. The potential applied to the X-ray tube is

Options:
9.930 kV
4.965 kV
19.860 kV
2.482 kV

Question Number: 73  Question Id: 827347373  Question Type: MCQ

In an experiment on Raman scattering, laser of certain frequency $\nu$ gets scattered by diatomic molecules of moment of inertia $I$. The Raman shifted frequency is proportional to

Options:
$\nu$
$I$
$I^{-1}$
$I^2$

Question Number: 74  Question Id: 827347374  Question Type: MCQ

A material at a certain temperature $T$ has two energy levels with a separation of wavelength of 0.1 $\mu$m. If the upper level is 1.75 as densely populated as the lower level, then $T$ is

Options:
$2.572 \times 10^4 K$
$2.572 \times 10^5 K$
$2.572 \times 10^2 K$
$2.572 \times 10^5 K$

Question Number: 75  Question Id: 827347375  Question Type: MCQ

In Compton scattering experiment X-rays of wavelength $3A^\circ$ is scattered by a substance such that the scattered photons are observed at an angle $\varphi = 90^\circ$. What is the energy of the recoil electron? Given that $h = 6.62 \times 10^{-34} Js$, and the rest mass of electron $m_0 = 9.1 \times 10^{-31} kg$.

Options:
1.2540e-018 Joules
3.2540e-018 Joules
4.2540e-018 Joules
5.2540e-018 Joules

Question Number: 76  Question Id: 827347376  Question Type: MCQ
In diamond, the angular distance between tetrahedral bonds are same as between the body diagonal of a cube. The value of the angle is given by

Options:
\[ \theta = \cos^{-1}\left(\frac{1}{3}\right) \]
\[ \theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right) \]
\[ \theta = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right) \]
\[ \theta = \tan^{-1}\left(\frac{1}{3}\right) \]

Question Number : 77  Question Id : 827347377  Question Type : MCQ

If \( V \) is the volume of a unit cell in Bravais lattice, the volume of a unit cell in reciprocal lattice is

Options:
\[ \frac{2\pi}{V} \]
\[ \frac{(\pi)^2}{V} \]
\[ \frac{(2\pi)^3}{V} \]
\[ \frac{\pi^3}{V} \]

Question Number : 78  Question Id : 827347378  Question Type : MCQ

What is the density of electrons in Na crystal, if the nearest neighbor distance in it is 1.82Å? 

Options:
0.215 m\(^{-1}\)
0.107 m\(^{-1}\)
3.640 m\(^{-1}\)
1.820 m\(^{-1}\)

Question Number : 79  Question Id : 827347379  Question Type : MCQ

The cell edge in NaCl crystal is \( a = 0.563nm \). If Bragg’s reflection has to occur at the smallest angle, the set of plane must correspond to the indices

Options:
011
100
110
111

Question Number : 80  Question Id : 827347380  Question Type : MCQ
In case of elastic vibration of crystal, if \( m \) is the mass of any atom, \( a \) - the distance between nearest atoms and \( \beta \) is the force constant then the longitudinal vibration frequency is maximum if the wave number \( k \) is

Options:
\[
\begin{align*}
\pi \\
\pm \frac{\pi}{a} \\
\pm \frac{a}{\pi} \\
\pi/2
\end{align*}
\]

Question Number : 81  Question Id : 827347381  Question Type : MCQ

In the measurement of specific heat \( C_v \) in the low temperature limit \( T \to 0 \), the electronic contribution to it is proportional to

Options:
\[
\begin{align*}
T^{-1} \\
\text{constant} \\
T^{-2} \\
T^{-3}
\end{align*}
\]

Question Number : 82  Question Id : 827347382  Question Type : MCQ

In free electron gas model, the relation between Fermi energy \( E_F \) and the number density of electron \( n \) is given by

Options:
\[
\begin{align*}
E_F &= \left( \frac{\hbar^2}{2m} \right) \left( \pi^2 n \right)^{3/2} \\
E_F &= \left( \frac{\hbar^2}{2m} \right) \left( 3\pi^2 n \right)^{3/2} \\
E_F &= \left( \frac{\hbar^2}{2m} \right) \left( 3\pi^2 n \right)^{2/3} \\
E_F &= \left( \frac{\hbar^2}{2m} \right) \left( 3\pi^2 n \right)^{-3/2}
\end{align*}
\]

Question Number : 83  Question Id : 827347383  Question Type : MCQ

The Curie temperature of a ferromagnetic substance is 125K. Then

Options:
The plot of inverse susceptibility \( \chi \) versus temperature \( T \) is linear with slope \( T_c \), the Curie temperature.
The susceptibility \( \chi \) gets doubled when the substance is cooled from 325K to 225K.
\( \chi^{-1} \) value is doubled when the substance is cooled from 325K to 225K.
All the magnetic dipoles get oriented in the direction of 60°.
The mobility of electron $\mu_e = 0.39 m^2 V^{-1} s^{-1}$ and that of hole $\mu_p = 0.19 m^2 V^{-1} s^{-1}$ in an intrinsic semiconductor (Germanium) at 300K. If $n_i = 2.4 \times 10^{19} m^{-3}$, then the conductivity of the semiconductor is

Options:
- 2.23 mho/m
- 1.23 mho/m
- 12.3 mho/m
- 0.123 mho/m

What is the Fermi level with respect to $E_i$ in Germanium at 300K, if $n = 10^{17} cm^{-3}$? Given that $n_i = 2.4 \times 10^{13} cm^{-3}, E_{Ge} = 0.7 eV$.

Options:
- 2.15 eV
- 4.30 eV
- 0.430 eV
- 0.215 eV

A sample of silicon of thickness 150$\mu$m and doped with $10^{23}$ phosphorous atoms / m$^3$ is kept in a magnetic field of 0.25Wb/m$^2$. The Hall voltage produced across the sample, if a current of 1mA is passed, will be

Options:
- 1.0416$\mu$V
- 10.416$\mu$V
- 104.16$\mu$V
- 1041.6$\mu$V

If the critical magnetic fields for a superconducting specimen are $1.35 \times 10^5 A/m$ and $3.95 \times 10^5 A/m$ at 15K and 13K respectively. What is the critical field at 0K?

Options:
- $1.179 \times 10^5 A/m$
- $11.79 \times 10^5 A/m$
- $5.79 \times 10^5 A/m$
- $8.79 \times 10^5 A/m$
The ratio of nuclear sizes of $^{27}$Al and $^{64}$Cu is approximately
Options:
7.5
0.75
0.075
0.0075

Question Number : 89  Question Id : 827347389  Question Type : MCQ

The nuclear spin of the $^3$Li$^7$ and $^6$C$^{14}$ nuclei are respectively
Options:
half integer and zero
integer and half integer
integer and zero
half integer and half integer

Question Number : 90  Question Id : 827347390  Question Type : MCQ

The original three quarks proposed by Gell -Mann and Zweig were labeled $u$ (for ‘up’), $d$ (for ‘down’) and $s$ (for ‘strange’). Which one of the following represents a proton?
Options:
$uuu$
$uud$
$ar{u}ar{d}$
$uds$

Question Number : 91  Question Id : 827347391  Question Type : MCQ

$^{88}$Ra$^{226}$ decays by emitting an $\alpha$-particle. What is the kinetic energy of the released $\alpha$-particle?
Options:
0.4871 MeV
4.871 MeV
48.71 eV
4.871 eV

Question Number : 92  Question Id : 827347392  Question Type : MCQ

In free space neutron decays as:
$\bar{\nu}_n \rightarrow \bar{\nu}_H + e^0 + [ ]$
The parenthesis represents a
Options:
Graviton
Photon
Neutrino
Antineutrino

Question Number : 93  Question Id : 827347393  Question Type : MCQ

If $5\beta$ - and $3\alpha$ - particles are emitted by a radioactive nucleus, then the ratio of number of proton to neutrons will be

Options :
\[
\frac{Z - 1}{A - Z} \quad \frac{Z - 6}{A - Z - 5} \quad \frac{Z - 1}{A - Z - 11} \quad \frac{Z}{A - Z - 13}
\]

Question Number : 94  Question Id : 827347394  Question Type : MCQ

The mean life of a radioactive substance is $T$. Calculate the number of decays between time 0 and time $t$, if the number decays per unit time at $t = 0$ is $n$?

Options :
\[
n e^{-t/T} \\
n e^{-tT} \\
nT[1 - e^{tT}] \\
n[1 - e^{t/T}]
\]

Question Number : 95  Question Id : 827347395  Question Type : MCQ

Atomic masses of hydrogen and helium are 1.00778 amu and 4.00216 amu respectively. What is the wavelength of radiation produced when 4 atoms of hydrogen are condensed to form an atom of helium?

Options :
\[
4.6 \times 10^{-14}m \\
4.6 \times 10^{-13}m \\
4.6 \times 10^{-12}m \\
4.6 \times 10^{-11}m
\]

Question Number : 96  Question Id : 827347396  Question Type : MCQ

If radioactive substances A and B have half lives 1 hour and 2 hour respectively, then the ratio of disintegration of B to that of A after a lapse of 2 hour is given by

Options :
\[
2:1
\]
1:3
3:1
1:2

Question Number : 97  Question Id : 827347397  Question Type : MCQ

An ionization chamber is charged to a potential of $800\text{V}$. If its capacity is $40\text{pF}$, then in passing an $\alpha$-particle producing $2 \times 10^5$ ion pairs, the percentage reduction in charge would be
Options :
$8.0 \times 10^{-5}\%$
$10.0 \times 10^{-5}\%$
$3.2 \times 10^{-4}\%$
$6.4 \times 10^{-4}\%$

Question Number : 98  Question Id : 827347398  Question Type : MCQ

The ‘dead time’ of a GM counter is $300\mu\text{s}$. If the counting rate is $1000$ per minute, find the true counting rate?
Options :
$1006.7/\text{min}$
$1005/\text{min}$
$905/\text{min}$
$1205/\text{min}$

Question Number : 99  Question Id : 827347399  Question Type : MCQ

A pion decays from rest to give a muon of $4\text{MeV}$ energy. What is the energy of the accompanying neutrino?
Options :
$29.66\text{MeV}$
$2.966\text{MeV}$
$296.6\text{MeV}$
$0.51\text{MeV}$

Question Number : 100  Question Id : 827347400  Question Type : MCQ

What is the threshold energy for the nuclear reaction $^{14}\text{N} (n, \alpha)^{11}\text{B}$ in $\text{MeV}$? Given that mass of $^{14}\text{N} = 14.007550 \text{amu}$; mass of neutron = $1.0087987 \text{amu}$; mass of $\alpha$-particle = $4.003879 \text{amu}$; mass of $^{11}\text{B} = 11.012811 \text{amu}$.
Options :
$1.52\text{MeV}$
$15.2\text{MeV}$
$0.152\text{MeV}$
$0.0152\text{MeV}$