## BHU M.Sc 2013

**Q1.** In a random walk problem, if the probability that a particle is found between $x$ to $x+dx$ is given as $P(x)=e^{-nx^2}$, the mean $x(\bar{x})$ is

(1) 0 (2) 1 (3) $\pi$ (4) None of these

**Q2.** The first law of thermodynamics represents conservation of energy where the change in the internal energy is equal to the transfer of heat when work is done on the system during the change of state. Mathematically this can be written as

(1) $dE=\delta Q+\delta W$ (2) $dE=dQ+\delta W$

(3) $dE=\delta Q+dW$ (4) None of these

**Q3.** Consider a gas contained in a box at a pressure $P$ and temperature $T$ having entropy $S$. If the box is divided into two parts of volume $V_1$ and $V_2$ with corresponding entropies $S_1$ and $S_2$, then $S-(S_1+S_2)$ is

(1) $>0$ (2) $<0$ (3) $=0$ (4) None of these

**Q4.** Consider a sensitive spring balance characterized by a spring constant $K$. The balance is in an environment whose temperature is $T$. A small object of mass $m$ is suspended to the spring. The thermal fluctuation in its position, that is $(x-\bar{x})^2$ is

(1) $3k_BT/2K$ (2) 0 (3) $k_BT/K$ (4) None of these

**Q5.** In an isobaric process the heat intake or release in a thermodynamic system is equal to the change in

(1) Helmholtz free energy (2) Gibbs free energy

(3) Enthalpy (4) None of these

**Q6.** In a canonical ensemble the entropy $S$ can be found to be

(1) $k_B \operatorname{In} Z$ (2) $k_B\beta E$ (3) $k_B(\beta E+\operatorname{In} Z)$ (4) None of these

**Q7.** For a spin $\frac{1}{2}$ system, if the pure state is

$$|\alpha\rangle = \frac{1}{\sqrt{2}}\left[\begin{pmatrix}1\\0\end{pmatrix}+\begin{pmatrix}0\\1\end{pmatrix}\right]$$

the density matrix for the up-spin state is

(1) $\begin{pmatrix}1 & 0\\0 & 0\end{pmatrix}$ (2) $\begin{pmatrix}0 & 0\\0 & 1\end{pmatrix}$ (3) $\begin{pmatrix}0 & 1\\0 & 0\end{pmatrix}$ (4) $\begin{pmatrix}0 & 0\\1 & 0\end{pmatrix}$

**Q8.** The photon statistics is characterized by the mean occupancy distribution as

(1) $\left(e^{\beta\varepsilon}-1\right)^{-1}$ (2) $\left(e^{\beta\varepsilon+\mu}-1\right)^{-1}$ (3) $\left(e^{\beta\varepsilon-\mu}+1\right)^{-1}$ (4) None of these

**Q9.** The density of states of a two-dimensional free Fermi gas depends on energy as

(1) $\varepsilon^{1/2}$ (2) $\varepsilon^{-1/2}$ (3) $\varepsilon^{0}$ (4) None of these

**Q10.** In an ideal Fermi gas, the specific heat varies with $T$ at a low temperature as

(1) $T^{0}$ (2) $T^{3/2}$ (3) $T^{1}$ (4) None of these

**Q11.** The magnetic flux density vector $B$ and vector potential $A$ are related by

(1) $A = \text{curl}B$ (2) $A = \text{div}\,B$ (3) $B = \text{div}\,A$ (4) $B = \text{curl}A$

**Q12.** The displacement vector $D$ and electric field strength $E$ are related by

(1) $D = E/\varepsilon$ (2) $D = \varepsilon E$ (3) $D = \varepsilon E^{2}$ (4) $D = \varepsilon E^{1/2}$

**Q13.** The dependence of phase velocity of an EM wave in a medium on the frequency of wave is called

(1) reflection (2) refraction (3) polarization (4) dispersion

**Q14.** For a good conductor, the skin depth varies

(1) inversely as frequency $\omega$ (2) directly as $\omega$

(3) inversely as $\sqrt{\omega}$ (4) directly as $\sqrt{\omega}$

**Q15.** A thin sheet of conducting material for EM wave acts as

(1) low-pass filter (2) high-pass filter (3) band-pass filter (4) attenuator

**Q16.** The dielectric constant of water is 80, however its refractive index is 1.33 invalidating the expression $n^2 = \varepsilon$. This is because

(1) the water molecule has no permanent dipole moment

(2) the boiling point of water is 100 °C

(3) the two quantities are measured by different experiments

(4) water is transparent to visible light

**Q17.** Which one of the following is the correct expression for one of the four fundamental equations of electromagnetic?

(1) $\text{div}D = \rho$ (2) $\text{curl}\, D = 0$ (3) $\text{curl}\, B = 0$ (4) $\text{div}H = \partial D/\partial t$

**Q18.** A plane EM wave travels in a vacuum with a velocity given by

(1) $c = \sqrt{\mu_0 \varepsilon_0}$ (2) $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ (3) $c = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ (4) $c = \sqrt{\frac{\varepsilon_0}{\mu_0}}$

**Q19.** For a material medium characterized by conductivity $\sigma$ and permittivity $\varepsilon$ exposed to sinusoidally varying field $E$ of frequency $\omega$. The ratio of conduction current density to displacement current density is

(1) $\frac{\sigma}{E\varepsilon}$ (2) $\frac{\sigma}{\omega E}$ (3) $\frac{\varepsilon}{(\omega\sigma)}$ (4) $\frac{\varepsilon E}{\omega}$

**Q20.** For $Cu$, $\sigma = 10^{-2}\,\text{S/m}$ and $\varepsilon = 3\varepsilon_0$, the conduction current and displacement current will be equal at the frequency

(1) 160 Hz (2) 60 kHz (3) 60 MHz (4) 16 MHz

**Q21.** In a dielectric material having $\varepsilon_r = 12$, the displacement current is 25 times greater than the conduction current at 100 MHz, the conductivity of dielectric is

(1) 0.00267 S/m (2) 0.0267 S/m (3) 2.67 S/m (4) 0.267 S/m

**Q22.** For a good conductor the presence of an alternating electric field having wavelength $\lambda$, the skin depth is

(1) much smaller than wavelength $\lambda$ (2) much larger than wavelength $\lambda$

(3) equal to the wavelength $\lambda$ (4) None of the above

**Q23.** For an EM wave in a lossy dielectric medium the loss tangent in terms of attenuation constant $\alpha$ and phase constant $\beta$ can be given as

(1) $\frac{2\alpha}{\alpha^2+\beta^2}$ (2) $\frac{2\beta}{\alpha^2+\beta^2}$ (3) $\frac{2\alpha\beta}{\beta^2-\alpha^2}$ (4) $\frac{2\alpha\beta}{\alpha^2-\beta^2}$

**Q24.** Wet marshy soil is characterized by $\sigma = 10^{-3}$ S/m, $\varepsilon_r = 15$, $\mu_r = 1$. At 10 GHz the soil may be considered as

(1) a good conductor (2) quasi-conductor
(3) quasi-dielectric (4) good dielectric

**Q25.** When a plane electromagnetic wave propagates in a linear, isotropic, dielectric medium, the electric field $E$ and magnetic field $H$ vectors are

(1) parallel to each other (2) mutually perpendicular to each other
(3) at an angle of $45°$ (4) None of the above

**Q26.** The amplitude of electric field component of sinusoidal plane wave having impedance 377 ohms in free space is 20 V/m. The power per square metre carried by the wave is

(1) $0.53\ \text{W/m}^2$ (2) $2.53\ \text{W/m}^2$ (3) $37.7\ \text{W/m}^2$ (4) $3.77\ \text{W/m}^2$

**Q27.** $\text{curl}E = -\partial B/\partial t$ is representing

(1) Ampere's law (2) Gauss's law
(3) Ohm's law (4) Faraday's law

**Q28.** A 300 MHz plane wave propagating through a non-conducting medium having $\mu_r = 1$, $\varepsilon_r = 78$. The velocity of wave through medium is

(1) $33.97\times10^5$ m/s (2) $3.39\times10^6$ m/s
(3) $3.32\times10^8$ m/s (4) $7.8\times10^7$ m/s

**Q29.** The direction of propagation of EM wave is given by the direction of

(1) vector $E$ (2) vector $H$
(3) vector $(E\times H)$ (4) None of these

**Q30.** In electromagnetic field $\sqrt{\mu/\varepsilon}$ has the dimension of

(1) an inductance (2) a capacitance

(3) an impedance (4) an electric field

**Q31.** One voltmeter of the range (0-200 millivolts) is connected across two rails, which are separated from each other as well as from the ground. When a train runs over these rails at a speed of 180 km/hour, then what will be the reading of the voltmeter? It is given that the vertical component of the earth's magnetic field is $0.2\times10^{-4}\,\text{Weber/m}^2$ and the rails are separated by a distance of 1 metre

(1) 2 millivolts (2) 20 millivolts (3) 1 millivolt (4) 10 millivolts

**Q32.** A solenoid, which has number of turns per unit length constant throughout its uniform length. It has self-inductance of $1.8\times10^{-4}$ henry and resistance 6 ohms. It has been broken into two identical coils. These identical coils are connected in parallel, then connected to a 12-volt battery of negligible resistance. The time constant of the circuit will be

(1) $6\times10^{-5}$ sec (2) $3\times10^{-5}$ sec (3) $1.5\times10^{-5}$ sec (4) $2\times10^{-5}$ sec

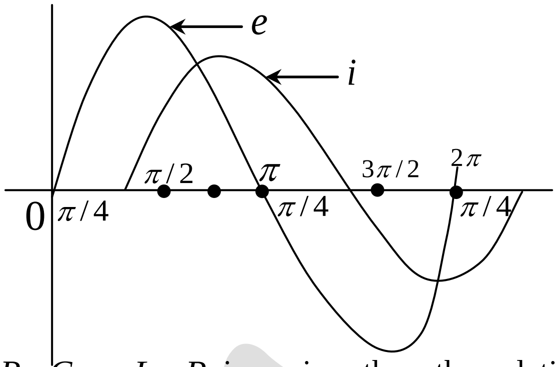
**Q33.** A small square loop of wire of side $l$ is placed inside a large square loop of side $L\,(L>>l)$. The loops are coplanar and their centres coincide. The mutual inductance $M$ of the system is

(1) $\frac{l}{L}$ (2) $\frac{L}{l}$ (3) $\frac{l^2}{L}$ (4) $\frac{L^2}{l}$

**Q34.** The capacitance of a telegraphic wire of length 200 km is 0.014 $\mu$F/km. If an AC of voltage 5 kHz is applied to this wave, then the value of the inductance connected in series with the wire so that the impedance of the circuit becomes minimum is

(1) 2.5 mH (2) 5.4 mH (3) 0.72 mH (4) 0.36 mH

**Q35.** When an AC source of e.m.f. $e = E_0 \sin(100t)$ is connected across a circuit, the phase difference between the e.m.f. $e$ and current $i$ in the circuit is observed to be $\pi/4$ as shown in the diagram



If the circuit contains possibly only of $R-C$ or $L-R$ in series, then the relation between the two elements are

(1) $R = 1\ \text{k}\Omega,\ C = 1\,\mu\text{F}$  (2) $R = 1\ \text{k}\Omega,\ L = 1\text{H}$

(3) $R = 1\ \text{k}\Omega,\ C = 10\,\mu\text{F}$  (4) $R = 1\ \text{k}\Omega,\ L = 10\,\text{H}$

**Q36.** The peak value of the AC voltage across the secondary of the transformer in a half-wave rectifier without filter is $9\sqrt{2}$ volts. The maximum d.c. voltage across the load will be about

(1) 9 V  (2) 4 V  (3) 6 V  (4) 3.2 V

**Q37.** The dominant mechanisms for the motion of charge carriers in forward biased and reverse biased $P-N$ junctions are

(1) drift in forward bias, diffusion in reverse bias

(2) diffusion in forward bias, drift in reverse bias

(3) diffusion in both forward and reverse bias

(4) drift in both forward and reverse bias

**Q38.** In an alternating circuit connected to an e.m.f. of 100 volts and frequency 50 Hz, a resistance of 10 ohms and an inductance of $\frac{1}{10\pi}$ henry are connected in series. The power dissipated in the circuit is

(1) 500 W  (2) 600 W  (3) 250 W  (4) 300 W

**Q39.** Two similar metallic loops $A$ and $B$ are placed on a table without touching each other. Current in loop $A$ increases with time. In its response loop $B$

(1) remains stationary as it was placed

(2) is attracted by loop $A$

(3) is repelled by loop $A$

(4) revolves about its centre of mass while the centre of mass remains stationary

**Q40.** Which one of the following Boolean expressions is not equal to the Boolean expression $(A+BC)\cdot(B+\bar{C}A)$ ?

(1) $(A+B)\cdot(A+C)\cdot(B+\bar{C})$ (2) $AB+A\bar{C}$

(3) $(AB+A\bar{C}+BC)$ (4) $(A+C)\cdot(B+\bar{C})$

**Q41.** Indicate the false statement about the need of modulation for radio communication

(1) Modulation reduces the antenna size

(2) Modulation avoids interference between the two neighbouring broadcasting stations

(3) Modulation is the process of superposition of high frequency radio wave with a low frequency radio wave

(4) By using high frequency carrier wave in modulation the power radiated by antenna increases

**Q42.** Which of the following semiconductor devices is used as demodulator in AM receiver?

(1) Transistor (2) Silicon controlled rectifier

(3) Unijunction transistor (4) $P-N$ junction diode

**Q43.** In a full wave rectifier circuit using centre tap transformer the d.c. voltage across the load is 16.48 volts, then the peak inverse voltage of each diode is

(1) 25.9 V (2) 51.8 V (3) 29.5 V (4) 58.1 V

**Q44.** A multistage amplifier consists of three stages. The voltage gains of the stages are 30, 50 and 80 respectively. The overall voltage gain in dB will be

(1) 101.58 (2) 50.79 (3) 33.98 (4) 38.06

**Q45.** An amplifier with negative feedback has a voltage gain of 100. It is found that with feedback an input signal of 0.6 V is required to produce a given output whereas without feedback the input signal must be only 50 mV for the same output. Then the voltage gain without feedback $A$ and feedback factor $\beta$ are

(1) $A = 1000, \beta = \frac{9}{1000}$ (2) $A = 1100, \beta = \frac{10}{1100}$

(3) $A = 1400, \beta = \frac{13}{1200}$ (4) $A = 1200, \beta = \frac{11}{1200}$

**Q46.** If in Hartley oscillator tank circuit $X_1$ and $X_2$ are pure inductive and $X_3$ is pure capacitative reactance, then the circuit will oscillate at the frequency for which

(1) $X_1 + X_2 - X_3 = 0$ (2) $X_1 + X_2 + X_3 = 0$

(3) $X_1 - X_2 + X_3 = 0$ (4) $X_1 - X_2 - X_3 = 0$

**Q47.** The hybrid parameter $h_{21}$ in case of transistor is known as

(1) input impedance with output shorted

(2) output admittance with input open

(3) forward current gain with output shorted

(4) reverse voltage gain with input open

**Q48.** Indicate the false statement about the consequences of early effect in transistor

(1) $\alpha$ decreases with increasing $|V_{CB}|$

(2) $I_B$ decreases with increasing $|V_{CB}|$

(3) $I_E$ increases with increasing $|V_{CB}|$

(4) voltage breakdown may occur in transistor for large $|V_{CB}|$

**Q49.** If the reverse saturation current of $Si$ diode doubles for each increase of 10 °$C$ in temperature, then the increase in temperature $\Delta T$ necessary to increase the reverse saturation current by a factor of 100 is

(1) 44.6 °$C$ (2) 64.6 °$C$ (3) 46.4 °$C$ (4) 66.4 °$C$

**Q50.** A resistance of $10\Omega$ and an inductance of 100 mH are connected in series with an AC voltage source $V = 50\sin(100t)$. The phase difference between the current in the circuit and applied voltage will be

(1) $\pi$  (2) $\frac{\pi}{2}$  (3) $\frac{\pi}{4}$  (4) zero

**Q51.** The gradient of a scalar function is

(1) scalar quantity  (2) vector quantity

(3) tensor quantity  (4) zero

**Q52.** Magnetic field $\vec{B}$ is

(1) a solenoidal vector  (2) an irrotational vector

(3) a tensor  (4) a scalar

**Q53.** Eigenvalues of the matrix

$$\begin{pmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{pmatrix} \text{ are}$$

(1) 1, 0, -1  (2) 1, 1, 0  (3) 2, 0, - 2  (4) 2, 0, 2

**Q54.** The differential equation $x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2 - n^2)y = 0$ has solution as

(1) Bessel function $J_n(x)$  (2) Hermite polynomial $H_n(x)$

(3) Legendre polynomial $P_n(x)$  (4) Laguerre polynomial $L_n(x)$

**Q55.** The spherical Bessel function $j_n(x)$ is related to the Bessel function $J_n(x)$ by the relation

(1) $j_n(x) = \sqrt{\frac{\pi}{2x}} J_{n+\frac{1}{2}}(x)$  (2) $j_n(x) = \sqrt{\frac{\pi}{2x}} J_n(x)$

(3) $j_n(x) = \sqrt{\frac{2x}{\pi}} J_{n+\frac{1}{2}}(x)$  (4) $j_n(x) = \sqrt{\frac{2x}{\pi}} J_n(x)$

**Q56.** The value of $J_0(x)$ at $x=0$ is given by

(1) 1 (2) 0 (3) $\infty$ (4) $\sqrt{\pi}$

**Q57.** Momentum of a charged particle moving in an electromagnetic field is

(1) given by its mass times its velocity

(2) zero

(3) given by its mass times its velocity + a term that depends on its charge, speed of light and vector potential characterzing the field

(4) given by its mass times its velocity + a term that depends on its charge, speed of light and scalar and vector potential characterizing the field

**Q58.** Which of the following vectors is not an eigenvector of the matrix $\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$?

(1) $\vec{r}=\left(\frac{1}{\sqrt{2}},\, -\frac{1}{\sqrt{2}},\, 0\right)$ (2) $\vec{r}=(0,\ 0,\ 1)$

(3) $\vec{r}=\left(\frac{1}{\sqrt{2}},\, \frac{1}{\sqrt{2}},\, 0\right)$ (4) $\vec{r}=(1,\ 0,\ -1)$

**Q59.** For any square matrix *A*, which of the following matrices is not Hermitian?

(1) $A+A^{+}$ (2) $AA^{+}$ (3) $A^{+}A$ (4) $A^{+}-A$

**Q60.** Line integral of the vector $\vec{A}=(x+y)\hat{i}+(2x-z)\hat{j}+(y+z)\hat{k}$ along the sides of the triangle cut from the plane $3x+2y+z=6$ by the coordinate axes is

(1) 21 (2) 36 (3) -16 (4) 1

**Q61.** Given a one-dimensional wave function $\Psi(x)=Ae^{-\alpha x^2}\ (\alpha>0)$, the normalization factor *A* would be

(1) $|A|=\left(\frac{2\alpha}{\pi}\right)^{1/4}$ (2) $|A|=\left(\frac{\pi}{2\alpha}\right)^{1/4}$ (3) $|A|=\left(\frac{2\alpha}{\pi}\right)^{1/2}$ (4) $|A|=\left(\frac{2\pi}{\alpha}\right)^{1/2}$

**Q62.** A quantum particle moves in a three-dimensional space with momenta $\vec{p} = (p_x, p_y, p_z)$ and position $\vec{r} = (x, y, z)$. The uncertainty in the measurement of position and momentum along $z$-axis is

(1) $\Delta z \Delta p_y \geq \hbar$ (2) $\Delta y \Delta p_z \geq \hbar$ (3) $\Delta x \Delta p_z \geq \hbar$ (4) $\Delta z \Delta p_z \geq \hbar$

**Q63.** The electron of the hydrogen atom is in its ground state. If we use the standard integral

$$\int_0^{\omega} e^{-x} x^n dx = n!$$

the expectation value $\langle r \rangle$ is

(1) $\frac{2}{3} a_0$ (2) $\frac{3}{2} a_0$ (3) $\frac{4}{3} a_0$ (4) $\frac{3}{4} a_0$

**Q64.** An electron is confined to a box of length $10^{-8}$ m. Calculation of the minimum uncertainty in its velocity, with $m_e = 9 \times 10^{-31}$ kg, $\hbar = 1.05 \times 10^{-34}$ J - sec, is

(1) $1.17 \times 10^4$ m/sec (2) $1.17 \times 10^6$ m/sec

(3) $1.17 \times 10^2$ m/sec (4) $1.17 \times 10^8$ m/sec

**Q65.** A particle of mass $m$ is restricted to move in one-dimension between two points such that $0 \leq x \leq a$. If the potential function is such that

$$\begin{aligned} V(x) &= \infty \qquad x < 0 \quad \text{and} \quad x > a \\ &= 0 \qquad 0 \leq x \leq a \end{aligned}$$

the particle will have discrete energy spectrum as

(1) $E_n = \frac{\pi^2 \hbar^2}{4ma^2} \cdot n^2 \quad n = 0, 1, 2, \cdots$ (2) $E_n = \frac{3\pi^2 \hbar^2}{2ma^2} (n+1)^2 \quad n = 0, 1, 2, \cdots$

(3) $E_n = \frac{\pi^2 \hbar^2}{2ma^2} (n+1)^2 \quad n = 0, 1, 2, \cdots$ (4) $E_n = \frac{3}{2} \frac{\pi^2 \hbar^2}{ma^2} \cdot n^2 \quad n = 0, 1, 2, \cdots$

**Q66.** In terms of lowering and raising angular momentum operators $J_-$ and $J_+$, the following relation is true

(1) $J_x^2+J_y^2=J_+J_-+\hbar J_z$ (2) $J_x^2+J_y^2=J_+J_-+\hbar J_z$

(3) $J_x^2+J_y^2=J_-J_z+J_+$ (4) $J_x^2+J_y^2=J_-J_+-\hbar J_z$

**Q67.** In hydrogen atom energy spectrum, the Brackett series are there where the transition takes place from higher orbits to

(1) third stationary orbit (2) second stationary orbit

(3) fifth stationary orbit (4) fourth stationary orbit

**Q68.** The ground state eigenfunction for a linear harmonic oscillator, in terms of $\alpha=\sqrt{\frac{mk}{\hbar^2}}$ where $k=$force constant and $m=$mass of the linear oscillator, is

(1) $\Psi(x)=\left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/4}e^{\alpha x^2/2}$ (2) $\Psi(x)=\left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/2}e^{-\alpha x^2/2}$

(3) $\Psi(x)=\left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/2}e^{-\alpha^2x^2/2}$ (4) $\Psi(x)=\left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/4}e^{+\alpha^2x^2/2}$

**Q69.** The matrix representation of $J_+=J_x+iJ_y$ for $j=\frac{1}{2}$ is

(1) $J_+=\hbar\begin{pmatrix}0&0\\1&0\end{pmatrix}$ (2) $J_+=\hbar\begin{pmatrix}0&1\\0&0\end{pmatrix}$ (3) $J_+=\hbar\begin{pmatrix}1&0\\0&0\end{pmatrix}$ (4) $J_+=\hbar\begin{pmatrix}0&0\\0&1\end{pmatrix}$

**Q70.** The energy of a linear harmonic oscillator of mass $m$ and angular frequency $\omega$ turns out to be a function of parameter $\alpha$ as

$$E(\alpha)=\frac{\hbar^2\alpha}{2m}+\frac{m\omega^2}{\hbar\alpha}$$

The minimum of this energy with respect to $\alpha$ is $\frac{1}{2}\hbar\omega$. The critical value of $\alpha$ turns out to be

(1) $\alpha_c=\frac{2\hbar}{m\omega}$ (2) $\alpha_c=\frac{3}{2}\frac{\hbar}{m\omega}$ (3) $\alpha_c=\frac{m\omega}{2\hbar}$ (4) $\alpha_c=\frac{m\omega}{\hbar^2}$

**Q71.** $S'$-frame of reference has uniform angular velocity with respect to $S$-frame. These frames of references are

(1) inertial with respect to each other (2) non-inertial with respect to each other

(3) both are inertial as well as non-inertial (4) both are neither inertial nor non-inertial

**Q72.** $S'$-frame of reference has uniform angular velocity with respect to the frame $S$. The velocity of light in the $S$-frame would be

(1) the same in $S'$-frame magnitude as well as directionwise

(2) the different in $S'$-frame magnitude as well as directionwise

(3) neither same nor different in magnitude as well as directionwise in $S'$-frame

(4) the same magnitudewise but different directionwise in $S'$-frame

**Q73.** The energy in electron volt, that would be generated after the annihilation of 1 gm of matter, is

(1) $5.6\times10^{32}$ eV (2) $6.5\times10^{23}$ eV (3) $6.5\times10^{36}$ eV (4) $5.6\times10^{43}$ eV

**Q74.** If the boost is along $x$-axis with a uniform velocity $\vec{v}$, the Lorentz invariant quantity is

(1) $y^2-c^2t^2$ (2) $z^2-c^2t^2$ (3) $y^2+z^2-c^2t^2$ (4) $x^2-c^2t^2$

**Q75.** Two particles are traveling in the opposite directions with speed $0.9c$ relative to the laboratory frame. Their relative speed would be

(1) $0.995c$ (2) $1.8c$ (3) $0.895c$ (4) $0.905c$

**Q76.** The length of a rod moving with velocity equal to $0.8c$, would be modified if the proper length is equal to 100 cm. The modified length of this moving rod would be equal to

(1) 50 cm (2) 60 cm (3) 70 cm (4) 65 cm

**Q77.** If the boost is along z-axis with uniform velocity, the Lorentz invariant quantity would be

(1) $z^2+c^2t^2$ (2) $z^2+x^2$ (3) $z^2+y^2$ (4) $x^2+y^2$

**Q78.** If $\gamma = -\frac{1}{\sqrt{1-\beta^2}}$, $\beta^2 = \frac{v^2}{c^2}$, it is clear that $\gamma^2 - \beta^2\gamma^2 = 1$. The choices of $\gamma$ and $\beta\gamma$ can be made in the language of trigonometrical functions as

(1) $\gamma = \mathrm{cosec}\,\theta,\ \beta\gamma = \cot v$ (2) $\gamma = \sec\theta,\ \beta\gamma = \tan\theta$

(3) $\gamma = \cosh\theta,\ \beta\gamma = \sinh\theta$ (4) None of these

**Q79.** The coherence length of a sodium discharge lamp

(1) of the order of fraction of a cm (2) of the order of a few cm

(3) of the order of a few m (4) of the order of a few km

**Q80.** Coherence time $t_{coh}$ and coherence length $l_{coh}$ are related by

(1) $l_{coh} = c\tau_{coh}$ (2) $\tau_{coh} = cl_{coh}$ (3) $l_{coh} \times \tau_{coh} = c$ (4) $l_{coh} = c^2\tau_{coh}$

**Q81.** In a Fresnel's biprism experiment one face of the biprism is coated with an absorbing material so that intensity of the light passing through it is reduced to 25% of its original intensity. The visibility of the fringe pattern is

(1) unaffected (2) 0.6 (3) 0.8 (4) zero

**Q82.** The sunlight is passed through a narrow slit and is allowed to illuminate a grating having 3000 lines per inch. The number of lines of sun after grating is

(1) seven (2) three (3) infinite (4) zero

**Q83.** For a lens of aperture $d$ and focal length $f$ illuminated by a light of wavelength $\lambda$ the radius of the Airy disc is

(1) $\frac{f\lambda}{d}$ (2) $\frac{1\cdot 22 f\lambda}{d}$ (3) $\frac{f\lambda}{1\cdot 22d}$ (4) $\frac{1\cdot 22\lambda^2}{\sqrt{fd}}$

**Q84.** The radius of the Rowland circle is equal to the

(1) radius of the concave grating

(2) half of the radius of the concave grating

(3) one-third of the radius of the concave grating

(4) twice the radius of the concave grating

**Q85.** In an anisotropic crystal, the refractive index is

(1) same in all directions
(2) different in different direction
(3) not well defined
(4) infinitely large

**Q86.** For a Fabry-Perot etalon with mirrors of reflectivity 0.9, the wavelength difference of two close lying lines at 5000 Å is of the order of

(1) 5 Å
(2) 0.5 Å
(3) 0.05 Å
(4) 0.005 Å

**Q87.** In Michelson interferometer, the circular fringes are

(1) fringes of equal inclination
(2) fringes of equal thickness
(3) fringes of equal inclination as well as equal thickness
(4) neither fringes of equal inclination nor fringes of equal thickness

**Q88.** In a grating the angular width of a principal maxima depends on

(1) number of lines per cm
(2) total number of lines
(3) total width of the ruled surface
(4) None of the above

**Q89.** When a plane polarized light is passed through a calcite crystal with electric vector at $45^\circ$ with the optic axis two rays are obtained on emergence. If one combines these two rays these will produce

(1) interference pattern
(2) linearly polarized light again
(3) elliptically polarized light
(4) circularly polarized light

**Q90.** In Young's double-slit experiment, the interference fringes are hyperbolic in shape. The eccentricity of such hyperbolae is of the order of

(1) 1
(2) $10^{-3}$
(3) $10^{6}$
(4) $\infty$

**Q91.** The Rydberg constant for H atom has the value in $\mathrm{cm}^{-1}$ as

(1) 109677.759
(2) 109707.387
(3) 109722.403
(4) 109728.84

**Q92.** Paschen series in H atom spectra is obtained as a result of transitions from level with principal quantum number $n_1$ to the level with principal quantum number $n_2$, where

(1) $n_1 = 1;\ n_2 = 2,\ 3,\ \cdots$
(2) $n_1 = 3;\ n_2 = 4,\ \cdots$
(3) $n_1 = 4;\ n_2 = 5,\ 6,\ \cdots$
(4) $n_1 = 6;\ n_2 = 7,\ 8,\ \cdots$

**Q93.** Ground state of H atom is

(1) $^2S_{1/2}$ (2) $^1S_0$

(3) $^3S_0$ (4) None of the above

**Q94.** In Na the principal series arises due to transition from

(1) upper *P* levels to the lowest *S* level (2) upper *S* levels to the lowest *P* level

(3) upper *D* levels to the lowest *P* level (4) upper *P* levels to the lowest *D* level

**Q95.** The two sodium *D* lines have wavelengths 5890 and 5896 Å. These arise due to transitions from $^2S_{1/2}$ to

(1) $^2P_{3/2}$ and $^2P_{1/2}$ (2) $^2P_{1/2}$ and $^2P_{3/2}$

(3) $^2D_{5/2}$ and $^2D_{3/2}$ (4) $^2D_{3/2}$ and $^2D_{5/2}$

**Q96.** The energy corresponding to shortest wavelength of Lyman series in the H atom spectrum is

(1) $-13.6$ eV (2) 13.6 eV (3) 10.2 eV (4) $-10.2$ eV

**Q97.** The radius of the Bohr first circular orbit of hydrogen atom is

(1) ~ 0.5 Å (2) ~ 1.0 Å (3) ~ 2.0 Å (4) ~ 4.0 Å

**Q98.** $D_1$ and $D_2$ lines of sodium belong to

(1) sharp series (2) principal series

(3) fundamental series (4) diffuse series

**Q99.** The radial part of the eigenfunction of electron in H atom satisfies the differential equation with solution as

(1) the Hermite polynomial (2) Bessel function

(3) Laguerre polynomial (4) Legendre polynomial

**Q100.** Lorentz unit *L* is given by

(1) $L = \frac{e\mathrm{H}}{4\pi mc^2}$ (2) $L = \frac{4\pi mc^2}{e\mathrm{H}}$ (3) $L = \frac{4\pi e^2}{ch}$ (4) $L = \frac{ch}{2\pi e^2}$

**Q101.** The transition ${}^1D_2 - {}^1P_1$ gives rise to 9 transitions in a weak magnetic field. These 9 transitions result in

(1) 9 lines (2) 6 lines (3) 3 lines (4) single line

**Q102.** The value of Rydberg constant

(1) decreases with increasing atomic number

(2) increases with increasing atomic number

(3) does not depend on atomic number

(4) increases as square of atomic number

**Q103.** Metastable state is

(1) state of multiplicity different from the ground state

(2) state of multiplicity of the ground state

(3) a state in which atom is most stable

(4) a state in which is least stable

**Q104.** The fine-structure separation due to spin-orbit interaction for ${}^2P$, ${}^2D$ and ${}^2F$ is in the order

(1) ${}^2P > {}^2D > {}^2F$ (2) ${}^2P < {}^2D < {}^2F$ (3) ${}^2P > {}^2F > {}^2D$ (4) ${}^2D > {}^2P > {}^2F$

**Q105.** In a normal Zeeman triplet, the unshifted component when absorbed parallel to the applied magnetic field

(1) appears absent (2) is plane polarized

(3) is circularly polarized (4) is elliptically polarized

**Q106.** An $X$-ray tube operated at 30 kV emits a continuous $X$-ray spectrum. The short wavelength limit $\lambda_{\min}$ (given that $e = 1.6 \times 10^{-19}$ coulomb, $c = 3 \times 10^{8}$ m/sec and $h = 6.624 \times 10^{-34}$ J − sec) is given by

(1) 0.1656 nm (2) 0.0414 nm (3) 0.0207 nm (4) 0.2040 nm

**Q107.** X-ray spectrum of a cobalt target $(Z = 27)$ contains strong $K_\alpha$ line of wavelength 0.1785 nm and a weak $K_\alpha$ line having wavelength 0.2285 nm due to impurity. The atomic number of impurity element is

(1) 24 (2) 27 (3) 30 (4) 23

**Q108.** For an FCC lattice the ratio of $d_{200}:d_{220}:d_{222}$ is

(1) $\sqrt{3}:\sqrt{6}:\sqrt{2}$ (2) $1:\sqrt{2}:\sqrt{6}$ (3) $1:2:3$ (4) $\sqrt{6}:\sqrt{3}:\sqrt{2}$

**Q109.** Magnesium has h.c.p. structure. The radius of magnesium atom is 0.1605 nm. The volume of unit cell of magnesium is

(1) $0.7\times10^{28}\,m^3$ (2) $2.8\times10^{-28}\,m^3$ (3) $1.4\times10^{28}\,m^3$ (4) $0.35\times10^{-28}\,m^3$

**Q110.** The spacing $d_{hkl}$ of the planes $(hkl)$ in a tetragonal crystal is

(1) $\left[\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}\right]^{-\frac{1}{2}}$ (2) $\left[\frac{h^2+k^2}{a^2}+\frac{l^2}{c^2}\right]^{-\frac{1}{2}}$

(3) $\left[\frac{4}{3}\left(\frac{h^2+hk+k^2}{a^2}\right)+\frac{l^2}{c^2}\right]^{-\frac{1}{2}}$ (4) $a\left[h^2+k^2+l^2\right]^{-\frac{1}{2}}$

**Q111.** Diamond has the following crystal structure

(1) hexagonal (2) simple cubic

(3) face-centred cubic (4) body-centred cubic

**Q112.** In the Kronig-Penny model, discontinuities in $E$ versus $k$ curve occur for

(1) $k=\frac{n\pi}{a}$ (2) $k=\frac{8n\pi}{a}$ (3) $k=\frac{n^2\pi}{a}$ (4) $k=\frac{n\pi}{4a}$

**Q113.** The Fermi energy of silver is 5.51 electron volt. The average energy of the free electrons in silver at $0^\circ K$ is give by

(1) 4.205 eV (2) 0.864 eV (3) 3.306 eV (4) 9.425 eV

**Q114.** A crystal system whose unit cell is specified by $a\neq b\neq c,\ \alpha=\gamma=90\neq\beta$ is known as

(1) monoclinic (2) rhombohedral (3) tetragonal (4) orthorhombic

**Q115.** Which of the following statements is true about the effective mass of electron in crystals?

(1) It is positive near the top of energy band.

(2) It is negative near the bottom of energy band

(3) It is constant through out the band

(4) It is negative near the top of energy band

**Q116.** For hexagonal close-packed structure, the ratio of lattice parameters $a$ and $c$, i.e., $\frac{c}{a}$ is given by

(1) $\frac{1}{2}\left(\frac{8}{3}\right)^{1/2}$ (2) $\left(\frac{3}{8}\right)^{1/2}$ (3) $\left(\frac{8}{3}\right)^{1/2}$ (4) $\frac{1}{2}\left(\frac{3}{8}\right)^{1/2}$

**Q117.** The specific heat $C_v$ due to free electrons in metals varies as

(1) $C_v \propto T$ (2) $C_v \propto T^2$ (3) $C_v$ is constant (4) $C_v \propto T^{-1}$

**Q118.** According to Debye model heat capacity $[C_\upsilon]_{lattice}$ at low temperature varies as proportional to

(1) $T$ (2) $T^3$ (3) $T^{-1}$ (4) $T^2$

**Q119.** According to Moseley's law, the relation between the atomic number $Z$ and frequency $\nu$ is given by

(1) $\nu \propto (Z-b)$ (2) $\nu \propto Z$ (3) $\nu \propto (Z-b)^3$ (4) $\nu \propto (Z-b)^2$

**Q120.** Indicate the statement about the semiconductors which is false

(1) $n$-type semiconductors are obtained by doping phosphorus into silicon

(2) The conductivity of all semiconductors always increases with temperature

(3) $p$-type semiconductors are obtained by doping boron into silicon

(4) Intrinsic semiconductors are insulators at $T = 0°K$

**Q121.** The electrical conductivity of a metal in terms of mass ($m$), charge ($e$), collision time $(\tau)$ and concentration ($n$) of electrons is given by

(1) $\frac{me\tau}{n}$ (2) $mne\tau$ (3) $\frac{ne^2\tau^2}{m}$ (4) $\frac{ne^2\tau}{m}$

**Q122.** According to Dulong and Petit's law, value of molar lattice specific heat is

(1) $\frac{3R}{2}$ (2) 3R (3) $\frac{R}{2}$ (4) R

**Q123.** Which of the statement is false?

(1) A semiconductor exhibits negative temperature coefficient of resistivity

(2) In an n-type semiconductor, as the density of donor atoms is increased, the Fermi level shifts towards the valence band

(3) Mobility carriers in a *p*-type semiconductors are holes

(4) In an intrinsic semiconductor, the Fermi level lies midway in the forbidden gap

**Q124.** The short wavelength limit of X-rays depend upon

(1) nature of the target (2) potential difference across the X-ray tube

(3) nature of the filament used (4) None of these

**Q125.** The de Broglie wavelength associated with an electron of mass $m$ and accelerated by a potential $V$ is

(1) $\frac{h}{\sqrt{2mVe}}$ (2) $\frac{\sqrt{2mVe}}{h}$ (3) $\frac{h}{\sqrt{Vem}}$ (4) $\frac{h}{2Vem}$

**Q126.** The number of ions in the unit cell of $CsCl$ crystal is

(1) 1 (2) 2 (3) 3 (4) 4

**Q127.** The Miller indices of the plane parallel to the $x$ and $y$ axes are

(1) (100) (2) (111) (3) (001) (4) (010)

**Q128.** The number of lattice points in a primitive cell is

(1) 2 (2) 3 (3) 1 (4) 4

**Q129.** If $n$ is the number of atoms in the unit cell of the cubic system, $N$ and $M$ are the Avogadro's number and atomic weight respectively and $\rho$ is the density of the element, then the lattice constant $a$ is given by

(1) $\left[\frac{M\rho}{nN}\right]^{1/3}$ (2) $\left[\frac{nM}{N\rho}\right]^{1/3}$ (3) $\left[\frac{nN}{M\rho}\right]^{1/3}$ (4) $\left[\frac{\rho N}{Mn}\right]^{1/3}$

**Q130.** On the application of forward bias to a *p*-*n* junction diode, the depletion width

(1) remains unchanged

(2) decreases

(3) increases

(4) increases in the beginning then becomes constant

**Q131.** The average energy of the $\gamma$-rays is

(1) $\approx 0.53\times10^{5}$ eV (2) $\approx 0.53\times10^{6}$ eV

(3) $\approx 0.53\times10^{4}$ eV (4) $\approx 0.53\times10^{3}$ eV

**Q132.** The half-life $(T)$ of a radioactive element is

(1) $T=\dfrac{0.782}{\lambda}$ (2) $T=\dfrac{0.693}{\lambda}$ (3) $T=\dfrac{0.936}{\lambda}$ (4) $T=\dfrac{0.369}{\lambda}$

**Q133.** The unit 'one-Rutherford' stands for

(1) $10^5$ disintegrations per sec (2) $10^7$ disintegrations per sec

(3) $10^4$ disintegrations per sec (4) $10^6$ disintegrations per sec

**Q134.** The unit 'one-Curie' of disintegration of radioactive decay corresponds to

(1) $3.7\times10^{10}$ disintegrations per sec (2) $3.7\times10^{9}$ disintegrations per sec

(3) $3.7\times10^{8}$ disintegrations per sec (4) $3.7\times10^{6}$ disintegrations per sec

**Q135.** A free neutron can decay to a proton through electron $\beta$-decay. The life-term of such a decay is approximately

(1) 2000 sec (2) 5000 sec (3) 1000 sec (4) 7000 sec

**Q136.** Radium nucleus has a half-life approximately equal to 1620 years. Thus, its decay constant would be

(1) $8.24\times10^{-6}$ per year (2) $2.48\times10^{-5}$ per year

(3) $8.24\times10^{-3}$ per year (4) $4.28\times10^{-4}$ per year

**Q137.** The minimum energy of the $\gamma$-rays to decay into electron-positron pair is

(1) 2.01 MeV (2) 1.02 MeV (3) 3.01 MeV (4) 4.02 MeV

**Q138.** Neutrons are the only particles that experience

(1) only electromagnetic interaction (2) only weak and gravitational interactions

(3) only strong and weak interactions (4) only strong and gravitational interactions

**Q139.** The radio-carbon, used in the carbon-dating, has the half-life time about

(1) 6057 years (2) 7057 years

(3) 5760 years (4) None of the above

**Q140.** The half-life $\left(T_{1/2}\right)$ and mean life $\left(\overline{T}\right)$ of radioactivity are connected by

(1) $\overline{T} = 1.44\,T_{1/2}$ (2) $\overline{T} = 5.45\,T_{1/2}$

(3) $\overline{T} = 4.54\,T_{1/2}$ (4) $\overline{T} = 0.693\,T_{1/2}$

**Q141.** The decay probability per unit time $(\lambda)$ and mean-life-time $\left(\overline{T}\right)$ of a radioactive nucleus, are related by

(1) $\overline{T} = 0.693\,\lambda$ (2) $\overline{T} = \frac{1}{\lambda}$ (3) $\overline{T} = \frac{0.693}{\lambda}$ (4) $\overline{T} = \frac{\lambda}{0.693}$

**Q142.** $\alpha$ -decay occurs in nuclei which contain number of nucleons

(1) 310 or more (2) 110 or more

(3) 210 or more (4) None of the above

**Q143.** A long-lived excited nucleus is called as

(1) isotope (2) isobar

(3) isomer (4) None of the above

**Q144.** Theory of $\alpha$ -decay process can be explained using the concepts of

(1) classical mechanics (2) quantum mechanics

(3) statistical mechanics (4) thermal physics

**Q145.** The liquid-drop model of nucleus is essential for the explanation of

(1) nuclear $\beta$ -decay (2) nuclear radioactivity in general

(3) nuclear transmutation (4) nuclear fission

**Q146.** A compound nucleus is formed for approximately

(1) $10^{-34}$ sec (2) $10^{-8}$ sec (3) $10^{-10}$ sec (4) $10^{-16}$ sec

**Q147.** The phenomenon of carbon cycle in stars is generated due to

(1) nuclear $\alpha$ -decay (2) nuclear fission

(3) nuclear fusion (4) None of the above

**Q148.** The 'hydrogen' bomb is made on the basis of

(1) nuclear fission (2) nuclear fusion

(3) nuclear transmutation (4) None of the above

**Q149.** The $\gamma$-rays are emitted when

(1) excited nuclei return to their ground state

(2) excited atoms return to their ground state

(3) excited molecules return to their ground state

(4) None of the above

**Q150.** The unit of nuclear cross-section is 'barn'. One barn is equal to

(1) $10^{-38}(\text{metre})^2$

(2) $10^{-28}(\text{metre})^2$

(3) $10^{-48}(\text{metre})^2$

(4) None of the above