D.U. (M.Sc Physics) 2018

Total No. of Question: 50

Time: 2 Hours **Maximum Marks: 200**

1. There are 50 questions in the Test Paper with four responses (a), (b), (c) and (d). Of them only one is correct as the best answer to the question concerned.
2. There will be **NEGATIVE MARKING** for wrong answer. Each correct answer shall be awarded 4 marks, while one mark will be deducted for each wrong answer.
3. Multiple answering of a question will cause the answer to be rejected.

Q1. A particle is confined in a one dimensional potential box with impenetrable walls at $x = \pm a$. Its energy eigenvalue is $2eV$ and corresponds to the eigenfunction of the first excited state. The lowest possible energy of the particle is

(a) 2.0 eV (b) $0.5eV$ (c) $4.0eV$ (d) $1.0eV$

Q2. The net magnetic moment of Iron atom in BCC crystal $\left(a = 2.857\,A^0\right)$ is $2.2\mu_B\left(\mu_B = 9.273\times10^{-24}\,Am^2\right)$. The saturation magnetization of Fe at $0K$ is

(a) 1750 Am^{-1} (b) 1750 Am^{-2} (c) 0 (d) 1749.6 kAm^{-1}

Q3. Three dice are thrown simultaneously. The probability that the same number will appear on all the three dice is

(a) $\frac{1}{36}$ (b) $\frac{1}{6}$ (c) $\frac{1}{18}$ (d) $\frac{1}{108}$

Q4. Let us model a star as a spherical black body at temperature T which radiates to distant points which are at absolute zero. Let us further model a dust cloud around the star as a black spherical shell whose temperature T_s is determined by radioactive equilibrium. What is T_s?

(a) $2^{-1/2}T$ (b) $2^{-1/4}T$ (c) T (d) $T/2$

Q5. Consider a Carnot reversible heat engine working between the temperature of melting ice and steam. The efficiency of this heat engine will be approximately equal to

(a) 37% (b) 27% (c) 100% (d) None of the above

Q6. Which one of the following is not a characteristic of CMOS configuration?

(a) CMOS devices have higher noise-margins

(b) CMOS devices have low input impedances

(c) CMOS devices have much lower Tran conductance than bipolar devices.

(d) CMOS devices dissipate lower static power than bipolar devices

Q7. The value of the integral

$$\int_0^{2\pi} \frac{d\theta}{(5-3\sin\theta)}$$

(a) $\frac{2\pi}{3}$ (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{4}$ (d) $\frac{3\pi}{4}$

Q8. Given $z = x + iy$, the contour integration $\oint_C \frac{dz}{z}$ is equal to (where C is any anti-clockwise contour going around the origin)

(a) $-\pi i$ (b) $2\pi i$ (c) πi (d) 0

Q9. Solution of the differential equation

$$\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 9y = 8e^x \text{ is}$$

(a) $Axe^{3x} + Be^x$ (b) $(Ax+B)e^{3x} + 2e^{2x}$

(c) $(Ax^2 + Bx)e^{4x} + 2e^{2x}$ (d) $(Ax+B)e^{3x} + 8e^x$

Q10. Train A and train B are running on adjacent rail tracks in the same direction with speeds $43\ m/s$ and $10\ m/s$, respectively, with train B ahead train of A sounds a whistle with frequency $270\ Hz$ in its rest frame. Assuming still air and a speed of sound of $330\ m/s$, the frequency of the sound as measured by a passenger at rest in train B is equal to

(a) $301\ Hz$ (b) $280\ Hz$ (c) $310\ Hz$ (d) $290\ Hz$

Q11. An Earth-like exoplanet orbits around a star having a mass $\frac{1}{27}$ times the mass of Sun. This exoplanet completes one revolution around the star in 365 days just like Earth. Assuming that orbits of both Earth as well as this exoplanet are circular, the distance of the exoplanet from its star is,

(a) one-ninth of the Earth-Sun distance (b) 3-times the Earth-Sun distance

(c) Same as the Earth-Sun distance (d) one-third of the Earth-Sun distance

Q12. Consider eight electrons in a one dimensional box of length 'a' extending from $x = 0$ to $x = a$. What is the minimum allowed total energy using Pauli's exclusion principle for the system ($m =$ mass of electron)

(a) $\frac{8h^2}{ma^2}$ (b) $\frac{15h^2}{2ma^2}$ (c) $\frac{15h^2}{4ma^2}$ (d) $\frac{10h^2}{ma^2}$

Q13. For an electromagnetic wave travelling in free space, given by $\vec{E} = E_m \sin(\omega t - \beta z)\hat{y}$, the magnetic field $\vec{B}$ will be given by

(a) None of the above

(b) $\vec{B} = -\frac{E_m \beta}{\omega}\sin(\omega t - \beta z)\hat{x}$

(c) $\vec{B} = -\frac{E_m \beta}{\omega}\cos(\omega t - \beta z)\hat{z}$

(d) $\vec{B} = \frac{E_m \beta}{\omega}\sin(\omega t - \beta z)\hat{y}$

Q14. The magnetic field required to bend a non-relativistic charged particle moving with velocity v into an arc of radius of curvature R is

(a) Inversely proportional to v^2 and directly proportional to R^2

(b) Inversely proportional to v and directly proportional to R

(c) Directly proportional to v and inversely proportional to R

(d) Directly proportional to v^2 and inversely proportional to R^2

Q15. An atom is placed in a magnetic field of sufficient strength for splitting the $3p$ level. The number of levels resulting due to splitting will be

(a) 1 (b) 4 (c) 3 (d) 2

Q16. In 3-dimensional space, a particle of mass m moves in a potential $B\sin 2\alpha r$ where r is the distance of the particle from the origin, B and α are real constants. Which of the following statement is correct?

(a) The motion is periodic in r with an oscillation length scale $\frac{2\pi}{\alpha}$

(b) The trajectory of the particle is always confined to plane passing through the origin

(c) The motion is periodic in r with an oscillation length scale $\frac{\pi}{\alpha}$.

(d) Symmetry implies that a radial momentum P_r is conserved because of the periodic nature of the potential.

Q17. Fourier transform of any function $f(x)$ is defined to be

$$F(k)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} f(x)\exp(-ikx)dx$$

then, given a function $g(x)=1$ for $|x|<1$ and zero otherwise, its Fourier transform $G(k)$ is

(a) $\sqrt{\frac{2}{\pi}}\frac{\sin(k)}{k}$ (b) $\sqrt{\frac{1}{\pi}}\frac{\exp(k)}{k}$ (c) $\sqrt{\frac{2}{\pi}}\cos(k)$ (d) $\sqrt{\frac{1}{\pi}}\frac{\exp(-k)}{k}$

Q18. The fine structure splitting of the $2p$ state of carbon and oxygen atoms in the $L-S$ coupling scheme will have the energy respectively as

(a) ${}^3P_2 >{}^3 P_1 >{}^3 P_0$ and ${}^3P_2 >{}^3 P_1 >{}^3 P_0$ (b) ${}^3P_2 <{}^3 P_1 <{}^3 P_0$ and ${}^3P_2 <{}^3 P_1 <{}^3 P_0$

(c) ${}^3P_2 >{}^3 P_1 >{}^3 P_0$ and ${}^3P_2 <{}^3 P_1 <{}^3 P_0$ (d) ${}^3P_2 <{}^3 P_1 <{}^3 P_0$ and ${}^3P_2 >{}^3 P_1 >{}^3 P_0$

Q19. The Boolean expression $(A+B)(A+\bar{B})(\bar{A}+B)$ is equivalent to

(a) $A\bar{B}$ (b) $\bar{A}B$ (c) $\overline{AB}$ (d) AB

Q20. Consider a rotating spherical planet such that the effective gravitational attraction at the equator is only 75% of that at the pole. If the linear velocity of a point on the equator is v_0, what is the escape velocity for a polar particle?

(a) $v_0\sqrt{8}$ (b) $v_0\sqrt{2}$ (c) $2v_0$ (d) $4v_0$

Q21. If $f(x)$ is non-negative continuous function for all x, such that $f(x)+f\left(x+\frac{1}{2}\right)=1, 0\le x\le\frac{1}{2}$, then $\int_0^1 f(x)dx$ is equal to

(a) 1 (b) $\frac{1}{4}$ (c) $\frac{1}{2}$ (d) 2

Q22. A charged particle of charge q and mass m enters with initial velocity u along the x direction into a region defined by $0\le x\le L$ in which a uniform electric field $\vec{E}$ is applied along the y direction. The charged particle gets deflected by distance D along the y direction when it emerges out of the region. Which of the following statements is false?

(a) D is directly proportional to u (b) D is directly proportional to $\frac{q}{m}$

(c) D is directly proportional to L^2 (d) D is directly proportional to $\vec{E}$

Q23. Which of the following current densities can generate the magnetic vector potential $\vec{A} = y^2\hat{x} + x^2\hat{y}$?

(a) $-\frac{2}{\mu_0}(\hat{x}+\hat{y})$ (b) $-\frac{2}{\mu_0}(\hat{x}-\hat{y})$ (c) $\frac{2}{\mu_0}(x\hat{x}+y\hat{y})$ (d) $\frac{2}{\mu_0}(x\hat{x}-y\hat{y})$

Q24. Let $z = x + iy$ where x and y are real and $i = \sqrt{-1}$. The points (x, y) in the plane for which $\frac{z+i}{z-i}$ is purely imaginary lie on

(a) a hyperbola (b) an ellipse (c) a circle (d) a straight line

Q25. Thermal runaway in a transistor biased in the active region is due to

(a) change in reverse collector saturation current due to rise in temperature

(b) breakdown under reverse biasing

(c) changed in β which increases with temperature

(d) base-emitter voltage V_{BE} which decreases with rise in temperature

Q26. Life-time of an excited state of an atom that always jumps to the ground state by emitting a photon spontaneously is 10^{-9} second. The frequency of the emitted photon is uncertain at least by an amount

(a) $10^4\ Hz$ (b) $10^8\ Hz$ (c) $10^5\ Hz$ (d) $10^6\ Hz$

Q27. In a hydrogen-like atom, an electron is bound to a heavy nucleus containing Z number of protons. In the framework of Bohr's atomic model, $mv_nr_n = n\hbar, n = 1, 2, 3, ...,$ where m, v_n and r_n are the electron's mass, speed and radius, respectively, corresponding to the n-th orbit. If $a_0 = \frac{\hbar^2}{me^2}$ then,

(a) $v_n = \frac{Ze^2}{n\hbar}$ and $r_n = \frac{n^2}{z}a_0$ (b) $v_n = \frac{Ze^2}{n\hbar}$ and $r_n = na_0$

(c) $v_n = \frac{Zne^2}{\hbar}$ and $r_n = \frac{n}{z}a_0$ (d) $v_n = \frac{e^2}{n\hbar}$ and $r_n = \frac{n}{z}a_0$

Q28. Four moles of an ideal gas undergo a reversible isothermal compression at 20^0C when $1850\,J$ of work is done on the gas. The change in entropy of gas in this process is

(a) $-1.6\,J/K$ (b) $+1.6\,J/K$ (c) $+6.3\,J/K$ (d) $-6.3\,J/K$

Q29. The degeneracy of the lowest Landau level

(a) Is constant with the magnetic field

(b) varies as function of temperature

(c) Varies linearly with the magnetic field

(d) varies exponentially with the magnetic field

Q30. The fraction of electrons excited across the energy gap of Silcon $\left(E_g = 1.1 eV\right)$ at room temperature $\left(300\,K\right)$ is

(a) 4×10^{-12} (b) 7×10^{-18} (c) 1.7×10^{-12} (d) 5.712×10^{-10}

Q31. A large and spherical soap film of thickness d has a refractive index $\frac{4}{3}$. A narrow beam of yellow light $\left(\lambda \approx 6400\,\overset{0}{A}\right)$ is incident on the film at an angle of 30^0. What is the value of d for which a constructive second order interference would occur for the reflected wave?

(a) $4800\,\overset{0}{A}$ (b) $3900\,\overset{0}{A}$ (c) $5200\,\overset{0}{A}$ (d) $5500\,\overset{0}{A}$

Q32. The real part of an analytic complex function is $u\left(x,y\right) = x^2 - y^2$. The imaginary part of the function is then

(a) $2xy$ (b) $x^2 - y^2 - 2xy$ (c) $x^2 + y^2$ (d) $x^2 + y^2 + xy$

Q33. A uniformly charged ring of total charge Q and of radius R, rotates about an axis perpendicular to its plane and passing through its centre, with angular velocity ω. The magnetic field produced at the centre of the ring is

(a) $\frac{3\mu_0 Q\omega}{2\pi R}$ (b) $\frac{3\mu_0 Q\omega}{4\pi R}$ (c) $\frac{\mu_0 Q\omega}{4\pi R}$ (d) $\frac{\mu_0 Q\omega}{2\pi R}$

Q34. A child of mass $3m$ sits on a swing, the base of which has mass m, while the rope (of length ℓ) has a negligible mass. An adult pulls back the swing (with the child) until the rope makes an angle of half-a-radian with the vertical, and, then, pushes with a force mg along the arc of a circle until the rope is exactly vertical and releases it. If the rope was always taut, for how long did the adult push?

(a) $\pi\sqrt{\frac{2\ell}{3g}}$ (b) $\frac{\pi}{3}\sqrt{\frac{\ell}{g}}$ (c) $\sqrt{\frac{\ell}{g}}$ (d) $\sqrt{\frac{2\ell}{3g}}$

Q35. The normalized wave functions ψ_1 and ψ_2 correspond to the ground state and the first excited states of a particle in a potential. The operator $\hat{A}$ acts on the wavefunctions as $\hat{A}\psi_1 = \psi_2$ and $\hat{A}\psi_2 = \psi_1$. The expectation value of the operator $\hat{A}$ for the state $\psi = \frac{(3\psi_1 + 4\psi_2)}{5}$ is

(a) 0 (b) 0.96 (c) 0.75 (d) -0.32

Q36. A particle of mass m is confined in the ground state of a one dimensional box extending from $x = -2L$ to $x = +2L$. The wave function of the particle in this state is

$$\psi(x) = \psi_0 \cos\left(\frac{\pi x}{4L}\right),$$

where ψ_0 is a constant. The energy eigenvalue corresponding to this state is

(a) $\frac{\hbar^2\pi^2}{32mL^2}$ (b) $\frac{\hbar^2\pi^2}{16mL^2}$ (c) $\frac{\hbar^2\pi^2}{4mL^2}$ (d) $\frac{\hbar^2\pi^2}{2mL^2}$

Q37. Let C be the unit circle, travelled counter clockwise. Evaluate

$$\oint_C \left[\left(e^{-x^2} - y^3\right)dx + x^3 dy\right]$$

(a) $\sqrt{\frac{\pi}{2}} - 2$ (b) $\sqrt{\frac{\pi}{2}} + 2$ (c) 2π (d) $\frac{3\pi}{2}$

Q38. Consider a system of 3 non-interacting identical fermions. Each particle can be in any one of four states whose energies are $-\varepsilon, 0, +\varepsilon$ and $+2\varepsilon$. Find the entropy of the system if its total energy $E = 0$

(a) $k\ln 2$ (b) 0 (c) $k\ln 3$ (d) $k\ln 4$

Q39. A uniform magnetic field B points along the z axis. At time $t = 0$, a point charge q of mass m is released from the origin with a velocity $\vec{v}$ making an angle 30^0 with the z-axis. When the point charge comes back again at $x = 0$, the z coordinate of the charge is

(a) $\frac{2\pi m|v|}{\sqrt{3}qB}$ (b) $\frac{\sqrt{3}\pi m|v|}{2qB}$ (c) $\frac{\pi m|v|}{qB}$ (d) $\frac{\pi m|v|}{2qB}$

Q40. A thin, uniform and rigid rod R of mass M and length L rests on a flat frictionless table top. A tiny piece of wood of mass $m = 0.01\,M$ sliding on the table towards R with a velocity $\vec{v}$ perpendicular to the length of the rod hits one end of R and gets stuck. The speed of the centre of mass and angular speed of the resulting system are respectively given by

(a) $\frac{v}{100}$ and $\frac{2v}{101L}$ (b) $\frac{v}{101}$ and $\frac{6v}{103L}$

(c) $\frac{v}{101}$ and $\frac{2v}{100L}$ (d) $\frac{v}{100}$ and $\frac{6v}{101L}$

Q41. The temperature dependence of the magnetic susceptibility (χ) of a paramagnetic material, with Curie temperature (T_c) is given by:

(a) $\frac{C}{(T+T_c)}$ for $T > T_c$ (b) $\frac{C}{(T-T_c)}$ for $T < T_c$

(c) $\frac{C}{(T+T_c)}$ for all temperatures (d) $\frac{C}{(T-T_c)}$ for $T > T_c$

Q42. A semiconductor has 10^{15} electrons/ cm^3 $\left(\mu_e = 5000\,cm^2/V.s\right)$ and 5×10^{14} $holes/cm^3$ $\left(\mu_h = 400\,cm^2/V.s\right)$. If a field of $100V/cm$ is applied to it, its total conductivity is

(a) $83.2(\Omega\,cm)^{-1}$ (b) $0.832(\Omega\,cm)^{-1}$

(c) $0.832(m\Omega\,cm)^{-1}$ (d) $8.32(m\Omega\,cm)^{-1}$

Q43. For a mole of idea gas at $T = 35^0C$, what is the work done for an isothermal expansion from a volume V_0 to $10V_0$?

(a) $6\times10^3\ J$ (b) $3\times10^3\ J$ (c) $10^3\ J$ (d) $10^4\ J$

Q44. An ideal monatomic gas, initially at $T = 20^0C$, expands adiabatically from a volume V_0 to $5V_0$. Then the final temperature is

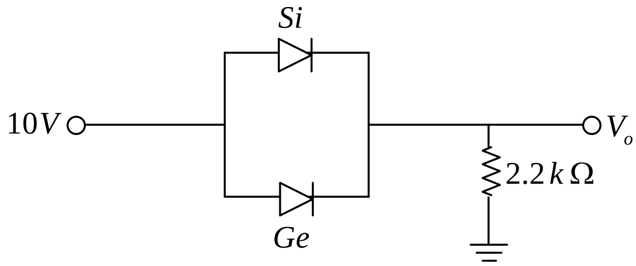
(a) -20^0C (b) -33^0C (c) -173^0C (d) -113^0C

Q45. Consider a body of mass $5g$, which is heated from 100 K to 300 K. The specific heat for the body is 0.1 cal/g/degree. The total charge in the entropy of the body is approximately equal to

(a) 0.5 cal/degree (b)100 cal/degree

(c) 50 cal/degree (d) 0 cal/degree

Q46. Two diodes (Si and Ge) are connected in parallel as shown in the figure. Determine the output voltage V_0. The cut-in voltage for Si and Ge diodes are $0.7V$ and $0.2V$ respectively.



(a) $-9.3\,V$ (b) $-9.8V$ (c) $+9.3V$ (d) $+9.8V$

Q47. Let $f: R \to R$ be given by

$f(x) = |x^2 - 1|, x \in R$. Then

(a) f is discontinuous at $x = \pm 1$

(b) f has local maxima at $x = 0$ but no local minimum

(c) f has local minima at $x = \pm 1$ and a local maximum at $x = 0$

(d) f has local minima at $x = \pm 1$ but no local maximum

Q48. An infinite wire having uniform charge per unit length λ (where λ is negative) lies parallel to an infinite ground conducting plane. The perpendicular distance between the wire and the plane is d. The maximum value of charge density induced on the plane is

(a) $\frac{|\lambda|}{\pi d}$ (b) $\frac{|\lambda|}{2\pi d}$ (c) $\frac{2|\lambda|}{\pi d}$ (d) $\frac{|\lambda|}{4\pi d}$

Q49. Two tuning forks with natural frequencies v_1 and v_2 respectively, are struck at the same time with equal force. The intensity, of the resulting sound, waxes and wanes with time period of 1.5 seconds while the frequency of the sound is $256\ Hz$. Hence v_1 and v_2 respectively, are

(a) $256.333\,Hz$ and $255.667\ Hz$ (b) $256.55\,Hz$ and $255.55\ Hz$

(c) $256\,Hz$ and $256.5\ Hz$ (d) $256.5\,Hz$ and $257\ Hz$

Q50. A blackbody at a temperature of $6000\ K$ emits radiation whose intensity spectrum peaks at $600\ nm$. If the temperature is reduced to $300K$, the spectrum will peak at

(a) $12\ nm$ (b) $120\ \mu m$ (c) $120\,nm$ (d) $12\,\mu m$