(PHYSICS)

Full Marks: 100 **Time: 2 Hours**

This booklet contains 50 Multiple Choice Questions (MCQs), each carrying 2 marks. For correct answer 2 marks will be awarded per question and for wrong answer 0.5 mark will be deducted per question.

Attempt all questions.

1. Electrical analogue of oscillator executing forced vibration is

   a. L-C series circuit driven by an ac source.
   b. L-C-R series circuit driven by an ac source.
   c. L-C-R series circuit driven by a dc source.
   d. L-R connected in parallel with C and driven by an dc source.

2. Two radioactive samples X (half life 3 years) and Y (half life 2 years) have been decaying for many years. Today the number of atoms in the sample X is twice the number of atoms in the sample Y. Both the samples had the same number of atoms

   a. 4 months ago b. 5 years ago c. 6 years ago d. Never before

3. A piece of semi conducting material is introduced in a circuit. If the temperature of the material is raised, the circuit current will

   a. increase b. remain the same c. decrease d. cease to flow

4. If $\{q, f(P)\}= \alpha f(p)$, where α is scalar and $\{\ ,\ \}$ denotes the Poisson bracket, then $f(p)$ is

   a. $e^{\alpha p}$ b. $e^{-\alpha p}$ c. $\alpha e^{-\alpha p}$ d. αe^{-p}

5. The frequency of an electron moving in first Bohr orbit is f. The frequency of an electron in n^{th} orbit is

   a. fn^2 b. fn c. f/n d. f/n^2

6. Consider a surface S defined by $S : x^2y + 2xz = 4$. Which of the following vector is then parallel to the surface S at the point (2, -2, 3) ?

   a. $6\hat{i} - 2\hat{j} - 5\hat{k}$ b. $6\hat{i} + 2\hat{j} + 5\hat{k}$

   c. $-6\hat{i} - 2\hat{j} + 5\hat{k}$ d. $6\hat{i} - 2\hat{j} + 5\hat{k}$

7. If M is a 2×2 matrix given by $\begin{bmatrix} 1 & \frac{1-i}{\sqrt{2}} \\ \frac{1+i}{\sqrt{2}} & 0 \end{bmatrix}$, then $\mathrm{Det}(\exp M) =$

   a. e b. e^2 c. $2i\sin(\sqrt{2})$ d. $\exp(-2\sqrt{2})$

8. If the vectors $\hat{i} - \hat{j} + 2\hat{k}$ and $\hat{i} + \hat{k}$ form the two sides of a triangle. The area of the triangle is

   a. 2 units b. $\frac{\sqrt{3}}{2}$ units c. $\frac{\sqrt{3}}{4}$ units d. $\frac{3}{2}$ units

9. Which one of the following molecules does not exhibit a rotational spectrum

   a. H_2 b. CO c. HCL d. HBr

10. A wave of frequency ω and wave vector $(\hat{i} + \hat{j} + \hat{k})\frac{\omega}{c}$ is propagating through a medium. The phase difference between the points A (0,1,2) and B (2,1,0) is

    a. $\frac{-4\,\omega}{c}$ b. $\frac{6\,\omega}{c}$ c. 0 d. $\frac{\omega}{c}$

11. The quantum statistics reduces to classical statistics under the following condition

    a. $\rho\lambda^3 >> 1$ b. $\rho\lambda^3 \approx 1$ c. $\rho\lambda^3 << 1$ d. $\rho = \lambda^3$

    Where ρ is the density of the system and λ being the thermal wavelength.

12. A faint star is just visible if 2000 photons/sec enter the eye. The amount of energy received by the eye per second (in watt) for the case sodium light of wavelength $\lambda = 5890\ \mathring{A}$ is

    a. 6.76×10^{-16} watt b. 6.76×10^{-13} watt

    c. 6.76×10^{-19} watt d. 6.76×10^{-17} watt

13. The activity of a radioactive substance decreases to 1/64 of its original value in 21 years. The half-life of the substance is

    a. 6.5 years b. 3.5 years c. 5.5 years d. 4.5 years

14. A particle has momentum p and kinetic energy T. Its rest mass m_0 is given by

    a. $\frac{p^2c^2-T^2}{2Tc^2}$ b. $\frac{p^2c^2-T^2}{Tc^2}$ c. $\frac{p^2c^2+T^2}{Tc^2}$ d. $\frac{p^2c^2+T^2}{2Tc^2}$

15. The 2's complement of binary no. 1010 is

    a. 0101 b. 0110 c. 1011 d. 1100

16. Let A and B be the Einstein spontaneous and stimulated emission coefficient respectively for a pair of level separated by a energy $h\nu$. The ratio A/B

    a. does not depend on ν b. is proportional to ν

    c. is proportional to ν^3 d. is proportional to ν^{-3}

17. The Fourier transform of a Gaussian function, G(x) is H(k). The function H(k) is

    a. triangular function b. parabolic function

    c. sink function d. Gaussian function

18. Collector current (I_c) is 1 mA for a transistor is CE mode, find the base current (I_B) if $\alpha = 0.998$

    a. 2μA b. 4μA c. 6μA d. 8μA

19. The energy of the simple harmonic oscillator is $(n + \frac{1}{2})h\nu$ where $n = 0, 1, 2, ..$ The partition function of the system is

    a. $\frac{e^{\frac{h\nu}{2kT}}}{1-e^{\frac{h\nu}{kT}}}$ b. $\frac{e^{\frac{h\nu}{2kT}}}{1+e^{-\frac{h\nu}{kT}}}$ c. $\frac{e^{-\frac{h\nu}{2kT}}}{1+e^{\frac{h\nu}{kT}}}$ d. $\frac{e^{-\frac{h\nu}{2kT}}}{1-e^{-\frac{h\nu}{kT}}}$

20. The rms speed of an ideal-gas molecule is greater than its average speed by about

    a. 15% b. 12% c. 9% d. 6%

21. For the case in which five particles share 6 units of energy. The probability to observe a particle with 2 units of energy for indistinguishable quantum particles with integral spin, is

    a. 0.150 b. 0.160 c. 0.170 d.0.180

22. An electron is trapped in a one-dimensional region of length 1.0×10^{-10} m (a typical atomic diameter). The energy of the ground state is

    a. 37.6 eV b. 3.76 eV c. 0.376 eV d. 376.0 eV

23. Constant binding energy per nucleon is a manifestation of

    a. Saturation property of nuclear force b. Spin dependence of nuclear force

    c. Charge independence of nuclear force d. None of the above

24. Consider the following energies:

    1. minimum energy needed to excite a hydrogen atom
    2. energy needed to ionize a hydrogen atom
    3. energy released in U-235 in fission
    4. energy needed to remove a neutron from a C-12 nucleus

    Rank them in order of increasing value

    a. 1, 2, 3, 4 b. 1, 3, 2, 4 c. 1, 2, 3, 4 d. 2, 1, 3, 4

25. Interference of light is evidence that

    a. the speed of light is very large b. light is a transverse wave

    c. light is electromagnetic in character d. light is a wave phenomenon

26. An unpolarized beam of light has intensity I_0. It is incident on a two polarized sheets. The angle between the axes of polarization of these sheets is θ. Find θ if the emerging light has intensity $I_0/4$:

    a. $\cos^{-1}(1)$ b. $\cos^{-1}(\sqrt{1/2})$ c.$\cos^{-1}(1/2)$ d. $\cos^{-1}(1/4)$

27. An ordinary differential equation is given by $x\frac{d^2y(x)}{dx^2} + (1-x)\frac{dy(x)}{dx} + ny(x) = 0$, where n is a non-negative integer. This differential equation is known as

a. Bessel differential equation
b. Hermite differential equation
c. Laguerre differential equation
d. Legendre differential equation.

28. Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. If yellow light is replaced by x-rays, the observed pattern will reveal

a. that the central maximum is narrower.
b. more number of fringes.
c. less number of fringes.
d. no diffraction pattern.

29. Consider a system of two atoms, each having only 3 quantum states of energies 0, E and $2E$. The system is in contact with a heat reservoir at temperature T. The partition function Z for the system, if the particles obey Fermi-Dirac statistics, is

a. $[1 + \exp(-E/kT) + \exp(-2E/kT)]^2$

b. $[1 + \exp(-E/kT) + \exp(-2E/kT)]^2/2$

c. $[1 + \exp(-E/kT) + \exp(-2E/kT)][1 + \exp(-2E/kT)]$

d. $[1 + \exp(-E/kT) + \exp(-2E/kT)] \exp(-E/kT)$

30. A plane surface with area 3.0 cm^2 is placed in a uniform magnetic field that is oriented at an angle of 30° to the surface. If the magnetic flux through this area is 0.90 mWb, what is the magnitude of the magnetic field ?

a. 6.0 T
b. 3.0 T
c. $\frac{6}{\sqrt{3}}$ T
d. $\frac{4}{\sqrt{3}}$ T

31. At 0 kelvin, semiconductors are

a. perfect metals
b. perfect semiconductors
c. perfect semimetals
d. perfect insulators

32. If θ be the paramagnetic Curie temperature and θ_f be the ferromagnetic Curie temperature of a substance then

a. $\theta < \theta_f$
b. $\theta = 2\theta_f$
c. $\theta = \theta_f$
d. $\theta > \theta_f$

33. The average energy of N independent three dimensional harmonic oscillators at temperature T is (k: Boltzmann constant)

a. 3NkT/2 b. 3NkT c. 3N(kT+1/2) d. NkT

34. When connected to a spring, a mass oscillates on a horizontal table with period P. A second spring with the same spring constant is now connected between the first spring and the mass. The new oscillation period of the system is

a. P b. $2P$ c. $\sqrt{2}P$ d. $\frac{P}{2}$

35. The phenomenon responsible for light propagation through optical Fibre is

a. diffraction b total internal reflection

c. refraction d. rectilinear propagation

36. One mole of an ideal gas expands slowly and isothermally at temperature T until its volume is double. The change of entropy of this gas for this process is

a. R ln 2 b. ln 2/T c. 0 d. RT ln 2

37. A particle of mass m is constrained to move on the plane curve $xy = C\,(C > 0)$ under gravity (y-axis vertical). The Lagrangian of the particle is given by

a. $\frac{1}{2}m\dot{x}^2(1+\frac{C^2}{x^4})+\frac{mgx}{x}$ b. $\frac{1}{2}m\dot{x}^2(1+\frac{C^2}{x^4})-\frac{mgx}{x}$

c. $\frac{1}{2}m\dot{x}^2(1+\frac{C^2}{x^2})+\frac{mgx}{x}$ d. $\frac{1}{2}m\dot{x}^2(1+\frac{C^2}{x^2})-\frac{mgx}{x}$

38. In a Young's double slit experiment the slit separation is made double. To maintain the same fringe spacing on the screen, the screen to slit distance D must be changed to

a. D/2 b. 2D c. D/$\sqrt{2}$ d. $\sqrt{2}$D

39. The minimum number of geostationary satellites needed for uninterrupted global coverage is:

a. 2 b. 3 c. 4 d. 6

40. The eigenvalues of an anti-Hermitian operator are

a. real b. complex
c. purely imaginary or equal to zero d. none of these

41. The reciprocal lattice of a two dimensional hexagonal lattice is a

    a. Hexagonal lattice with same orientation as real space lattice
    b. bcc lattice
    c. fcc lattice
    d. Hexagonal lattice but rotated 30° with respect to real space lattice.

42. The Peltier coefficient π at temperature T related to the thermo-emf ϵ by the relation

    a. $\pi = -T\frac{d^2\epsilon}{dT^2}$ b. $\pi = -T^2\frac{d^2\epsilon}{dT^2}$ c. $\pi = T\frac{d\epsilon}{dT}$ d. none of these

43. The intensity of radiation of an oscillating electric dipole is

    a. maximum along its axis b. maximum in its equatorial plane
    c. minimum at an angle 45° with its axis d. the same in all directions

44. Consider X-ray diffraction from a crystal with a face centered cubic (fcc) lattice. The lattice plane from which there is **NO** diffraction peak is

    a. (212) b. (111) c. (200) d. (311)

45. The Coriolis effect pushes a moving object towards the ——— in the Northern hemisphere and towards the ———in the Southern Hemisphere. The blanks are respectively

    a. left, left b. left, right c. right, left d. right, right

46. A bottle is floating upright in a large bucket of water. In equilibrium it is submerged to a depth d_0 below the surface of the water. If it is pushed down to a depth d ($d > d_0$) and released, it will execute simple harmonic motion. The time period of the oscillations of the bottle is

    a. $2\pi\sqrt{\frac{d}{g}}$ b. $2\pi\sqrt{\frac{d_0}{g}}$ c. $2\pi\sqrt{\frac{d-d_0}{g}}$ d. $2\pi\sqrt{\frac{d+d_0}{g}}$

47. An electron is introduced in a region of uniform electric and magnetic fields at right angles to each other (let us say $\mathbf{E} = E\,\hat{i}$, $\mathbf{B} = B\,\hat{k}$). For what initial velocity will the electron move with constant velocity (both the direction and the magnitude of velocity are constant)?

    a. $\frac{E}{B}\,\hat{j}$ b. $-\frac{E}{B}\,\hat{j}$ c. $\frac{B}{E}\,\hat{j}$ d. $-\frac{B}{E}\,\hat{j}$

48. A classical ideal gas of atoms with mass m is confined in a 3-D potential $V = V(x, y, z) = \frac{\lambda}{2}(x^2 + y^2 + z^2)$ at a temperature T. If k_B denotes the Boltzmann constant, then the root mean square (RMS) distance of the atoms from the origin is

a. $\sqrt{(\frac{3k_BT}{\lambda})}$ b. $\sqrt{(\frac{3k_BT}{2\lambda})}$ c. $\sqrt{(\frac{2k_BT}{3\lambda})}$ d. $\sqrt{(\frac{k_BT}{\lambda})}$

49. A particle moves under the influence of central force in an orbit given by $r = k\theta^4$, where k is a constant , r is the distance from the origin. It then follows that the angle θ varies with time t as

a. $\theta \propto t^{1/9}$ b. $\theta \propto t^{1/8}$ c. $\theta \propto t^{1/7}$ d. $\theta \propto t^{1/6}$

50. In an electromagnetic field, which one of the following remains invariant under Lorentz transformation ?

a. $\vec{E} \times \vec{B}$ b. $E^2 - c^2B^2$ c. B^2 d. E^2