1. If $r \neq 0$, $\vec{\nabla} \cdot \left(\frac{\hat{r}}{r^2}\right)$ is equal to

   A) $2/r^3$. B) $-2/r^3$. C) 0 D) $-3/(2r^3)$.

2. The coordinates of the three vertices of a triangle are $(0,0,0), (1,1,0)$ and $(-2,1,0)$, then the area of the triangle is

   A) $\frac{3}{2}$ B) $\frac{1}{2}$ C) 1 D) 3

3. $\vec{\nabla} \cdot (\vec{A} \times \vec{B})$ is equal to

   A) $\vec{B} \cdot (\vec{\nabla} \times \vec{A}) + \vec{A} \cdot (\vec{\nabla} \times \vec{B})$. B) $-\vec{B} \cdot (\vec{\nabla} \times \vec{A}) - \vec{A} \cdot (\vec{\nabla} \times \vec{B})$.
   C) $-\vec{B} \cdot (\vec{\nabla} \times \vec{A}) + \vec{A} \cdot (\vec{\nabla} \times \vec{B})$. D) $\vec{B} \cdot (\vec{\nabla} \times \vec{A}) - \vec{A} \cdot (\vec{\nabla} \times \vec{B})$.

4. The trace of a 2×2 hermitian matrix A is $\pi/2$, then the determinant of the matrix $\exp(iA)$ is

   A) $-i$. B) i. C) 1 D) -1

5. The eigenvalues of the matrix $A = \begin{pmatrix} 1 & -i \\ i & 1 \end{pmatrix}$ are

   A) 0 and 2. B) 0 and -2. C) 0 and 1. D) 0 and -1.

6. If ϵ_{ijkl} denotes the Levi-Civita symbol in four dimensions, the value of $\epsilon_{ijkl}\epsilon_{ijkl}$ is

   A) 12 B) 48 C) 24 D) 6

7. Which of the following are the two linearly independent solutions of the differential equation $\frac{d^2y}{dx^2} + 6\frac{dy}{dx} + 9y = 0$

   A) $\exp(-3x)$ and $x\exp(-3x)$. B) $\exp(-3x)$ and $x^2\exp(-3x)$.
   C) $\exp(-3x)$ and $\exp(+3x)$. D) $\exp(-3x)$ and $x\exp(+3x)$.

8. The Fourier series for the function $f(x) = x^2$, for $-\pi < x < +\pi$ is given by

$$f(x) = \frac{\pi^2}{3} + 4\sum_1^\infty (-)^n \frac{\cos(nx)}{n^2}, \text{ then } \sum_1^\infty \frac{1}{n^2} \text{ is}$$

A) $\pi^2/3$. B) $\pi^2/12$. C) $\pi^2/6$. D) $4\pi^2/9$.

9. Which of the following can possibly be the real part of an analytic function if its imaginary part is $(\frac{y^2}{2} - \frac{x^2}{2} + 2xy)$?

A) $x^2 + y^2 + xy$. B) $x^2 + y^2 + 2xy$. C) $x^2 + y^2 - 2xy$. D) $x^2 - y^2 + xy$.

10. The residue of $f(z) = z^2 \sin\left(\frac{1}{z}\right)$ at $z = 0$ is

A) $+\frac{1}{6}$ B) $-\frac{1}{6}$ C) 0 D) 1

11. A body of mass m moving with kinetic energy T strikes a stationary body of mass m. As a result of of the collision, both stick together and moves with a common velocity. The energy loss in the collision process is

A) $T/4$. B) T. C) $T/8$. D) $T/2$.

12. If two particles with equal masses are moving with the same velocity $\vec{v}$, then the velocity of the of the centre of mass frame is

A) $2\vec{v}$. B) $\vec{v}/2$. C) $\vec{v}$. D) zero.

13. A particle is experiencing a force $\vec{F} = -ayz\hat{i} + bzx\hat{j} - cxy\hat{k}$. The work done by the force is independent of the path provided,

A) $a = -b = c$. B) $a = -b = -c$. C) $a = b = c$. D) $a = b = -c$.

14. The number of degrees of freedom of two particles constrained to move in a plane with fixed distance between them is

A) 3 B) 4 C) 2 D) 1

15. For a system described by the Lagrangian $L = \frac{m}{2}\left(\dot{x}^2 + \dot{y}^2 + \dot{z}^2\right) - mgz$, where g is a constant,

A) x and z are cyclic coordinates.
B) y and z are cyclic coordinates.
C) x and y are cyclic coordinates.
D) z is a cyclic coordinate.

16. The Lagrangian of a one dimensional system is $L = \frac{m}{2}\dot{x}^2 + q\dot{x}x - \frac{k}{2}x^2$, where k and q are constants. The corresponding Hamiltonian is

A) $H = \frac{(p+qx)^2}{2m} + \frac{k}{2}x^2$.
B) $H = \frac{(p-qx)^2}{2m} + \frac{k}{2}x^2$.
C) $H = \frac{(p-qx)^2}{2m} - \frac{k}{2}x^2$.
D) $H = \frac{(p+qx)^2}{2m} - \frac{k}{2}x^2$.

17. The Lagrangian of a three dimensional system is

$$L = \frac{m}{2}\left(\dot{x}^2 + \dot{y}^2 + \dot{z}^2\right) - \frac{k}{2}(x^2 + y^2)$$

where k is a constant. If $\vec{P}$ is the linear momentum, then

A) $\vec{P}$ is conserved.
B) P_x and P_y are conserved.
C) P^2 is conserved.
D) P_z is conserved.

18. The Hamiltonian of a three dimensional system is $H = \frac{\left(\vec{p} - e\vec{A}(\vec{r})\right)^2}{2m}$, where e is a constant. The Hamilton's equations of motion for $\vec{r}$ is

A) $\dot{\vec{r}} = \{\vec{p} + e\vec{A}(\vec{r})\}/m$.
B) $\dot{\vec{r}} = \{\vec{p} - e\vec{A}(\vec{r})\}/m$.
C) $\dot{\vec{r}} = \vec{p}/m$.
D) $\dot{\vec{r}} = \{\vec{p} - e\vec{A}(\vec{r})\}/(2m)$.

19. The angular frequency of a particle with mass m executing a uniform circular motion under the influence of a central potential $V(r) = kr^2$ is

A) $\sqrt{\frac{k}{2m}}$.
B) $\sqrt{\frac{k}{m}}$.
C) $\sqrt{\frac{3k}{2m}}$.
D) $\sqrt{\frac{2k}{m}}$.

20. A traveling wave is described by $y(x,t) = y_0 \sin(10x + 100t)$, where x and t are measured in meters and seconds respectively. The phase velocity of the wave is

A) 10m/s.
B) 0.1m/s.
C) (40π)m/s.
D) $(10/\pi)$m/s.

21. The wavelength λ of the second harmonic mode in an open pipe of length L is

A) $\lambda = L/2$. B) $\lambda = 2L$. C) $\lambda = L$. D) $\lambda = L/4$.

22. A particle and a frame $\mathcal{K}'$ is moving with a speed v and V respectively along positive x-axis in a frame $\mathcal{K}$, then the speed of the particle in the frame $\mathcal{K}'$ is

A) $(v - V)/(1 + vV/c^2)$.
B) $(v - V)/(1 - vV/c^2)$.
C) $(v + V)/(1 - vV/c^2)$.
D) $(v + V)/(1 + vV/c^2)$.

23. A frame $\mathcal{K}'$ is moving with a speed v in the negative y-direction when viewed in a frame $\mathcal{K}$. If $1/\gamma^2 = 1 - v^2/c^2$, an event (x, y, z, t) in $\mathcal{K}$ is related to the event (x', y', z', t') in $\mathcal{K}'$ as

A) $t = \gamma(t' - vy'/c^2),\ x = x',\ y = \gamma(y' - vt')$ and $z = z'$.
B) $t = \gamma(t' + vy'/c^2),\ x = x',\ y = \gamma(y' - vt')$ and $z = z'$.
C) $t = \gamma(t' - vy'/c^2),\ x = x',\ y = \gamma(y' + vt')$ and $z = z'$.
D) $t = \gamma(t' + vy'/c^2),\ x = x',\ y = \gamma(y' + vt')$ and $z = z'$.

24. A particle with rest mass energy 6MeV is moving and its energy is 10MeV. The momentum of the particle is

A) $8\text{MeV}/c^2$. B) $4\text{MeV}/c$. C) $4\text{MeV}/c^2$. D) $8\text{MeV}/c$.

25. A sphere of radius R is uniformly charged with charge density ρ_0. The magnitude of the electric field at a distance r $(r < R)$ from the centre of the sphere is

A) $\dfrac{3\rho_0 r}{\epsilon_0}$. B) $\dfrac{4\pi\rho_0 r}{3\epsilon_0}$. C) $\dfrac{\rho_0 r}{3\epsilon_0}$. D) $\dfrac{3\rho_0 r}{4\pi\epsilon_0}$.

26. Consider a plane dielectric interface in the xy-plane, without any free surface charges, separating two media with permittivities $4\epsilon_0$ and $2\epsilon_0$. If the electric field at the interface in the region with permittivity $4\epsilon_0$ is $(2\hat{\imath} + 3\hat{\jmath} + 4\hat{k})$V/m, the electric field at the interface in the other region is

A) $(2\hat{\imath} + 3\hat{\jmath} + 2\hat{k})$V/m.
B) $(4\hat{\imath} + 6\hat{\jmath} + 8\hat{k})$V/m.
C) $(2\hat{\imath} + 3\hat{\jmath} + 8\hat{k})$V/m.
D) $(4\hat{\imath} + 6\hat{\jmath} + 4\hat{k})$V/m.

27. If a surface current, $\vec{K} = K\hat{\jmath}$, of infinite extent is flowing in the xy-plane, the magnetic field in the region $z > 0$ is

A) $-\mu_0 K\hat{\imath}/2$. B) $\mu_0 K\hat{\imath}$. C) $\mu_0 K\hat{k}$. D) $\mu_0 K\hat{\imath}/2$.

28. Three charges $2q$, $-q$ and $-q$ are kept at the points $(-a,0,0)$, $(0,0,0)$ and $(a,0,0)$ respectively. The electric dipole moment of this charge distribution is

A) $+3qa\hat{i}$. B) $-2qa\hat{i}$. C) $+2qa\hat{i}$. D) $-3qa\hat{i}$

29. The magnetic field at the point $(a,0,0)$ due to a magnetic dipole of moment $\vec{m} = m\hat{i}$ kept at the origin is

A) $\frac{\mu_0 m}{4\pi a^3}\hat{i}$. B) $\frac{\mu_0 m}{2\pi a^3}\hat{i}$. C) $-\frac{\mu_0 m}{2\pi a^3}\hat{i}$. D) $-\frac{\mu_0 m}{4\pi a^3}\hat{i}$.

30. Consider two vector potentials $\vec{A}$ and $\vec{A}'$ such that $\vec{A}' = \vec{A} + \vec{a}$ and the corresponding magnetic fields $\vec{B}$ and $\vec{B}'$. If a_0 is a constant, which of the following choice of $\vec{a}$ will lead to different magnetic fields?

A) $\vec{a} = a_0(y\hat{i} - x\hat{j})$. B) $\vec{a} = a_0(y\hat{i} + x\hat{j})$.
C) $\vec{a} = a_0(x\hat{i} + y\hat{j})$. D) $\vec{a} = a_0(x\hat{i} - y\hat{j})$.

31. The electric potential $\phi(\vec{r})$ due to a charge distribution is $\phi(\vec{r}) = \frac{q}{4\pi}\frac{\exp(-kr)}{r}$. Using the relation $(\nabla^2 - k^2)\phi(\vec{r}) = -q\delta(\vec{r})$, the total charge of the corresponding charge distribution is

A) q B) $-q$ C) $2q$ D) 0

32. The electric field at a given space time point of a transverse electromagnetic wave propagating in vacuum in the direction $(\hat{i} + \hat{j})/\sqrt{2}$ is $E_0(\hat{i} - \hat{j})/\sqrt{2}$, then the corresponding magnetic field is

A) $\vec{B} = E_0\hat{k}/c$. B) $\vec{B} = -E_0\hat{k}/c$.
C) $\vec{B} = -E_0\hat{k}/(\sqrt{2}c)$. D) $\vec{B} = E_0\hat{k}/(\sqrt{2}c)$.

33. Consider an electromagnetic wave incident from a medium with dielectric permittivity ϵ_1 on the interface of another medium with dielectric permittivity ϵ_2. If both media is having the same magnetic permeability, the Brewster's angle θ_B is such that

A) $\tan\theta_B = \epsilon_1/\epsilon_2$. B) $\tan\theta_B = \epsilon_2/\epsilon_1$.
C) $\tan^2\theta_B = \epsilon_2/\epsilon_1$. D) $\tan^2\theta_B = \epsilon_1/\epsilon_2$.

34. For a hollow metallic rectangular wave guide of dimensions a and b such that $a > b$, the lowest cutoff frequency for TE mode is

A) $c\pi/a$. B) $c\pi/(2a)$. C) $2c\pi/a$. D) $c\pi/b$.

35. Consider the propagation of TE waves along the $+z$-direction through a hollow metallic rectangular wave guide with boundaries at $x = 0,\ x = a,\ y = 0$, and $y = b$. If B_0 is a constant and $m,\ n = 0, 1, 2, 3, \ldots$, then the x and y dependence of B_z is

A) $B_z = B_0 \sin(m\pi x/a)\cos(n\pi y/b)$. B) $B_z = B_0 \cos(m\pi x/a)\cos(n\pi y/b)$.
C) $B_z = B_0 \cos(m\pi x/a)\sin(n\pi y/b)$. D) $B_z = B_0 \sin(m\pi x/a)\sin(n\pi y/b)$.

36. In the presence of a constant magnetic field, $\vec{B} = B\hat{k}$, a particle of mass m and charge q is moving in a circular path in the xy-plane. Its velocity is $v\hat{i}$, when it is at the point $(0,0,0)$, then the centre of the circle is at

A) $\left(0,\ \frac{mv}{qB},\ 0\right)$. B) $\left(-\frac{mv}{qB},\ 0,\ 0\right)$.
C) $\left(\frac{mv}{qB},\ 0,\ 0\right)$. D) $\left(0,\ -\frac{mv}{qB},\ 0\right)$.

37. Which of the following set of Maxwell's equations can be used to establish the continuity equation, $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$

A) $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ and $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$
B) $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ and $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
C) $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ and $\vec{\nabla} \cdot \vec{B} = 0$
D) $\vec{\nabla} \cdot \vec{B} = 0$ and $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

38. The electrostatic potential corresponding to a uniform electric filed, $\vec{E}$ is

A) $\vec{E} \cdot \vec{r}$. B) $-\vec{E} \cdot \vec{r} \cos(\theta)$. C) $-\vec{E} \cdot \vec{r}$. D) $\vec{E} \cdot \vec{r} \cos(\theta)$.

39. Consider a cylindrical resonant cavity with plane metallic end surfaces at $z = 0$ and $z = d$. If $p = 0, 1, 2, 3, \ldots$, for TM standing wave modes, which of the following is true?

A) $E_z = \psi(x,y)\sin(p\pi z/d)$. B) $E_z = \psi(x,y)\cos(p\pi z/d)$.
C) $B_z = \psi(x,y)\cos(p\pi z/d)$. D) $B_z = \psi(x,y)\sin(p\pi z/d)$.

40. For a harmonic transverse electromagnetic plane wave propagating in the direction $\hat{k}$ the time averaged Poynting vector is

A) $\sqrt{\epsilon/\mu}\ |\vec{E}|^2\ \hat{k}$. B) $\sqrt{\mu/\epsilon}\ |\vec{E}|^2\ \hat{k}/2$.
C) $\sqrt{\mu/\epsilon}\ |\vec{E}|^2\ \hat{k}$. D) $\sqrt{\epsilon/\mu}\ |\vec{E}|^2\ \hat{k}/2$.

41. Two point charges q and $-q$ are kept in the xy-plane at $x = -a$ and $x = +a$ respectively. The electric field at the point $(0, y)$ due this charges are

A) $\frac{q}{2\pi\epsilon_0}\frac{a}{(a^2+y^2)^{3/2}}\hat{i}$. B) $\frac{q}{2\pi\epsilon_0}\frac{y}{(a^2+y^2)^{3/2}}\hat{i}$.
C) $\frac{q}{4\pi\epsilon_0}\frac{a}{(a^2+y^2)^{3/2}}\hat{i}$. D) $\frac{q}{4\pi\epsilon_0}\frac{y}{(a^2+y^2)^{3/2}}\hat{i}$.

42. If G is the Gibbs free energy which of the following statement is true?

A) $dG = SdT + VdP$. B) $dG = -SdT + VdP$.
C) $dG = SdT - VdP$. D) $dG = -SdT - VdP$.

43. If k, Q_N and U are Boltzmann constant, partition function and internal energy respectively, then

A) $U = -kT^2\frac{\partial}{\partial T}(\ln Q_N)$. B) $U = kT\frac{\partial}{\partial T}(\ln Q_N)$.
C) $U = -kT\frac{\partial}{\partial T}(\ln Q_N)$. D) $U = kT^2\frac{\partial}{\partial T}(\ln Q_N)$.

44. If T_F is the Fermi temperature, the energy U of an ideal Fermi gas for $T << T_F$ is given by

A) $U = 2NkT_F/3$. B) $U = NkT_F/5$.
C) $U = 3NkT_F/5$. D) $U = 3NkT_F/2$.

45. If an ideal gas with initial temperature T_i and volume V_i is adiabatically changed to a volume V_f, the final temperature T_f is

A) $T_f = T_i\left(\frac{V_i}{V_f}\right)^{\gamma-1}$. B) $T_f = T_i\left(\frac{V_i}{V_f}\right)^{\gamma}$.
C) $T_f = T_i\left(\frac{V_f}{V_i}\right)^{\gamma-1}$. D) $T_f = T_i\left(\frac{V_f}{V_i}\right)^{\gamma}$.

46. If U is the internal energy for a blackbody cavity, then

A) $3U = PV$. B) $2U = 3PV$. C) $U = 3PV$. D) $U = PV$.

47. If the ground state energy of a hydrogen like atom is E_g, the energy of a state with radial quantum number $n_r = 4$ and orbital angular quantum number $l = 2$ is

A) $E_g/9$. B) $E_g/16$. C) $E_g/4$. D) $E_g/25$.

48. If the wave function of a one dimensional quantum system is $\psi(x) = N \exp(-x^2/\sigma^2 - ipx/\hbar)$, where N is the normalization constant, then the expectation value of the momentum for this state is

A) p. B) $\hbar/\sigma$. C) $-\hbar/\sigma$. D) $-p$.

49. If $\hat{H} = \dfrac{p^2}{2m} + \dfrac{1}{2} m\omega^2 x^2$ is the one dimensional harmonic oscillator Hamiltonian and $\hat{a} = \sqrt{\dfrac{m\omega}{2\hbar}}\hat{x} + i\sqrt{\dfrac{1}{2m\hbar\omega}}\hat{p}$, then the commutator $[\hat{H}, \hat{a}^\dagger]$ is equal to

A) $-\hbar\omega\hat{a}^\dagger$. B) $\hbar\omega\hat{a}$. C) $\hbar\omega\hat{a}^\dagger$. D) $-\hbar\omega\hat{a}$.

50. Consider two electrons with spins $\vec{s}_1$ and $\vec{s}_1$ respectively. The expectation value of $\vec{s}_1 \cdot \vec{s}_2$ for the triplet (total spin one) state is equal to

A) $\hbar^2/4$. B) $3\hbar^2/2$. C) $-\hbar^2/4$. D) $3\hbar^2/4$.

51. The state of a one dimensional quantum system given as $\psi(x) = N \exp[-(x-a)^2/\sigma^2]$, where N, σ and a are constants, then the expectation value of the position operator, $\langle \hat{x} \rangle$ is

A) $-a$. B) a. C) $1/\sigma$. D) $-1/\sigma$.

52. The energy of a three dimensional harmonic oscillator state is $9\hbar\omega/2$, then it is

A) 6-fold degenerate. B) 15-fold degenerate.
C) 21-fold degenerate. D) 10-fold degenerate.

53. For an arbitrary operator $\hat{A}$ and its adjoint operator $\hat{A}^\dagger$,

A) $\langle\psi|\hat{A}|\phi\rangle = \langle\phi|\hat{A}^\dagger|\psi\rangle$. B) $\langle\psi|\hat{A}|\phi\rangle = \langle\psi|\hat{A}^\dagger|\phi\rangle^*$.
C) $\langle\psi|\hat{A}|\phi\rangle = \langle\psi|\hat{A}^\dagger|\phi\rangle$. D) $\langle\psi|\hat{A}|\phi\rangle = \langle\phi|\hat{A}^\dagger|\psi\rangle^*$.

54. If $\hat{\vec{p}}$ and $\hat{\vec{L}}$ are momentum and angular momentum operators respectively, the commutator $[\hat{L}_x, \hat{p}_z]$ is equal to

A) $-i\hbar\hat{p}_y$. B) $+i\hbar\hat{p}_y$. C) $-i\hbar\hat{p}_x$. D) $+\hbar\hat{p}_x$.

55. If $E_n,\ n = 1, 2, 3, \ldots$ denotes the discrete bound state energies of a particle in an infinitely deep one dimensional potential, then $E_{n+1} - E_n$ is given by

A) $(n+1)E_1$. B) $(2n+2)E_1$. C) $(2n+1)E_1$. D) $(4n+1)E_1$.

56. For a one dimensional quantum system in a potential $V(x) = k\delta(x - a)$, where k and a are constants, the wavefunction $\psi(x)$ and its first derivative $\psi'(x)$ are such that

A) both $\psi(x)$ and $\psi'(x)$ are discontinuous at $x = a$.
B) $\psi(x)$ is continuous and $\psi'(x)$ is discontinuous at $x = a$.
C) $\psi(x)$ is discontinuous and $\psi'(x)$ is continuous at $x = a$.
D) both $\psi(x)$ and $\psi'(x)$ are continuous at $x = a$.

57. The total angular momentum quantum number j by coupling two angular momenta with quantum numbers j_1 and j_2 are found to be $j = 5/2$. If $j_2 = 1$, the possible values of j_1 are

A) 7/2 and 5/2 only. B) 5/2 and 3/2 only.
C) 7/2, 5/2 and 3/2 only. D) 1/2 only.

58. If $|j, m\rangle$ and $|m_1; m_2\rangle$ denotes the basis vectors in the coupled and uncoupled representations respectively, in general a state with $j = j_1 + j_2$ and $m = j_1 + j_2 - 1$ is a linear combinations of

A) $|j_1; j_2 - 1\rangle$ and $|j_1 - 1; j_2\rangle$.
B) $|j_1 + 1; j_2 - 2\rangle$ and $|j_1 - 2; j_2 + 1\rangle$.
C) $|j_1; j_2 - 2\rangle$ and $|j_1 - 2; j_2\rangle$.
D) $|j_1 - 1; j_2 - 1\rangle$ and $|j_1 - 1; j_2\rangle$.

59. If $\hat{A}_S$ and $\psi_S(t)$ respectively denotes operator and state vectors in the Schrodinger picture and $\hat{U} = \hat{U}(t, t_0)$ is the time evolution operator such that $\psi_S(t) = \hat{U}(t, t_0)\psi_S(t_0)$, then the operator $\hat{A}_H(t)$ and the state vector $\psi_H(t)$ in the Heisenberg picture are

A) $\psi_H(t) = \hat{U}\psi_S(t)$ and $\hat{A}_H(t) = \hat{U}^{-1}\hat{A}_S\hat{U}$.
B) $\psi_H(t) = \hat{U}^{-1}\psi_S(t)$ and $\hat{A}_H(t) = \hat{U}\hat{A}_S\hat{U}^{-1}$.
C) $\psi_H(t) = \hat{U}\psi_S(t)$ and $\hat{A}_H(t) = \hat{U}\hat{A}_S\hat{U}^{-1}$.
D) $\psi_H(t) = \hat{U}^{-1}\psi_S(t)$ and $\hat{A}_H(t) = \hat{U}^{-1}\hat{A}_S\hat{U}$.

60. An observable $\hat{A}$ is such that $\hat{A}|a_k\rangle = a_k|a_k\rangle$ and $\langle a_j|a_k\rangle = \delta_{jk}$ For a system in the state $|\psi\rangle = |a_1\rangle + 2|a_2\rangle + 3|a_3\rangle$ the probability that a measurement of the observable represented by $\hat{A}$ to have a value a_2 is

A) 2/3. B) 4/9. C) 2/7. D) 1/7.

61. The Hamiltonian of a one dimensional quantum system is $H = \hat{p}^2/(2m) + m\omega^2\hat{x}^2/2 + \lambda m\omega^2\hat{x}$ where λ is a constant. If $n = 0, 1, 2, \ldots,$ the corresponding bound state energy of the system is

A) $(n + 1/2)\hbar\omega + m\omega^2\lambda^2/2$. B) $(n + 1/2)\hbar\omega - m\omega^2\lambda^2/2$.
C) $(n + 1/2)\hbar\omega - m\omega^2\lambda^2$. D) $(n + 1/2)\hbar\omega + m\omega^2\lambda^2$.

62. The junction capacitance of pn junction

A) decrease on reverse bias.
B) decrease on forward bias.
C) is zero on reverse bias.
D) independent of bias.

63. A current amplifier is characterized by

A) high input impedance and low output impedance.
B) low impedance for both input and out put.
C) low input impedance and high output impedance.
D) high impedance for both input and out put.

64. The basic memory element is

A) NOT gate. B) op-amp.
C) shift register. D) flip flop.

65. the binary 10001 corresponds to decimal number

A) 18 B) 17 C) 33 D) 9

66. The truth table given below corresponds to the operation

A	B	C
0	0	0
1	0	0
0	1	0
1	1	1

A) OR B) NOR C) AND D) NAND

67. The ripple factor in a rectifier circuit indicates the

A) amount of a.c voltage present in the output.
B) amount of d.c voltage present in the output.
C) change in d.c output when load changes.
D) change in d.c voltage when in put a.c voltage changes.

68. The JFET is

A) a bipolar device. B) a current controlled device.
C) a form of op-amp. D) a unipolar device.

69. The purpose of offset nulling in an op-amp is to

A) reduce the gain. B) zero the output error voltage.
C) equalize the output signal. D) increase the gain.

70. Solar cell work on the principle of

A) electron hole generation in a semiconductor by temperature rise.
B) photo electric effect.
C) electron hole generation in a pn junction by incident photons.
D) thermionic emission.

71. For an oscillator the product A_v and attenuation of the feed back β of the circuit must be

A) equal to 1. B) less than one. C) 10. D) 100.

72. For operation as an amplifier the base of a npn transistor has to be

A) negative with respect to the emitter.
B) zero bias.
C) positive with respect to collector.
D) positive with respect to the emitter.

73. Which of the following gates are known as universal gates?

A) AND and OR. B) AND and NOT.
C) NAND and NOR. D) OR and XOR.

74. Most commonly used material for optical fiber is

A) silica. B) silicon. C) alumina. D) germanium.

75. Sky wave propagation make use of

A) direct propagation of radio waves between antennas in the line of sight.
B) reflection of radio waves by ionized layers in the upper atmosphere.
C) radio waves that reflect by earth surface.
D) waves transmitted with help of satellites.

76. The process of converting the digital signal to analog is achieved by designing

A) a resistive divider or ladder circuit
B) a comparator circuit
C) a circuit using gates
D) a circuit using MOSFET

77. The Boolean equation Y= AB$\overline{C}$+ABC is equivalent to

A) Y= A$\overline{C}$. B) Y= $\overline{C}$+$\overline{C}$. C) Y = BC. D) Y =AB.

78. On comparison of frequency modulated and amplitude modulated waves

A) FM carrier wave has long wavelength and can be used for transmission grater distance than AM waves.
B) it is less likely that frequency of FM wave accidentally modulated producing noise.
C) AM waves has less chance to be accidentally modulated by external disturbance.
D) AM waves can be used for only short distance communication.

79. If R_H is the Rydberg constant for hydrogen in cm^{-1} the series limit for Lyman and Blamer series occur at

A) R_H and $R_H/4$ respectively. B) $R_H/2$ and $R_H/4$ respectively.
C) R_H and $R_H/2$ respectively. D) Both at R_H.

80. The spectroscopic term value for the ground state of helium atom is given by

A) $^3S_1$. B) $^3P_3$. C) $^1S_0$. D) $^1P_1$.

81. The number of Zeeman levels corresponding to the spectral notation $^2D_{5/2}$ is

A) 6 levels. B) 5 levels.
C) 3 levels. D) 2 levels.

82. Which of the following statement is correct? Hyperfine structure arise due to

A) the interaction of nuclear spin with total electronic angular momentum of electron.
B) the interaction between electron spin and orbital angular momentum.
C) the presence of isotopes.
D) the application of strong external magnetic field.

83. The doublet D_1 and D_2lines in sodium spectrum can be explained by considering

A) relativistic correction.
B) Bohr atom model.
C) earths magnetic field.
D) $l - s$ coupling.

84. Which of the molecule given below show pure rotational spectra?

A) CO_2 B) H_2 C) CO D) N_2

85. The first absorption line in the rotational spectra of diatomic molecules appears at the wave number

A) $h/(8\pi^2 Ic)$. B) $4\pi^2 Ic/h$. C) $h/(4\pi^2 Ic)$. D) $8\pi^2 Ic/h$.

86. Raman shift is

A) independent of incident frequency but depends on scatterer.
B) independent of both incident frequency scatterer.
C) independent of scatterer but depends on incident frequency.
D) dependent on both incident frequency and scatterer.

87. The intensity of vibration-electronic spectra of molecules is governed by

A) Pauli's exclusion principle.
B) Born-Oppenheimer approximation.
C) Bear-Lambert law.
D) Frank-Condon principle.

88. The NMR spectrometer operating at a frequency 60MHz shows a chemical shift for a compound as 6ppm. What will be the chemical shift if measured using a NMR spectrometer operating at 360 MHz with the same applied magnetic field?

A) 36ppm. B) 6ppm. C) 1ppm. D) 12ppm.

89. Which of the following statement is **not** correct in the context of a laser?

A) The emitted radiation do not have precisely defined frequency.
B) The emitted radiation is highly coherent and intense.
C) Lasing action require population inversion.
D) More photons comes out compared to incident photon.

90. The electron spin resonance spectra falls in the

A) visible wavelength region.
B) infrared frequency.
C) Radio frequency region.
D) long wavelength edge of microwave region.

91. The nearest neighbor distance in the case of fcc structure with lattice parameter a is

A) $\sqrt{2}\, a/2$. B) $a/2$. C) $\sqrt{(\frac{a}{2})}$ D) a.

92. Miller indices of the plane parallel to zy-plane is

A) (010). B) (100). C) (001). D) (011).

93. X-rays are diffracted from crystals because

A) the crystal has completely random arrangement of atoms.
B) of multiple reflections from different sides of the crystal.
C) of phonon vibrations.
D) the crystal has periodic arrangement of atoms.

94. The electrical conductivity σ is given by the relation

A) $\sigma = ne/\mu$. B) $\sigma = ne\mu$. C) $\sigma = n^2e\mu$. D) $\sigma = ne$.

95. The lattice specific heat at low temperature varies as

A) T^3. B) $1/T^3$. C) T. D) $1/T$.

96. If E_F is the Fermi energy of sodium at 0K, then the Fermi energy at 10000K will be

A) $2E_F$. B) $10E_F$. C) $0.93E_F$. D) $100E_F$.

97. The Fermi level in a n-type semiconductor at 0K lie at

A) half way between donor level and conduction band.
B) below the donor level.
C) half way between acceptor and valance band.
D) half way between the conduction band and valance band.

98. The velocity of electrons corresponding to the point of inflexion on $E - k$ diagram is

A) decreases linearly as k increases.
B) zero.
C) maximum.
D) increases linearly as k increases

99. The majority carriers in a semiconductor is electrons if the Hall coefficient is

A) positive.
B) zero.
C) cannot be determined from Hall coefficient.
D) negative.

100. Cooper pairs are formed

A) at high temperature, where the thermal energy is sufficient to create Cooper pairs.
B) at very low temperature, where the thermal energy is not sufficient to disrupt the pair binding.
C) at a critical magnetic field strength where the superconductivity is destroyed.
D) at a temperature equivalent to the melting point of the material.

101. Piezoelectric effect is the

A) production of election hole pair in a semiconductor by photons.
B) ejection of electron from a metal surface by the photon.
C) production of electric charge on the surface of mechanically strained dielectric.
D) production of electric charge on the the surface by heat.

102. The factor responsible for spontaneous polarization in ferroelectric is

A) permanent electric dipoles. B) orbital motion of electrons.
C) magnetic dipoles. D) presence of ionized impurities.

103. Magnetic susceptibility of a magnetic material is given by

A) $\chi = H/M$. B) $\chi = M/H$. C) $\chi = \mu_0 H + M$. D) $\chi = \mu_0(M + H)$.

104. Band gap of Si at room temperature is close to

A) 1.1 eV. B) 2.1 eV. C) 0.67 eV. D) 6.0 eV.

105. X-rays are produced when an element of high atomic weight is bombarded by

A) neutrons. B) protons. C) electrons. D) α particles.

106. Nuclear radius R is proportional to

A) $A^{2/3}$. B) $A^{1/3}$. C) $A^{3/2}$. D) A.

107. The average binding energy per nucleon in a nucleus is

A) 7.8 eV. B) 931 MeV. C) 7.8 keV. D) 7.8 MeV.

108. Which one of the following particles have spin other than half?

A) proton B) electron C) photon D) neutrino

109. The deviation of the charge distribution from spherical symmetry can be estimated by measuring its

A) electric quadrupole moment. B) electric dipole moment.
C) magnetic dipole moment. D) charge.

110. A deuteron in the ground state consists of

A) one proton and one neutron with anti parallel spins.
B) one proton and one neutron with parallel spins.
C) two protons with parallel spins.
D) two neutrons with parallel spins.

111. Spin and parity of $_5B^{11}$ nucleus can be predicted by shell model as

A) $\frac{3}{2}^+$.   B) $\frac{1}{2}^-$.   C) $\frac{1}{2}^+$.   D) $\frac{3}{2}^-$.

112. Which among the following is a material used as the moderator in nuclear reactors?

A) aluminum   B) cadmium   C) carbon   D) uranium

113. The particle neutrino was proposed by Pauli to explain

A) the continuous spectra of the β particles.
B) the γ ray emission.
C) the α ray emission.
D) the stability of magic numbered nuclei.

114. The contribution of Coulomb energy in the semiempirical mass formula of a nucleus $_ZX^A$ is proportional to

A) $Z/A^{2/3}$.   B) $(Z-1)/A^{1/3}$.
C) $A/Z^{1/3}$.   D) $Z(Z-1)/A^{1/3}$.

115. The quark structure of the proton is

A) *udd*.   B) *uud*.   C) *ddd*.   D) *uuu*.

116. Nuclear forces are

A) short range and spin independent.
B) long range and attractive.
C) short range and spin dependent.
D) long range and repulsive.

117. Nuclear fusion requires high temperature because

A) nuclei must posses high kinetic energy to overcome the Coulomb repulsion.
B) all nuclear reactions absorbs heat.
C) nuclei must posses high kinetic energy to overcome the repulsion due nuclear interaction.
D) there is tensor component in the nuclear force.

118. The scintillation counter works on the principle of

A) electron-hole pair production in the material when particle strikes on it.
B) conversion of ultra violet light to visible light.
C) the emission of light from certain materials when charged particle strikes on it.
D) the carrier generation in the depletion region of a junction when a charged particle strikes on it.

119. Which of the following is a baryon?

A) pion B) neutron C) neutrino D) muon

120. The half life of radioactive element with decay constant λ is

A) $\ln 2/\lambda$. B) $2/\lambda$. C) $1/\lambda$. D) $1/(2\lambda)$.