1. The adjacent sides of a parallelogram can be represented by the vectors
$\vec{A} = 2\hat{\imath} + 3\hat{\jmath}$ and $\vec{B} = -\hat{\imath} + \hat{\jmath}$. The area of the parallelogram is
A) $\sqrt{5}$ B) $\sqrt{13}$ C) $\sqrt{2}$ D) 5

2. Two sides of a triangle can be represented by the vectors $\vec{A} = \hat{\imath} + 2\hat{\jmath} + 3\hat{k}$ and
$\vec{B} = 2\hat{\imath} + 3\hat{\jmath} + 4\hat{k}$. Which of the following vectors can represent its third side?
A) $\hat{\imath} + \hat{\jmath} + \hat{k}$ B) $3\hat{\imath} + \hat{\jmath} + 7\hat{k}$
C) $-\hat{\imath} - \hat{\jmath} + \hat{k}$ D) $3\hat{\imath} + 5\hat{\jmath} + \hat{k}$

3. The line integral $\oint \vec{A} \cdot d\vec{r} = 0$ for every closed curve if
A) $\vec{\nabla} \cdot \vec{A} = 0$ B) $\vec{\nabla} \cdot \vec{A} \neq 0$
C) $\vec{\nabla} \times \vec{A} = 0$ D) $\vec{\nabla} \times \vec{A} \neq 0$

4. The determinant of an orthogonal matrix is
A) ± 1 B) 0
C) any value D) always imaginary

5. Which of the following matrices is Hermitian?
A) $\begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix}$ B) $\begin{bmatrix} 0 & i \\ -i & 0 \end{bmatrix}$

C) $\begin{bmatrix} i & 0 \\ 0 & i \end{bmatrix}$ D) $\begin{bmatrix} i & 0 \\ 0 & -i \end{bmatrix}$

6. The number of elements in a tensor of rank r in n-dimensional space is
A) r^n B) n^r
C) $r \times n$ D) $r! \, n$

7. Which of the following is a linear differential equation?
A) $y^3 = 4x + 5$ B) $\dfrac{dy}{dx} + 4y^2 + 6 = 0$

C) $\dfrac{d^2 y}{dx^2} + \omega^2 y = 0$ D) $\dfrac{d^2 y}{dx^2} + \omega^2 \sin y = 0$

8. When the function $f(x) = x^5$ is expanded as a Fourier series
$f(x) = a_0 + \sum_{n=1}^{\infty} a_n \cos nx + \sum_{n=1}^{\infty} b_n \sin nx$ in the interval $[-\pi, \pi]$,
A) $b_n = 0, \ a_0 = 0, \ a_n \neq 0$ B) $b_n \neq 0, \ a_0 \neq 0, \ a_n \neq 0$
C) $b_n \neq 0, \ a_0 = 0, \ a_n = 0$ D) $b_n \neq 0, \ a_0 = 0, a_n \neq 0$

9. The value of the integral $I = \dfrac{1}{2\pi i} \oint_C \dfrac{dz}{z-3}$ where C is the circle $|z|=1$ is
A) $\dfrac{1}{2}$ B) 0 C) 2 D) 1

10. A physical quantity Q is related to four observables a, b, c and d as $Q = \frac{a^2 b^3}{c\sqrt{d}}$.
The percentage errors involved in the measurement of a, b, c and d are 1%, 2%, 3% and 4% respectively. The percentage error in the calculated value of Q is
A)   5%   B)   4%   C)   3%   D)   13%

11. The number of degrees of freedom of an ant free to move on the surface of a sphere is
A)   6   B)   3   C)   2   D)   1

12. A force $\vec{F} = 2\hat{\imath} + 3\hat{\jmath}$ N acts at the point (4, 1) m in the x-y plane. The moment of the force about the origin is
A)   0   B) $8\hat{\imath} + 3\hat{\jmath}$ Nm
C) $10\hat{k}$ Nm   D) $-10\hat{k}$ Nm

13. An isolated particle of mass m is moving in the horizontal (x-y) plane along the x - axis, at a certain height above the ground. It suddenly explodes into two fragments of masses $\frac{m}{3}$ and $\frac{2m}{3}$. An instant later, the smaller fragment is at $y = +16$ cm. The larger fragment at this instant is at
A) $y = -8$ cm   B) $y = +8$ cm
C) $y = +32$ cm   D) $y = -32$cm

14. The Lagrangian of a particle moving in an inverse square law force field can be written as
A) $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta})$ B) $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2)$

C) $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{k}{r}$ D) $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{k}{r^2}$

15. A canonical transformation in classical Hamiltonian dynamics
A)   Cannot be time dependent
B)   Can only be made for the Cartesian coordinates and momenta
C)   Cannot be made if there is more than one degree of freedom
D)   Leaves the canonical Poisson Bracket relations unchanged

16. Which of the following expressions gives the pseudo force experienced by a particle moving in a rotating frame?
A) $-2m(\vec{\omega} \times \vec{v})$ B) $-2m(\vec{v} \times \vec{\omega})$
C) $\frac{mv^2}{r}$ D) $-2m\vec{\omega} \times (\vec{\omega} \times \vec{v})$

17. A travelling wave in a stretched string is described by the equation
$y = A\sin(kx - \omega t)$. The maximum particle velocity is
A) $\frac{x}{t}$ B) $A\omega$ C) $\frac{\omega}{k}$ D) $\frac{d\omega}{dk}$

18. Two smooth spheres, one of mass m moving with a velocity of 30m/s and the other moving with a velocity of 20m/s, make a direct elastic collision. After the collision, they exchange their velocities. The mass of the second sphere is

A) m B) $2m$ C) $4m$ D) $\dfrac{m}{2}$

19. An elementary particle has a mean life of 1μs while at rest. If it moves with a speed of 2.7×10^8 ms^{-1} relative to an observer, its lifetime as measured by the observer is

A) 2.3 μs   B) 1 μs   C) 0.5 μs   D) 230 μs

20. The minimum energy required for a γ-ray photon for pair production is

A) 0.51 MeV   B) 1.02 MeV   C) 935 MeV   D) 1.6 MeV

21. A spring of force constant k is cut into two equal parts. The force constant of each part is

A) k B) $\dfrac{k}{2}$ C) $2k$ D) $4k$

22. ABCD is a rhombus shaped uniform metal plate. I_1, I_2 and I_3 are respectively its moments of inertia about AC, BD and an axis perpendicular to the plate through its centre. Then
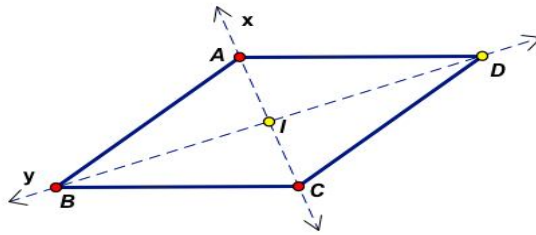
A) $I_1 > I_2$; $I_3 = I_1 + I_2$ B) $I_1 < I_2$; $I_3 = I_1 + I_2$
C) $I_1 < I_2$; $I_3 \neq I_1 + I_2$ D) $I_1 > I_2$; $I_3 \neq I_1 + I_2$

23. The acceleration due to gravity on the surface of a planet whose mass is twice the mass of the Earth is found to be the same as the acceleration due to gravity on the surface of the Earth. If R_E is the radius of Earth, the radius of the planet must be

A) $2\,R_E$ B) $4\,R_E$ C) $\dfrac{R_E}{2}$ D) $\sqrt{2}\,R_E$

24. In the case of scattering in a central force field, the scattering cross section depends on the energy E of the incident particle as

A) E B) E^{-2} C) E^2 D) E^{-1}

25. An electron of mass m_e, initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p, also initially at rest, takes time t_2 to move through the same distance in this electric field. Neglecting the effect of gravity, the ratio $(\dfrac{t_2}{t_1})$ is nearly equal to

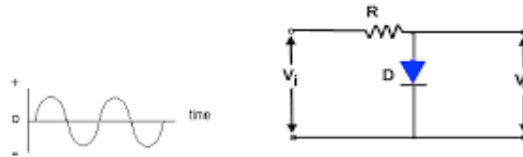A) 1   B) 1836   C) $\sqrt{\dfrac{m_e}{m_p}}$ D) $\sqrt{\dfrac{m_p}{m_e}}$

3

26. The electric field at a point on the surface of a conductor is
A) Zero
B) Normal to the surface
C) Inclined at 45^0 to the surface
D) Tangential to the surface

27. Three electric dipoles, each constituted by charges $+q$ and $-q$, are placed inside a cube. The net electric flux coming out of the cube is
A) $\dfrac{3q}{\varepsilon_0}$
B) $\dfrac{3q}{2\varepsilon_0}$
C) 0
D) $\dfrac{-3q}{2\varepsilon_0}$

28. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at $x = 0$ and positive plate is at $x = 3d$. The slab is equidistant from the plates. The capacitor is given some charge. As x varies from 0 to $3d$,
A) The magnitude of the electric field remains the same.
B) The direction of the electric field remains the same.
C) The magnitude of the electric field is maximum inside the slab.
D) The electric potential increases at first, then decreases and again increases.

29 The electrostatic potential in a certain region of space is given by
$\phi(\vec{x}) = 2x^2 + 2y^2 - 4z^2$. The charge density in the region is
A) 0
B) $-\dfrac{8}{\varepsilon_0}$
C) $\dfrac{8}{\varepsilon_0}$
D) $-\dfrac{24}{\varepsilon_0}$

30. What is the polarisation of the electromagnetic wave whose electric field is given below?
$$E_x = 3E_0 \cos(2x + 3y - 400t)$$
$$E_y = 2E_0 \cos(2x + 3y - 400t + \pi)$$
$$E_z = 0$$
A) Elliptically polarised
B) Circularly polarised
C) Plane polarised
D) Unpolarised

31. The law which enables us to calculate the magnetic field at any point in the region around a current carrying conductor is
A) Gauss's law
B) Biot-Savart law
C) Faraday's law
D) Lenz's law

32. In a certain region of space, there exists a magnetic field $\vec{B}$ due to a displacement current of density 10Am^{-2}. There is no conduction current in the region. Then the magnitude of $(\vec{\nabla} \times \vec{B})$ in the region is
A) 0
B) $10\,\mu_0$
C) $\dfrac{10}{\mu_0}$
D) $10\,\varepsilon_0\mu_0$

33. A current carrying loop lying in the plane of the paper is in the shape of an equilateral triangle of side a. It carries a current I in the clockwise direction. If $\hat{n}$ denotes the outward normal to the plane of the paper, the magnetic dipole moment due to the current loop is
A) $-\dfrac{1}{2}a^2 I\,\hat{n}$
B) $a^2 I\,\hat{n}$
C) $\dfrac{\sqrt{3}}{2}a^2 I\,\hat{n}$
D) $-\dfrac{\sqrt{3}}{4}a^2 I\,\hat{n}$

34. A vector potential is associated with any
    A) Scalar field
    B) Vector field
    C) Solenoidal field
    D) Irrotational field

35. $\vec{E}$ and $\vec{B}$ denote the electric and magnetic field vectors. Then which of the following statements is TRUE at the boundary between two different media?
    A) Normal component of $\vec{B}$ is continuous
    B) Normal component of $\vec{E}$ is continuous
    C) Tangential component of $\vec{E}$ is discontinuous
    D) Tangential component of $\vec{B}$ is continuous

36. In the case of propagation of electromagnetic waves along the length (z-direction) of a rectangular waveguide, the Transverse Electric (TE) wave has
    A) $B_z = 0$ everywhere and $E_z = 0$ at the boundary
    B) $B_z = 0$ at the boundary
    C) $B_z \neq 0$ and at the boundary $E_z = 0$
    D) $E_z = 0$ everywhere and at the boundary, $\dfrac{\partial B_z}{\partial n} = 0$

37. For a plane electromagnetic wave represented by

    $\vec{E} = \hat{x}\, E_0 \cos(kz - \omega t);$

    $\vec{H} = \hat{y}\, H_0 \cos(kz - \omega t),$ the instantaneous value of the Poynting vector is

    A) $\hat{z}\, H_0{}^2 \cos(kz - \omega t)$
    B) $\hat{z}\, E_0{}^2 \cos^2(kz - \omega t)$
    C) $\hat{z}\, E_0 H_0 \cos(kz - \omega t)$
    D) $\hat{z}\, E_0 H_0 \cos^2(kz - \omega t)$

38. For a monochromatic plane electromagnetic wave in vacuum, the electric field has maximum value of $10^{-3} Vm^{-1}$. The maximum value of magnetic flux density is
    A) 3.0×10^5 T
    B) 3.0×10^{-5} T
    C) 3.3×10^{-12} T
    D) 3.3×10^{-11} T

39. ρ_{free} denotes density of free charges, ρ_{bound} denotes density of polarization charges and ρ_{total} denotes the charge density due to both kinds of charges. Which of the following equations is a valid Maxwell's equation inside matter?
    A) $\vec{\nabla}.\vec{D} = \rho_{free}$
    B) $\vec{\nabla}.\vec{D} = \rho_{bound}$
    C) $\vec{\nabla}.\vec{D} = \rho_{total}$
    D) $\vec{\nabla}.\vec{D} = \rho_{free}/\varepsilon_0$

40. The physical quantity invariant under Lorentz transformation is
    A) Current
    B) Charge
    C) Current density
    D) Charge density

41. An electron moving in the +X direction experiences a Lorentz force in the +Z direction. The magnetic field $\vec{B}$ has components
A) $B_x = 0$; B_y is +ve; $B_z = 0$
B) B_x can be +ve, -ve, or zero ; B_y is -ve, $B_z = 0$
C) B_x can be +ve, -ve, or zero ; B_y is +ve, $B_z = 0$
D) B_x is +ve, B_y is -ve, $B_z \neq 0$

42. The change in entropy is
A) Negative in a reversible process
B) Negative in an irreversible process
C) Positive in a reversible process
D) Positive in an irreversible process

43. A system in thermal equilibrium consists of two subsystems A and B that interact only weakly with each other. If Z_A and Z_B are the canonical partition functions of A and B respectively, the partition function of the total system is, to a good approximation, given by
A) $Z_A + Z_B$ B) $Z_A - Z_B$
C) $Z_A Z_B$ D) Z_A/Z_B

44. Water vapour and liquid water coexist in thermodynamic equilibrium at 100^0C in a closed container. If μ and S denote the chemical potential and entropy respectively, at the interface,
A) $\mu_{vapour} > \mu_{liquid}$ B) $\mu_{vapour} = \mu_{liquid}$
C) $S_{vapour} < S_{liquid}$ D) $S_{vapour} = S_{liquid}$

45. The quantum statistics reduces to classical statistics (ρ is the number density of the particles and λ is the thermal de Broglie wavelength) under the condition
A) $\rho\lambda^3 \approx 1$ B) $\rho\lambda^3 >> 1$
C) $\rho\lambda^3 << 1$ D) $\rho = 0$

46. Which of the following will obey B-E statistics?
A) Electrons   B) Neutrons
C) Liquid He^3 D) Liquid He^4

47. Of the following particles moving with same speed, the one having shortest de-Broglie wavelength is
A) Proton   B) Neutron
C) Electron   D) α-particle

48. The uncertainty in the momentum of a proton residing in an atomic nucleus of diameter 10^{-15}m is of the order of
A) 10^{-34} kg.m/s   B) 10^{-49} kg.m/s
C) 10^{-19} kg.m/s   D) 10^{-27} kg.m/s

49. Which of the following wave functions can be a solution of the Schrodinger equation for a particle likely to be found at any value of x?

A) $\psi(x) = Ae^{x^2}$
B) $\psi(x) = Ae^{-x^2}$
C) $\psi(x) = A\sec x$
D) $\psi(x) = A\tan x$

50. The ground state energy of a particle in an infinite square-well potential of width L is E. If the width of the well is doubled, the ground state energy becomes

A) 2E
(B) E/2
C) 4E
D) E/4

51. In the ground state of a quantum harmonic oscillator, the probability density is maximum

A) At a distance equal to half the maximum amplitude
B) At the extreme positions as in the case of its classical counter part
C) At the mean position
D) At a distance equal to $(2/3)^{rd}$ of the maximum amplitude

52. The probability of penetration through a potential barrier increases as

A) The height of the barrier increases
B) The width of the barrier decreases
C) The width of the barrier increases
D) None of the above

53. Which of the following is a valid commutation relation among orbital angular momentum operators? (The symbols have their usual meanings)

A) $\vec{L} \times \vec{L} = -i\hbar\,\vec{L}$
B) $[L_i, L_j] = i\hbar\,\epsilon_{ijk}\,L_k$
C) $[L^2, L_x] = i\hbar\,L_x$
D) $[L^2, L_x] = i\hbar\,L_y$

54. The commutator $[f(p_x),\ x] =$

A) $i\hbar\,\dfrac{\partial f}{\partial p_x}$
B) $-i\hbar\,\dfrac{\partial f}{\partial p_x}$
C) $\dfrac{1}{i\hbar}\dfrac{\partial f}{\partial p_x}$
D) $-\dfrac{1}{i\hbar}\dfrac{\partial f}{\partial p_x}$

55. The spin matrix $\hat{S}_y$ of an electron in the $\hat{S}_z$ representation is

A) $\dfrac{1}{2}\hbar\begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}$
B) $\dfrac{1}{2}\hbar\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}$
C) $\dfrac{1}{2}\hbar\begin{pmatrix}0 & -i\\ i & 0\end{pmatrix}$
D) $\begin{pmatrix}0 & -i\\ i & 0\end{pmatrix}$

56. In momentum representation, the operator for position co-ordinate is

A) $-i\hbar\nabla$
B) $-i\hbar\,\dfrac{\partial}{\partial p}$
C) $\hat{r}$
D) $i\hbar\,\dfrac{\partial}{\partial p}$

57. The eigen functions of the Hamiltonian operator for the hydrogen atom are denoted by U_{nlm}. Which of the following wave functions can be an energy eigen function of the hydrogen atom? (The suffixes n, l and m have their usual meanings)

A) $\psi = a\,U_{321} + b\,U_{421} + c\,U_{320}$
B) $\psi = a\,U_{410} + b\,U_{421} + c\,U_{420}$
C) $\psi = a\,U_{321} + b\,U_{431} + c\,U_{211}$
D) $\psi = a\,U_{321} + b\,U_{221} + c\,U_{421}$

58. The wave function $\psi(\vec{r})$ of a particle moving in three-dimensional space has the physical dimensions of

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

59. Which of the following statements is TRUE for Schrodinger picture?

A) Both operators and state vectors change with time

B) The operator that effects time translation of state kets is $e^{-\frac{\hat{H}t}{\hbar}}$
C) Basis vectors change with time
D) Expectation value of any observable taken with respect to an energy eigen state does not change with time

60. In time independent perturbation theory, for a system with Hamiltonian $H = H^0 + H'$, H^0 being the unperturbed part, the first order correction to energy is given by

A) $E_n^{(1)} = H_{nn}^0$
B) $E_n^{(1)} = \sum_m H_{mn}'$
C) $E_n^{(1)} = H_{nn}'$
D) $E_n^{(1)} = \frac{1}{2} H_{nn}'$

61. The vectors $|i\rangle$, $i = 1, 2, 3, \ldots$ constitute a complete orthonormal basis. Then which of the following statements is WRONG?

A) Any arbitrary vector $|\alpha\rangle$ can be expanded as $|\alpha\rangle = \sum_i C_i |i\rangle$
B) $\langle i|j\rangle = \delta_{ij}$
C) Any arbitrary vector $|\alpha\rangle$ can be written as $|\alpha\rangle = \sum_i \langle i|\alpha\rangle$
D) $\sum_i |i\rangle\langle i| = I$, the identity operator

62. As temperature increases, electrical conductivity of a semiconductor

A) Decreases
B) Increases
C) Remains the same
D) First increases and then decreases

63. The electrical resistivity of intrinsic germanium at room temperature is $0.47\Omega m$. The mobilities of electrons and holes are respectively $0.39\ m^2/V.s$ and $0.19\ m^2/Vs$. The intrinsic concentration of electrons and holes are respectively given by

A) $n = 2.292 \times 10^{19} m^{-3}$, $p = 2.292 \times 10^{19} m^{-3}$
B) $n = 4.584 \times 10^{19} m^{-3}$, $p = 4.584 \times 10^{19} m^{-3}$
C) $n = 2.292 \times 10^{19} m^{-3}$, $p = 1.545 \times 10^{19} m^{-3}$
D) $n = 1.545 \times 10^{19} m^{-3}$, $p = 2.292 \times 10^{19} m^{-3}$

64. As temperature increases, the reverse saturation current in a p-n junction diode
    A)   Decreases   B)   Increases
    C)   Remains the same   D)   First increases and then decreases

65. For the circuit with the input waveform shown below,

    the output waveform is

    A)   B)   C)   D)

66. For a bipolar junction transistor, which of the following relation is TRUE?
    A) $(\alpha)_{ac} = \left(\frac{\Delta I_E}{\Delta I_C}\right)_{V_{CB}}$ B) $(\alpha)_{ac} = \left(\frac{\Delta I_E}{\Delta I_C}\right)_{V_{CE}}$

    C) $(\beta)_{ac} = \left(\frac{\Delta I_C}{\Delta I_E}\right)_{V_{CB}}$ D) $(\beta)_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$

67. In the transistor circuit shown below, $V_{CC} = +20V$, $R_C = 5K$, $R_1 = 100K$,
    $R_2 = 10K$, $R_E = 1K$. Then the emitter current I_E is approximately equal to
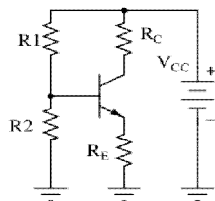
    A)   1.8 mA   B)   1 mA   C)   5 mA   D)   3 mA

68. Negative feedback in an amplifier always helps to
    A)   Increase its gain   B)   Decrease its output impedance
    C)   Stabilize its gain   D)   Control its output

69. Thermal runaway is not possible in FET because
    A)   Only majority carriers take part in conduction and the carrier mobility
          decreases as temperature increases
    B)   The transconductance increases as temperature increases
    C)   The drain current increases as temperature increases
    D)   The channel resistance decreases as temperature increases

70. For the circuit with the input waveform shown below,

the output waveform is

A) B) C) D)
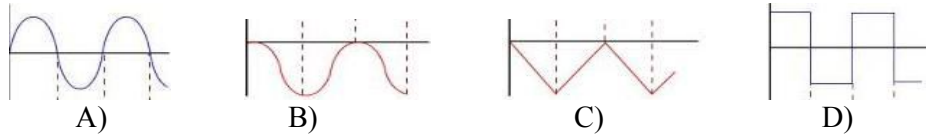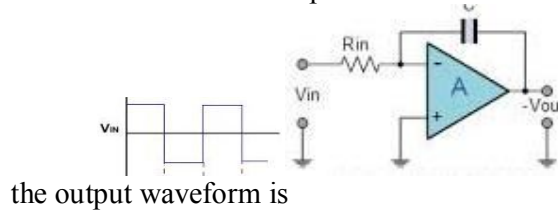
71. In the operational amplifier circuit shown below, $R_{in} = 100\Omega$, $R_f = 1K$, $V_{in} = +10mV$. Then $V_{out} =$
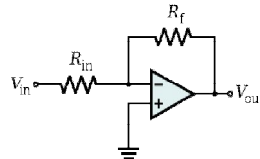

A) $-10mV$ B) $-11mV$ C) $+100mV$ D) $-100mV$

72. Which of the following Boolean identities is WRONG?
A) $A\bar{A} = 1$ B) $A + \bar{A}B = A + B$
C) $A + BC = (A + B)(A + C)$ D) $A(A + B) = A$

73. The output of an exclusive-OR gate is HIGH if
A) All inputs are LOW B) All inputs are HIGH
C) The inputs are unequal D) The inputs are equal

74. For the following circuit,
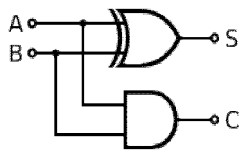
A) $S = A \oplus B$; $C = A.B$ B) $S = A.B$; $C = A \oplus B$
C) $S = \bar{A} \oplus \bar{B}$; $C = A.B$ D) $S = A.B$; $C = \bar{A} \oplus \bar{B}$

75. The total propagation delay through a master-slave flip-flop is 50 ns. The maximum clock frequency that can be used with this flip-flop is
A) 10 MHz B) 20 MHz
C) 10 GHz D) 20 GHz

76. Identify the odd term among the following group
A) Twisted pair cable B) Coaxial cable
C) Optical fibre D) Microwaves

77. The rate at which information can be carried through a communication channel depends on
    A) Transmission loss
    B) Transmitted power
    C) Bandwidth
    D) None of the above

78. The 2014 Nobel Prize in Physics was awarded for
    A) The theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles.
    B) The invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources.
    C) For the discovery of the accelerating expansion of the Universe through observations of distant supernovae.
    D) For groundbreaking experiments regarding the two-dimensional material graphene.

79. Which of the following sets of four quantum numbers (n, l, m_l, m_s) is allowed for an electron in hydrogen atom?
    A) $(3, 3, 2, -\frac{1}{2})$
    B) $(2, 1, 0, \frac{1}{2})$
    C) $(2, 1, -2, -\frac{1}{2})$
    D) $(2, 1, 0, \frac{3}{2})$

80. Which electronic transition of doubly ionised lithium (Li^{++}) gives rise to radiation of the same wavelength as H_α line of hydrogen spectrum?
    A) $n = 9 \to n = 6$
    B) $n = 3 \to n = 2$
    C) $n = 6 \to n = 3$
    D) $n = 6 \to n = 2$

81. The radiation of wavelength 5890 $\mathring{A}$ emitted by a Sodium vapour lamp corresponds to the electronic transition
    A) $3\,^2P_{1/2} \to 3\,^2S_{1/2}$
    B) $3\,^2P_{3/2} \to 2\,^2S_{1/2}$
    C) $3\,^2P_{3/2} \to 3\,^2S_{1/2}$
    D) $3\,^2S_{1/2} \to 2\,^2P_{1/2}$

82. The ground state electron configuration of Carbon ($Z = 6$) is $1s^2\,2s^2\,2p^2$. Which of the following is not a possible spectral term for the first excited state with electron configuration $1s^2\,2s^2\,2p\,3s$?
    A) $^1P_1$
    B) $^3P_1$
    C) $^1S_0$
    D) $^3P_2$

83. In presence of an external magnetic field (normal Zeeman effect), the transition $^1D_2 \to {}^1P_1$ splits into
    A) 15 lines
    B) 8 lines
    C) 6 lines
    D) 9 lines

84. Which of the following can be the core diameter of a single mode optical fibre ?
    A) 10 μm
    B) 100 μm
    C) 500 μm
    D) 1000 μm

85. Which of the following statements is WRONG?
    A)   Population inversion is not possible in 2 level systems.
    B)   Population inversion is achieved more easily in 3 level systems than in 4 level systems.
    C)   Optical pumping is more suitable for solid state lasers than for gas lasers.
    D)   The visible output of He-Ne laser has a wavelength of 632.8 nm.

86. The microwave spectrum of HCl consists of a series of lines spaced 20.68 cm^{-1} apart. The wavelength of the line corresponding to the transition J = 10 ← 9 is nearly
    A)   206.8 μm   B)   48 μm
    C)   20.68 μm   D)   24 μm

87. A molecule can give rise to an infra red spectrum only if
    A)   Its dipole moment changes as it rotates
    B)   Its polarizability changes as it rotates
    C)   Its dipole moment changes as it vibrates
    D)   Its polarizability changes as it vibrates

88. The symmetric stretching vibration of CO_2 molecule is
    A)   Both Raman and Infra red active
    B)   Both Raman and Infra red inactive
    C)   Raman inactive and Infra red active
    D)   Raman active and Infra red inactive

89. The vibrational coarse structure of two electronic levels of a molecule is shown in the figure. Which of the following transitions will be the most intense one?

→ internuclear distance
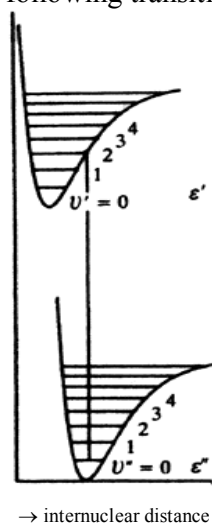
    A) $v'' = 0 \rightarrow v' = 0$ B) $v'' = 0 \rightarrow v' = 1$
    C) $v'' = 0 \rightarrow v' = 2$ D) $v'' = 0 \rightarrow v' = 3$

90. Mossbauer spectroscopy is concerned with
   A) Transitions between nuclear energy levels
   B) Transitions between electronic states of a molecule
   C) Interactions between electrons and external magnetic field
   D) Interactions between nuclei and external magnetic field

91. To which of the following crystal systems, a unit cell with $a = b = 5.2$Å, $c = 9.4$ Å, $\alpha = \beta = 90^0$, $\gamma = 120^0$ belongs ?
   A) Monoclinic   B) Hexagonal
   C) Triclinic   D) Tetragonal

92. d is the interplanar spacing for a certain set of planes in a crystal. Bragg reflection can occur from these planes only for wavelength λ such that
   A) $\lambda = d$ B) $\lambda \geq 2d$
   C) $\lambda \leq d$ D) $\lambda \leq 2d$

93. Which of the following is NOT a statement of the Bragg condition? (The symbols have their usual meanings)
   A) $2d\ sin\ \theta\ =\ n\lambda$ B) $\Delta\vec{k}\ =\ \vec{G}$
   C) $\vec{a_i}\ .\Delta\vec{k}\ =\ 2\pi v_i$ D) $2\vec{k}\ .\vec{G}\ =\ G^2$

94. The number of phonons occupied in various modes is in accordance with
   A) Maxwell- Boltzmann statistics
   B) Bose-Einstein statistics
   C) Fermi-Dirac statistics
   D) None of the above

95. The theory of lattice vibrations based on harmonic approximation is successful in explaining
   A) Thermal expansion.
   B) Constancy of specific heat of solids at high temperatures.
   C) Unequal values of isothermal and adiabatic elastic constants.
   D) The dependence of elastic constants on temperature and pressure.

96. For T > 0 K, the probability of occupancy of Fermi level is
   A) 75%   B) 90%
   C) 100%   D) 50%

97. Measurement of Hall coefficient in a semiconductor enables the determination of
   A) Sign and mass of charge carriers
   B) Sign and concentration of charge carriers
   C) Mass and concentration of charge carriers
   D) Temperature coefficient of resistance

98. The poalrisation vector $\vec{P}$ of a dielectric is related to the macroscopic electric field $\vec{E}$ through the relation
   A) $\vec{P} = \varepsilon_0 \chi \vec{E}$ B $\vec{P} = \varepsilon_0 \frac{\chi}{\vec{E}}$
   C) $\vec{P} = \varepsilon_0 \mu_0 \vec{E}$ D) $\vec{P} = \varepsilon_0 \vec{E}$

99. Which of the following statements is WRONG with regard to ferroelectric materials?
   A) They exhibit spontaneous polarization.
   B) They exhibit hysteresis in the P versus E plot.
   C) Their dielectric constant is independent of temperature
   D) They find application in making memory devices

100. As the isotopic mass of a superconductor decreases, the transition temperature
   A) Decreases   B) Becomes 0 K
   C) Remains the same   D) Increases

101. Which of the following aspects of superconductivity is not explained by BCS theory?
   A) Existence of energy gap at temperatures below the critical temperature
   B) High temperature superconductivity
   C) Quantization of magnetic flux in superconducting ring in the unit of $\frac{h}{2e}$
   D) Different critical temperatures for isotopes

102. Which of the following is NOT TRUE during a second order phase transition? (V, S, G and C respectively represents volume, entropy, Gibb's free energy and specific heat)
   A) $\Delta V = 0$ B) $\Delta C = 0$
   C) $\Delta S = 0$ D) $\Delta G = 0$

103. Which of the following statements is WRONG with regard to diamagnetism?
   A) It is a rare phenomenon.   B) It is generally a weak phenomenon.
   C) It is related to Lenz's law. D) $\mu < \mu_0$ for a diamagnet.

104. The domain structure of a ferromagnet arises from the possibility of having
   A) Large hysteresis loop
   B) Small hysteresis loop
   C) A configuration with lower energy
   D) None of the above

105. The value of Bohr magneton is approximately
   A) 5.05×10^{-27} J T^{-1} B) 5.05×10^{-24} J T^{-1}
   C) 9.27×10^{-27} J T^{-1} D) 9.27×10^{-24} J T^{-1}

106. The unified atomic mass unit (u) is defined as
   A)   One sixteenth of the mass of a ^{16}O atom in its ground state
   B)   The mass of a ^{1}H atom in its ground state
   C)   One twelfth of the mass of a ^{12}C atom in its ground state
   D)   The mass of a proton

107. Which of the following is NOT a magic nucleus?
   A) $^{12}C_6$ B) $^{16}O_8$
   C) $^{119}Sn_{50}$ D) $^{208}Pb_{82}$

108. Magnetic dipole moment of a nucleus has no contribution from
   A)   Orbital motion of protons   B)   Spin of protons
   C)   Orbital motion of neutrons   D)   Spin of neutrons

109. Which of the following is NOT a feature of nuclear force?
   A)   Short ranged   B)   Charge dependent
   C)   Spin dependent   D)   Has a non-central part

110. Which of the following nuclei cannot be used for NMR studies?
   A) ^{4}He B) ^{1}H C) ^{13}C D) ^{14}N

111. Density of atomic nucleus is of the order of
   A) 10^3 kg.m^{-3} B) 10^8 kg.m^{-3}
   C) 10^{10} kg.m^{-3} D) 10^{17} kg.m^{-3}

112. Which of the following statements is WRONG regarding pair production?
   A)   A minimum energy is required for the γ-ray photon.
   B)   The photon disappears and an electron-positron pair is produced.
   C)   The process can take place in free space.
   D)   The process takes place in the presence of a nuclear field.

113. The half-life of a certain radioactive substance is 3 days. What fraction of the initial number of atoms in a sample of the substance will have decayed after 12 days?
   A)   1/16   B)   1/8   C)   7/8   D)   15/16

114. There exists a uniform electric field $\vec{E}$ in a certain region. The interaction energy of a quadrupole Q with this field is
   A)   QE   B)   0   C)   -QE   D) QE^2

115. Which of the following nuclear models assumes a complex refractive index for the nucleus?
   A)   Liquid drop model   B)   Shell model
   C)   Optical model   D)   Independent particle model

116. The location of the proposed India-based Neutrino Observatory is
    A)   Kalpakkam   B)   Theni
    C)   Thumba   D)   Tharapur

117. Lawson criterion is concerned with the design of
    A)   Thermonuclear fusion reactors
    B)   Fission reactors
    C)   Neutrino detectors
    D)   Neutron detectors

118. In β-decay,
    A)   Electrons are always emitted B)   Parity is conserved
    C)   Parity is not conserved   D)   Charge is not conserved

119. The particle which was first predicted based on group theoretical classification and discovered later is
    A) Λ^0 B) Ξ^0 C) Ω^- D) Σ^-

120. The particle x that can give rise to the reaction $x + p \rightarrow n + e^+$ is
    A) ν_e B) $\bar{\nu}_e$ C) ν_μ D) $\bar{\nu}_\mu$