A

16624 **120 MINUTES**

1. One of the eigen values of the matrix $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ is +1. The corresponding normalized eigen vector is

   A) $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ B) $\frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$

   C) $\frac{1}{\sqrt{2}}\begin{pmatrix} i \\ 1 \end{pmatrix}$ D) $\frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ -1 \end{pmatrix}$

2. A piece of wire 132 cm long is bent successively in the shape of equilateral triangle, hexagon, square and circle. The enclosed plane surface is of largest area when the wire is bent into the shape of

   A) Circle B) Square

   C) Hexagon D) Equilateral triangle

3. The Laplace transform of 1 is

   A) 1 B) $\int_0^\infty e^{-st}dt$

   C) $\int_0^\infty e^{st}dt$ D) $\int_{-\infty}^\infty e^{st}dt$

4. A_i and B_{jk} are two arbitrary tensors of rank one and two respectively. $\square_{ijk}$ is the Levi-Civita symbol in 3 dimensions. Then what is the nature of the quantity $A_iB_{jk}\square_{ijk}$?

   A) A scalar B) A tensor of 3rd rank

   C) A tensor of 6th rank D) A vector

5. Dirac delta function $\delta(ax)$ is

   A) 0 B) $\delta(x)$

   C) $\frac{1}{a}\delta(x)$ D) a $\delta(x)$

6. Which one of the following sets form a group under multiplication?

   A) All integers from - ∞ to + ∞

   B) (1, -1)

   C) All integers from 0 to + ∞

   D) All integers from 1 to + ∞

7. Let $\vec{r}$ denote the position vector of any point in three dimensional space. Then $\vec{\nabla} \cdot (\hat{r}\, r^n)$ is

   A) $(n+2)r^{n-1}$ B) nr^{n-1}

   C) 0 D) $(n+2)r^n$

8. If A is a Hermitian matrix, then det(exp(A)) is given by

   A) det(A) B) A

   C) tr(A) D) exp(tr(A))

9. The Legendre polynomials $P_n(x)$ satisfy the orthonormality relation

A) $\int_{-1}^{1} P_n(x)P_m(x)dx = \frac{2}{2n+1}\delta_{m,n}$

B) $\int_{-1}^{1} P_n(x)P_m(x)dx = \delta_{m,n}$

C) $\int_{-\infty}^{1} P_n(x)P_m(x)dx = \frac{2}{2n+1}\delta_{m,n}$

D) $\int_{-1}^{1}[P_n(x)]^2\,dx = 1$

10. Beta functions B(p,q) and gamma functions $\Gamma(p)$ are related by

A) $B(p,q) = \Gamma(p)\Gamma(q)$

B) $B(p,q) = \Gamma(p) + \Gamma(q)$

C) No relationship exists among them

D) $B(p,q) = \frac{\Gamma(p)\Gamma(q)}{\Gamma(p+q)}$

11. The value of the integral $\int_{-\infty}^{\infty} \frac{dx}{1+x^2}$ is

A) π B) $\frac{\pi}{2}$ C) 0 D) 2π

12. The Green's function for the Laplace operator ∇^2 in three-dimensional space is given by

A) $\frac{1}{|\vec{r}_1 - \vec{r}_2|}$ B) $\frac{1}{4\pi}\,\frac{1}{|\vec{r}_1 - \vec{r}_2|}$

C) $\frac{1}{4\pi}\,\frac{1}{|\vec{r}_1 - \vec{r}_2|}\,e^{ik|\vec{r}_1 - \vec{r}_2|}$ D) $\frac{|\vec{r}_1 - \vec{r}_2|}{4\pi}$

13. The series $\sum_0^\infty z^n$

A) Converges to $f(z) = \frac{1}{1-z}$ if $|z| < 1$

B) Converges to $f(z) = \frac{1}{1-z}$ if $|z| > 1$

C) Diverges if $|z| < 1$

D) Converges to $f(z) = \frac{1}{1+z}$ if $|z| < 1$

14. The shortest path between any two points in the x-y plane can be represented by the equation

A) $y = a\,x + b\,x^2$ where a and b are constants

B) $\frac{dy}{dx} = a\,x + b$, where a and b are constants

C) $y = a\,x + b$, where a and b are constants

D) $y = a\,x^2$ where a is a constant

15. The following examples illustrate constraints in mechanical systems. Which among them is a non-holonomic constraint?

A) A simple pendulum composed of a weight and an inextensible string attached at the top end to a pivot.

B) A rigid body in uniform motion under the action of a conservative force field.

C) Foucault pendulum

D) A particle moving in a smooth horizontal plane.

16. The Lagrangian of a system in two dimensions is given by $L = \frac{1}{2}m\dot{x}^2 - m\dot{x}\,\dot{y}$. Then the Hamiltonian of the system is

A) $\frac{1}{2m}p_x^2 + \frac{1}{m}p_x p_y$ B) $\frac{1}{2m}p_x^2 - \frac{1}{m}p_x p_y$

C) $\frac{1}{2m}p_y^2 + \frac{1}{m}p_x p_y$ D) $\frac{1}{2m}p_y^2 + p_y\dot{y}$

17. The Lagrangian of a particle moving in a plane under the influence of a central potential is given by $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - V(r)$. The angular momentum of the particle is

A) $mr\theta$ B) $mr^2\dot{\theta}$ C) $mr\dot{\theta}$ D) $m\dot{r}$

18. The Hamilton-Jacobi equation for a harmonic oscillator is

A) $\frac{1}{2m}[(\frac{\partial S}{\partial q})^2 + m^2\omega^2 q^2] = 0$

B) $\frac{1}{2m}[(\frac{\partial S}{\partial q})^2 + m^2\omega^2 q^2] + \frac{\partial S}{\partial t} = 0$

C) $\frac{1}{2m}[(\frac{\partial S}{\partial q}) + m^2\omega^2 q^2] = 0$

D) $\frac{1}{2m}[(\frac{\partial S}{\partial q}) + m^2\omega^2 q^2] + \frac{\partial S}{\partial t} = 0$

19. In order that the work done by a force $\vec{F}$ is independent of the physical path taken by the particle, the necessary and sufficient condition is that $\vec{F}$ can be expressed as

A) $\vec{F} = -\vec{\nabla}V(r)$ B) $\vec{F} = -V(r)$

C) $\vec{F} = \vec{\nabla}.\vec{V}(r)$ D) $\vec{F} = \vec{\nabla}\times V(r)$

20. Hamilton's canonical equations of motion are

A) $\frac{d}{dt}(\frac{\partial L}{\partial \dot{q}}) - \frac{\partial L}{\partial q} = 0$ B) $\dot{q}_i = \frac{\partial H}{\partial p_i}$; $\dot{p}_i = -\frac{\partial H}{\partial q_i}$

C) $q_i = \frac{\partial H}{\partial \dot{p}_i}$; $p_i = -\frac{\partial H}{\partial \dot{q}_i}$ D) $\dot{q}_i = \frac{\partial H}{\partial \dot{p}_i}$; $\dot{p}_i = -\frac{\partial H}{\partial \dot{q}_i}$

21. A particle moves under the influence of an attractive force of the form $F = -ar^n$. Its path can be a closed one if

A) n = -1 B) for any value of n

C) n = -2 D) n = 2

22. A dynamical variable u(q, p, t) will be a constant of motion (H is the Hamiltonian and the symbol [ ] represents Poisson bracket) if

A) $\frac{\partial u}{\partial t} + [u, H] \neq 0$ B) $[u, H] \neq 0$

C) $[u, H] = 0$ D) $\frac{\partial u}{\partial t} + [u, H] = 0$

23. The Poisson bracket formed between any pair of the components of the angular momentum vector $\vec{L}$ satisfies

A) $[L_i, L_j] = 0$ B) $[L_i, L_j] = i\,\epsilon_{ijk}L_k$

C) $[L_i, L_j] = 1$ D) $[L_i, L_j] = \epsilon_{ijk}L_k$

24. The number of degrees of freedom of a rigid body is
A) 1 B) 6 C) infinity D) 3

25. Space craft A is moving at a speed 0.9c with respect to earth. If another spacecraft B is to pass A at a relative speed of 0.50c in the same direction then the speed of B is
A) 0.50c B) 0. 9c C) 0.97c D) 0.94c

26. The energy equivalent of one atomic mass unit is
A) 1.5×10^{-10} J B) 931 eV
C) 1 J D) 931 KeV

27. The de Broglie wavelength of a charged particle of charge q, accelerated through a potential difference of V volts is
A) $\lambda = \frac{h}{2mqV}$ B) $\lambda = \frac{h}{\sqrt{2mqV}}$
C) 0 D) $\lambda = \frac{1}{\sqrt{2mqV}}$

28. Consider a hydrogen atom placed in a uniform electric field. Then
A) The electric field has no effect on the energy levels of the atom.
B) The electric field perturbs the ground state energy of the atom.
C) The ground state energy of the atom is not affected by the field.
D) The field does not affect the first excited state of the atom.

29. The parity of spherical harmonics $Y_{l,m}(\theta, \varphi)$ is
A) $(-1)^m$ B) $(-1)^l$ C) $(-1)^{l+m}$ D) 1

30. The commutator $[x, p_x^{\,n}]$ is equal to
A) $ni\hbar p_x^{\,n-1}$ B) $ni\hbar p_x^{\,n}$
C) $i\hbar p_x^{\,n-1}$ D) $-ni\hbar p_x^{\,n-1}$

31. If $|\psi\rangle = \sum c_n |n\rangle$ where n = 1,2,3, …. , then c_n is given by
A) $c_n = \langle n|\psi\rangle$ B) $c_n = \langle n|n\rangle$
C) $c_n = \langle \psi|\psi\rangle$ D) $c_n = \langle \psi|n\rangle$

32. Expectation value of S_x^2 in an eigen state of S_z is
A) 0 B) 1 C) $\hbar$ D) $\frac{1}{4}\hbar^2$

33. The average value of $\frac{1}{r}$ for an electron in the hydrogen atom whose wave function is given by $\frac{1}{\sqrt{\pi a^3}} e^{-\frac{r}{a}}$ is
A) 1 B) a C) a/2 D) $\frac{1}{a}$

34. For scattering by a hard sphere of radius a, the total s-wave scattering cross section is

A) a^2 B) $4\pi a^2$ C) a D) πa^2

35. If $\boldsymbol{\alpha}$ stands for the Dirac matrix, the velocity operator of the Dirac particle is given by

A) $\boldsymbol{\alpha}$ B) $\boldsymbol{\alpha}^2$ C) $c\,\boldsymbol{\alpha}$ D) $\boldsymbol{\alpha}^3$

36. Choose the correct statement

A) Fermions are described by antisymmetric wave functions and they obey Pauli's exclusion principle.

B) Fermions are described by symmetric wave functions and they obey Pauli's exclusion principle.

C) Bosons are described by symmetric wave functions and they obey Pauli's exclusion principle.

D) Bosons are described by antisymmetric wave functions and they do not obey Pauli's exclusion principle.

37. The ground state wave function for the harmonic oscillator is given by $\varphi = N\exp\left(-\frac{x^2}{2a}\right)$. Then $(\nabla x)(\nabla p)$ for this state is

A) $2a$ B) a C) $\frac{1}{2}\hbar$ D) $\hbar\omega$

38. Ultraviolet light of wavelength 350 nm is incident on a potassium surface. If the work function of potassium is 2.2 eV, the kinetic energy of the photoelectron is

A) 1.3eV B) 13 eV C) 5.0 eV D) 0.35 eV

39. Choose the correct statement appropriate for Klein-Gordon equation:

A) Probability density is always positive.

B) Probability density is not always positive and energy can be negative.

C) It can describe particles with spin.

D) Probability density is always positive but energy can be negative.

40. A 10 g marble is in a box of width 10 cm. Then its lowest possible energy is

A) 5.5×10^{-32} J B) 2.5×10^{-64} J

C) 5.5×10^{-64} J D) 10.5×10^{-64}J

41. A thermally insulated container holds N_0 molecules of an ideal monatomic gas at absolute temperature T_0. Molecules escape from the container through small holes in the walls and in such a process at a temperature T, the average kinetic energy of a molecule is 2kT. The number of molecules that remain in the container when the temperature has fallen to ½ T_0 is

A) $N_0/2$ B) $N_0/4$ C) $N_0/8$ D) $N_0/5$

42. The r.m.s speed of oxygen (mass of oxygen molecule is 5.31×10^{-26} kg) at 0^o C is

A) 0 B) 461 m/s C) 46.1 m/s D) 561 m/s

43. In a 2n dimensional phase space, the volume of a phase cell is
A) h^n B) h^{2n} C) h D) h^3

44. Wein's displacement law says that
A) $\frac{\lambda_m}{T}$ = a constant B) $\lambda_m T$ = a constant
C) $\lambda_m T^2$ = a constant D) $\lambda_m \nu$ = a constant

45. The energy density of black body radiation at temperature T is proportional to
A) T B) T^2 C) T^4 D) T^{-2}

46. A linear harmonic oscillator is in thermal equilibrium with a heat bath at temperature T. Its partition function is given by
A) $z(T) = \sum_n \log \frac{(n+\frac{1}{2})\hbar\omega}{kT}$ B) $z(T) = \sum_n \exp\left(\frac{(n+\frac{1}{2})\hbar\omega}{2kT}\right)$
C) $z(T) = \sum_n \exp\left(-\frac{(n+\frac{1}{2})\hbar\omega}{kT}\right)$ D) $z(T) = \frac{(n+\frac{1}{2})\hbar\omega}{kT}$

47. In a canonical ensemble, a system A of fixed volume is in contact with a large reservoir B. Then
A) A can exchange only energy with B.
B) A can exchange only particles with B.
C) A can exchange energy and particles with B.
D) Chemical potential remains unchanged.

48. The concept of degenerate electron gas finds application in
A) Ferromagnetism B) Diamagnetism
C) Thermionic emission D) White dwarfs

49. The Planck radiation formula reduces to
A) Rayleigh-Jeans formula on the shorter wavelength side.
B) Rayleigh-Jeans formula on the longer wavelength side.
C) Wien's radiation formula on the longer wavelength side.
D) Stefan's formula on the longer wavelength side.

50. The only processes that can take place in nature are those for which the entropy change ΔS is given by
A) $\Delta S \geq \mathbf{0}$ B) $\Delta S \leq 0$
C) $\Delta S = 0$ D) $\Delta S \leq 1$

51. In the case of irrotational fields represented by $\vec{F}$,
A) $\vec{\nabla} \times \vec{F} = 0$ and $\vec{F}$ is the gradient of some scalar, $\vec{F} = -\vec{\nabla} U$
B) $\vec{\nabla} \cdot \vec{F} = 0$ everywhere and $\vec{F}$ is the gradient of some scalar, $\vec{F} = -\vec{\nabla} U$
C) $\vec{\nabla} \times \vec{F} = 0$ and $\vec{F}$ is the curl of some vector, $\vec{F} = \vec{\nabla} \times \vec{A}$
D) $\vec{\nabla} \cdot \vec{F} = 0$ everywhere and $\vec{F}$ is the curl of some vector, $\vec{F} = \vec{\nabla} \times \vec{A}$

52. The field outside a uniformly charged sphere of charge q and radius a is

A) $\frac{q}{a}$ B) $\frac{q}{a^2}$ C) $\frac{q}{4\pi\epsilon_0 a}$ D) $\frac{q}{4\pi\epsilon_0 a^2}$

53. Two long parallel conducting wires carrying currents in the same direction are kept at a distance d apart. The force per unit length is

A) $\frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}$ B) $\frac{\mu_0}{2\pi}\frac{I_1 I_2}{d^2}$ C) $\frac{\mu_0}{2\pi}\frac{I_1 I_2}{2d}$ D) $\frac{\mu_0}{\pi}\frac{I_1 I_2}{d}$

54. The diffraction pattern of a single slit of width a and illuminated by light of wavelength λ is formed on a screen kept at a distance D ($\gg a$) from the slit. Then the distance of the first minimum of the diffraction pattern from the central maximum is

A) $\frac{\lambda D}{a}$ B) $\frac{\lambda}{a}$ C) $\frac{\lambda D}{2a}$ D) $\frac{2\lambda D}{a}$

55. In a Young's double hole arrangement, the spacing between the holes is 0.1cm and the screen is 50 cm away from the plane of the holes. When a thin mica sheet (n = 1.5) is introduced in the path of one of the interfering beams, the central fringe gets shifted by 0.2cm. The thickness of the mica sheet is

A) 7.0×10^{-4} cm B) 8.0×10^{-4} cm
C) 8.0×10^{-5} cm D) 8.0×10^{-4} mm

56. In the Michelson interferometer arrangement, if one of the mirrors is moved by a distance 0.08 mm, 250 fringes cross the field of view. The wavelength of the light is

A) 6000 Á B) 6500 Á
C) 6400 Á D) 5400 Á

57. A left circularly polarised beam (λ = 5893 Á) is incident normally on a calcite crystal of thickness 0.005141 mm, cut with its optic axis parallel to the surface. Refractive index of calcite for O-ray and E-ray are n_0 = 1.65830 and n_e = 1.48641. The emergent beam is

A) Plane polarised B) Left circularly polarised
C) Elliptically polarised D) Right circularly polarised

58. For silver, magnetic permeability $\mu = 4\pi \times 10^{-7}$ N/A^2 and electrical conductivity $\sigma = 3 \times 10^7\ \Omega^{-1}m^{-1}$. Its skin depth at a frequency of 10^8 Hz is

A) 9×10^{-4} cm B) 0
C) 9×10^{-4} mm D) 9×10^{-4} nm

59. The equation $\vec{\nabla}.\vec{B} = 0$ implies

A) The existence of magnetic monopoles
B) The absence of magnetic monopoles
C) The existence of electric monopoles
D) The existence of electric dipoles

60. In the case of hollow cylindrical wave guides,
A) TEM waves can occur inside it
B) Transverse magnetic waves can exist for which $E_x = 0$
C) Transverse electric waves can exist for which $E_x \neq 0$
D) TEM waves cannot occur inside it

61. The power radiated by a single point charge is proportional to
A) Its velocity B) Its acceleration
C) **S**quare of its acceleration D) Square of its velocity

62. The Coulomb gauge condition is given by ($\vec{A}$ is the vector potential and ϕ is the scalar potential associated with electromagnetic field)
A) $\vec{\nabla}.\vec{A} = 0$ B) $\vec{\nabla} \times \vec{A} = 0$
C) $\frac{\partial \vec{A}}{\partial t} + \vec{\nabla}.\vec{A} = 0$ D) $\vec{\nabla}$ □ = 0 and $\vec{\nabla}.\vec{A} = 0$

63. The Poynting vector $\vec{S}$ is given by
A) $\vec{S} = \vec{E} \times \vec{B}$ B) $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$
C) $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{H}$ D) $S = \vec{E} . \vec{B}$

64. The concept of displacement current was introduced by
A) Ampere B) Maxwell C) Coulomb D) Gauss

65. The longest wavelength present in the Balmer series (the value of Rydberg constant is $1.097 \times 10^7 m^{-1}$)
A) 543 nm B) 579.3 nm C) 600 nm D) 656 nm

66. The concept of electron spin was introduced to explain
A) Pauli's exclusion principle B) Stern-Gerlach experiment
C) Stability of electron orbits D) Stark effect

67. In a He-Ne laser,
A) The laser transition takes place in Ne
B) The laser transition takes place in He
C) The colour of the laser light is blue
D) Ne atoms are used to excite He atoms

68. In the microwave spectrum of CO, the $J = 0 \rightarrow J = 1$ absorption line occurs at a frequency of 1.15×10^{11} Hz. The bond length of CO molecule is (reduced mass of CO molecule is 1.14×10^{-26} kg)
A) 0.113 mm B) 0.113 nm
C) 0.226 nm D) 0.226 mm

69. The number of fundamental vibrations that a nonlinear N- atomic molecule can have is
A) 3N -5 B) 2N – 6 C) 3N – 6 D) 3N

70. A planar AB_3 molecule has 4 fundamental vibrations. Then
A) All vibrations are Raman and IR active
B) The symmetric stretching mode is Raman active and IR inactive
C) The symmetric stretching mode is IR active and Raman inactive
D) The symmetric stretching mode is both Raman and IR active

71. The term symbols of the ground states of ^{12}Mg and ^{13}Al are respectively
A) $^1S_0$ and $^2P_{1/2}$ B) $^1S_0$ and $^2P_{3/2}$
C) $^3S_0$ and $^1P_{1/2}$ D) $^1S_{1/2}$ and $^2P_{1/2}$

72. Sodium atom is subjected to a weak magnetic field. The number of possible spectral lines in place of the doublet will be
A) 8 B) 6 C) 10 D) 4

73. Hyperfine splitting of atomic spectral lines is due to
A) Spin-orbit coupling
B) Application of external magnetic field
C) Application of external electric field
D) The effect of nuclear spin on the electron angular momentum

74. Franck-Condon principle states that
A) An electronic transition takes place so rapidly that a vibrating molecule does not change its internuclear distance during the transition.
B) An electronic transition takes place so rapidly that a rotating molecule does not change its internuclear distance during the transition.
C) A rotational transition takes place so rapidly that a vibrating molecule does not change its internuclear distance during the transition.
D) A vibrational transition takes place so rapidly that a rotating molecule does not change its internuclear distance during the transition.

75. Choose the correct statement:
A) NMR spectrometers operate at microwave frequencies.
B) NMR spectrometers operate in the radio frequency range.
C) NMR spectrometers operate at optical frequencies.
D) ESR spectrometers operate at short radio frequency range.

76. Mossbauer spectroscopy is concerned with
A) The emission of gamma rays by excited nuclei and their reabsorption by another nuclei in the ground state
B) The emission of radio waves from nuclei
C) The decay of excited nuclei
D) The absorption of gamma rays by molecules

77. Electron spin resonance spectroscopy is shown by
A) Atoms or molecules containing electrons with paired spins
B) Atoms or molecules containing electrons with unpaired spins
C) Nuclei containing nucleons with unpaired spins
D) The interaction of electric field with the nuclei

78. In a Ruby laser, ruby rod consists of
A) Al_2O_3 crystal with some aluminium atoms replaced by silicon atoms.
B) Al_2O_3 crystal with some aluminium atoms replaced by chromium atoms.
C) Al_2O_3 crystal with some oxygen atoms replaced by helium atoms.
D) Al_2O_3 crystal.

79. The time taken for 60% of a sample of radon to decay (half life of radon is 3.82 days) is
A) 50.5 days B) 5.05 years C) 5.05 days D) 3.05 days

80. 1 barn is
A) 10^{-25} m^2 B) 10 m^2 C) 10^{-28} m^{-2} D) 10^{-28} m^2

81. The process $p + e^- \rightarrow n + \nu$ is
A) Beta decay B) Positron decay
C) Electron capture D) Not an allowed one

82. The order of energy of gamma rays is
A) eV B) KeV C) GeV D) MeV

83. Which of the following pairs of nuclei are mirror nuclei?
A) $_{13}Al^{27}$ and $_{14}Si^{28}$ B) $_{13}Al^{27}$ and $_{13}Al^{26}$
C) $_{13}Al^{27}$ and $_{14}Si^{27}$ D) $_{14}Si^{27}$ and $_{14}Si^{28}$

84. Choose the correct statement:
A) A neutron and a proton can form a stable deuteron ground state if their spins are parallel.
B) A neutron and a proton can form a stable deuteron ground state if their spins are antiparallel.
C) A neutron and a proton cannot form a stable ground state.
D) A neutron and a proton cannot form a stable triplet state.

85. Identify the missing element in the reaction $^{9}_{4}Be + ^{4}_{2}He \rightarrow 3\ ^{4}_{2}He + ?$
A) $^{1}_{0}n$ B) $^{1}_{1}n$ C) $^{9}_{4}Be$ D) $^{1}_{1}H$

86. Light elements in stars are produced by
A) Nuclear fission B) Nuclear fusion
C) Chemical reaction D) Nuclear transmutation

87. Which of the following particles are responsible for holding together quarks to form hadrons?
A) Mesons B) Glue balls
C) Intermediate vector bosons D) Gluons

88. The solar neutrino mystery implies
A) Neutrinos are massless
B) Neutrinos can have very small mass
C) Neutrinos can appear in different flavours
D) Neutrinos do not possess any charge

89. If A is the mass number of an atom, then its nuclear radius R is proportional to
A) $A^{1/3}$ B) A C) $A^{1/2}$ D) $A^{-1/3}$

90. Nuclear fission can be explained by
A) Shell model B) Independent particle model
C) Liquid drop model D) Collective model

91. Semi empirical mass formula gives
A) The binding energy of the nucleus
B) Energy levels of the nucleus
C) The rate of nuclear reactions
D) Energy released in nuclear fission

92. Which of the following reactions can occur?
A) $\Lambda^0 \rightarrow \pi^+ + \pi^-$ B) $\pi^- + p \rightarrow n + \pi^0$
C) $p + p \rightarrow n + p + e^-$ D) $\gamma + n \rightarrow \pi^+ + p$

93. The structure of NaCl crystal is
A) Body centred cubic B) Orthorhombic
C) Face centred cubic D) Face centred triclinic

94. The Wiedmann-Franz law states that the ratio of thermal conductivity to electrical conductivity is proportional to
A) T^2 B) T^{-1} C) T D) $T^{1/2}$

95. Choose the correct statement:
A) When arsenic is added to silicon crystal, it becomes an n-type semiconductor
B) When arsenic is added to silicon crystal, it becomes a p-type semiconductor.
C) When gallium is added to silicon crystal, it becomes an n-type semiconductor.
D) When arsenic is added to silicon crystal, its forbidden band increases.

96. Which of the following statements regarding Van der Waals forces is correct?
A) They can hold inert gas atoms together to form solids at low temperature but they cannot hold such atoms together to form molecules
B) They can hold inert gas atoms together to form solids at low temperature and they can also hold such atoms together to form molecules
C) They cannot hold inert gas atoms together to form solids at low temperature but they can hold such atoms together to form molecules
D) They cannot hold inert gas atoms together to form solids at low temperature and they cannot hold such atoms together to form molecules

97. A phonon of wave vector $\vec{K}$ is created by the inelastic scattering of a photon from wave vector $\vec{k}$ to $\vec{k'}$. Then the wave vector selection rule is ($\vec{G}$ is the reciprocal lattice vector)

A) $\vec{k'} + \vec{K} = \vec{k} + \vec{G}$ B) $\vec{k} = \vec{k'} + \vec{K}$

C) $\vec{k'} = \vec{k} + \vec{K} + \vec{G}$ D) $\vec{k} = \vec{K} + \vec{G}$

98. The heat capacity of electron gas is

A) Proportional to the cube of the temperature (T^3)
B) Inversely proportional to the temperature T
C) A constant
D) Proportional to the temperature T

99. The Fermi energy of Copper is 7.04 eV. Then its Fermi temperature is

A) 8.12 K B) 8.12×10^4 K

C) 8.12×10^2 K D) 4×10^4 K

100. In band theory, the Bloch wave function is

A) A regular harmonic function with constant amplitude.
B) A plane wave function with an amplitude having period of the crystal lattice.
C) A plane wave function.
D) None of the above statements is correct

101. In a superconductor, energy gap is caused by

A) The electron-electron interaction forming a bound state.
B) The electron-lattice interaction.
C) The electron-photon interaction.
D) No energy gap exists.

102. Colour centre is a lattice defect which

A) Emits visible light B) Emits ultra violet light

C) Absorbs visible light D) Absorbs phonons

103. Josephson effect implies

A) Current flow between superconductors separated by a thin conductor.
B) Current flow through a superconductor.
C) Current flow between superconductors separated by a thin insulator.
D) Current flow through a superconductor placed in a magnetic field.

104. Which of the following statements is correct? (T_N is the Neel temperature)

A) In an antiferromagnet, spins are ordered anti parallel for $T > T_N$
B) In an antiferromagnet, spins are ordered antiparallel for $T < T_N$
C) In an antiferromagnet, spins are ordered parallel for $T < T_N$
D) In a ferromagnet, spins are ordered anti parallel for $T < T_N$

105. A d. c voltage of 5.0 μV is applied across a Josephson junction. The frequency of the radiation emitted at the junction is
A) 24 GHz B) 2.4 Hz C) 24 Hz D) 2.4 GHz

106. If d is the interplanar spacing in a crystal, Bragg reflection can occur only for wavelength λ such that
A) $\lambda \geq d$ B) $\lambda \leq d$ C) $\lambda \leq 2d$ D) $\lambda \geq 2d$

107. A low pass filter has upper cut off frequency of 450 kHz. Another filter has lower cut off frequency of 455 kHz, passing all frequencies above this frequency 455 kHz. If these are connected in parallel, what will be the nature of the resulting circuit?
A) Low pass filter with upper cut off frequency of 455 kHz.
B) High pass filter with lower cut off frequency of 450 kHz.
C) Band pass filter with a band width of 5 kHz.
D) Band stop filter with a stop band width of 5 kHz.

108. Zener diodes are used in circuits
A) To maintain constant current
B) To maintain constant voltage drop
C) To increase the dynamic resistance
D) To increase the voltage drop

109. The amplification factor μ, the transconductance g_m and the drain resistance r_d of FET are related as
A) $r_d \mu = g_m$ B) $r_d g_m = \mu$
C) $r_d = \mu g_m$ D) $r_d \mu g_m = 1$

110. A CE transistor amplifier has the following characteristics: $R_L = 2000\ \Omega$, $h_{fe} = 24$ and $h_{ie} = 900\ \Omega$. Its power in decibel unit is
A) 128 dB B) 1280 dB C) 31.1 dB D) 3.11 dB

111. An operational amplifier has internal gain $A = 10^5$, series input resistance $R_1 = 1000\ \Omega$ and voltage feedback resistance = $R_f = 10^4\ \Omega$. Then the inverting and non inverting gains are respectively
A) – 10 and 11 B) – 11 and 10
C) – 1 and 11 D) – 10 and 10

112. An operational amplifier has a slew rate given by the manufacturer as 5V/ μs. At a signal frequency of 0.1 MHz, the maximum undistorted sine-wave amplitude is
A) 79.6V B) 7.96 μV C) 7.96 V D) 0.796 V

113. The information received in serial form can be converted into parallel form for further processing using
A) Shift register B) Operational amplifier
C) Schmitt trigger D) Ripple counter

114. A silicon diode has a forward current of 30mA at 1V. The approximate bulk resistance of this diode is
A) 20 Ω B) 10 Ω C) – 1 Ω D) 5 Ω

115. Which one of the following is not a Boolean identity?

A) $A + \overline{B} = \overline{A}.\overline{B}$ B) $A + \overline{A}B = A + B$

C) $(A + \overline{B})B = AB$ D) $A(A + B) = A$

116. In the case of a bulk silicon solar cell,

A) The maximum achievable energy-conversion efficiency is unlimited

B) The quantity and cost of material consumption are less

C) The energy pay back is very less

D) The maximum achievable energy-conversion efficiency is limited

117. The physical mechanism by which semiconductor LED emit light is

A) Stimulated recombination of electron-hole pairs and simultaneous emission of photons.

B) Spontaneous recombination of electron-hole pairs and simultaneous emission of photons

C) Spontaneous recombination of electron-hole pairs and simultaneous emission of phonons.

D) Spontaneous recombination of electron-hole pairs and simultaneous absorption of photons.

118. In a conventional single mode fibre, the value of zero total dispersion wavelength is

A) 1300 μm B) 1400 nm

C) 1300 nm D) 1450 nm

119. Consider a step index fibre with refractive indices of the core as n_1 and that of the cladding as n_2. Its numerical aperture is

A) $\sqrt{(n_1^2 - n_2^2)}$ B) $\sqrt{n_1 - n_2}$

C) $(n_1^2 - n_2^2)$ D) $\sqrt{(n_2^2 - n_1^2)}$

120. The truth table given below corresponds to

A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

A) AND operation B) OR operation

C) NOR operation D) NAND operation
