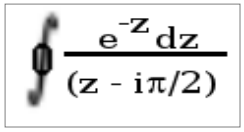
12924 120 MINUTES

1. **V** represents a solenoidal vector field. The value of the net flux crossing any arbitrary closed surface will be

   A) Zero B) Infinity
   C) Finite and positive D) Finite and negative

2. The value of the contour integral



   over the closed curve C is

   A) -2π B) 2π
   C) $2i\pi$ D) $e^{-\pi/2}$

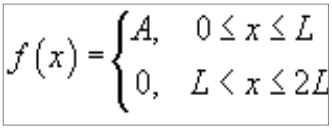
3. If A is a Hermitian matrix, then e^{iA} will be

   A) A real matrix B) Orthogonal to A
   C) Unitary D) Skew-Hermitian

4. A and B are two arbitrary vectors. What is the nature of the quantity A_iB_j?

   A) A scalar B) A vector
   C) A tensor of 3rd rank D) A tensor of 2nd rank

5. A periodic function is defined as



   The value of b_{2k}, the coefficient of sin(2kx) in the Fourier expansion of the function is

   A) 0 B) $2A/(2k-1)\pi$
   C) $A/2\pi$ D) $A/k\pi$

6. The equation of the curve passing through (2, 7/2) and having a slope equal to $1 - 1/x^2$ is

   A) $y = x^2 + x + 1$ B) $xy = x + 1$
   C) $xy = x^2 + x + 1$ D) $xy = y + 1$

7. If **A** is any vector and **i** , **j** and **k** are the unit vectors along the respective axes, then the expression $|\mathbf{A} \times \mathbf{i}|^2 + |\mathbf{A} \times \mathbf{j}|^2 + |\mathbf{A} \times \mathbf{k}|^2$ is equal to

   A) A^2 B) $2A^2$ C) $3A^2$ D) Zero

8. In a radioactivity measurement, the total counts for a time period t is N_t and the background counts for the same interval of time is N_b. What is the statistical error in the net counts $(N_t - N_b)$?

   A) $\sqrt{(N_t - N_b)}$ B) $\sqrt{(N_t + N_b)}$ C) $\sqrt{N_t}$ D) $\sqrt{N_b}$

9. A is an n X n matrix. If |A| denotes its determinant, what is |-A| equal to?

A) $-|A|$ B) $|A|$

C) $(-1)^n|A|$ D) Not defined

10. Which of the following does the integral

$$\frac{n!}{2\pi i}\oint \frac{f(\omega)\,d\omega}{(\omega-z)^{n+1}}$$

correspond to?

A) $[df(z)/dz]^n$ B) $d^nf(z)/dz^n$

C) $n!df(z)/dz$ D) $f(\omega - z)$

11. A generalized force F acts on a system of particles. Then

A) F will always have the dimensions of a force.

B) F can sometimes have the dimensions of a force.

C) F will never have the dimensions of a force.

D) $\int Fdq$ will sometimes have dimensions of energy, where q is the generalized co-ordinate.

12. In the classical scattering of a particle in a central force field,

A) The angle of scattering increases when the impact parameter decreases.

B) The angle of scattering increases when the impact parameter increases.

C) The angle of scattering first increases as the impact parameter increases, then remains constant.

D) The angle of scattering is independent of the impact parameter.

13. The Lagrangian of a particle is given by $L = \frac{1}{2} m(\dot{x}^2+\dot{y}^2+\dot{z}^2) + kz$ with k = a constant. Then

A) The x component of the momentum is a constant

B) The y component of the momentum is a constant

C) Both x and y components of the momentum are constants

D) The angular momentum is a constant.

14. A particle of mass m moves under the influence of a force $F(x,t) = -k\ x\ \exp(-t/\tau)$ where k and τ are positive constants. Identify the correct expressions for the Lagrangian L and the Hamiltonian H :

A) $L = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} k x^2\exp(-t/\tau)$ and $H = \frac{1}{2} m \dot{x}^2 - \frac{1}{2} k x^2\exp(-t/\tau)$

B) $L = \frac{1}{2} m \dot{x}^2 - \frac{1}{2} k x^2\exp(-t/\tau)$ and $H = \frac{1}{2} m \dot{x}^2 - k x^2\exp(-t/\tau)$

C) $L = \frac{1}{2} m \dot{x}^2 - \frac{1}{2} k x^2\exp(-t/\tau)$ and $H = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} k x^2\exp(-t/\tau)$

D) $L = \frac{1}{2} m \dot{x}^2 - k x^2\exp(-t/\tau)$ and $H = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} k x^2\exp(-t/\tau)$

15. A particle of reduced mass moves with angular momentum L in an attractive central force field having inverse square dependence on r. This motion can be described by an effective potential (k being the constant of proportionality for the force)

A) $k/r^2 + L^2/2\ r^2$ B) $-k/r + L^2/2\ r^2$

C) $k/r + 2\ r^2/L^2$ D) $k/r + 2\ L^2/r^2$

16. A massless spring with a spring constant k is compressed by a distance s and the launches a ball of mass m. What should be s so that the ball reaches a velocity v ultimately?

A) $v\sqrt{(k/m)}$ B) $v\sqrt{(m/k)}$ C) k/m D) m/k

17. A moon orbits a distant planet in an elliptical orbit. The distance covered by the moon each day

A) Is greatest when the moon is nearest to the planet
B) Is greatest when the moon is farthest to the planet
C) Remains the same irrespective of its distance from the planet
D) Remains the same irrespective of its distance from the sun

18. Which of the following transformations is **not** canonical?

A) $Q = aq + bp$ and $P = cq + dp$ with $ad-bc = 1$
B) $Q = q$ and $P = p$
C) $Q = p$ and $P = -q$
D) $Q = p$ and $P = q$

19. A meter stick with a speed of 0.8c moves past an observer. In the observer's reference frame, how long does it take the stick to pass the observer?

A) 1.6 ns B) 2.5 ns C) 4.2 ns D) 5.5 ns

20. The Hamilton-Jacobi equation is expressed as $H + \partial S/\partial t = 0$ where H is the Hamiltonian and S is the Hamilton's principal function. Then, if L is the Lagrangian, S satisfies

A) $S = \int L dt + \text{constant}$ B) $S = \int H dt$

C) $S = L + H$ D) $S + L = 0$

21. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a . For small oscillations, the period, T, of the pendulum is

A) $2\pi\sqrt{(l/g)}$ B) $2\pi\sqrt{[l/(g-a)]}$

C) $2\pi\sqrt{[l/(g+a)]}$ D) $2\pi\sqrt{[la/g(g+a)]}$

22. The total energy of a system of particles is a constant. This is a consequence of

A) Mass energy equivalence
B) Symmetry under space translations
C) Symmetry under time translations
D) Symmetry under space inversion

23. A variable F is a constant of motion for a system. Then
   A) The Poisson bracket with the Lagrangian {F, L} will be zero.
   B) The Poisson bracket with the Hamiltonian {F, H} will be zero.
   C) Both Poisson brackets will be zero.
   D) Any one of the Poisson brackets can be zero.

24. What will be the velocity of an alpha particle when its mass is 3 times its rest mass?
   A) 94% of the velocity of light
   B) 50% of the velocity of light
   C) 33% of the velocity of light
   D) 17.3% of the velocity of light

25. Which statement is TRUE about the Lorentz force?
   A) Always acts at right angles to the direction of motion of a charged particle.
   B) Always acts in the direction of the motion of the charged particle
   C) Produces no acceleration of the charged particle.
   D) Acts only on all types of elementary particles.

26. The dominant mode in a rectangular waveguide is the TE_{10} mode because
   A) This mode has the highest cutoff wavelength.
   B) This mode has the lowest cutoff wavelength.
   C) This mode only has no cut off.
   D) There is no attenuation for this mode.

27. An electrostatic field $\mathbf{E}(\mathbf{r})$ and the corresponding scalar potential $V(\mathbf{r})$ exists in a region of space containing a charge distribution $\rho(\mathbf{r})$. One of the following quantities is linearly related to $\rho(\mathbf{r})$. Which one is it?
   A) $\nabla^2 E$ B) ∇V C) $\nabla . E$ D) $\nabla X E$

28. As a coil is removed from a magnetic field an emf is induced in the coil which causes a current to flow within the coil. The current interacts with the magnetic field and produces a force which
   A) Acts at right angles to the direction of motion of the coil.
   B) Acts along the direction of motion of the coil.
   C) Acts opposite to the direction of motion of the coil.
   D) Causes the coil to flip over.

29. An infinitely long straight conductor carrying a current I is placed at the centre of a loop of wire carrying a current I' such that it is perpendicular to the plane of the loop. What will be the force acting on the wire?
   A) It will be directed outward along a radius of the loop
   B) It will be directed inward along a radius of the loop
   C) It will be directed along the length of the wire
   D) There will be no force on the wire

30. In the TM mode of propagation along the Z axis of electromagnetic waves through a rectangular waveguide kept with its axis along the z direction?
A) Only H_z is present.
B) $H_z = 0$ and $E_z = 0$.
C) Magnetic lines of force are perpendicular to the Z axis.
D) Magnetic lines of force are parallel to the Z axis.

31. Pick the correct boundary conditions at the interface separating two media?
A) The normal component of **B** is continuous whereas the tangential component of **H** is discontinuous by an amount equal to the surface current density.
B) The tangential component of **B** is continuous whereas the normal component of **H** is discontinuous by an amount equal to the surface charge density.
C) The normal component of **D** is continuous whereas the tangential component of **E** is discontinuous by an amount equal to the surface charge density.
D) The tangential component of **E** is continuous whereas the normal component of **D** is discontinuous by an amount equal to the surface current density.

32. An electron moves with constant velocity without deflection through electric and magnetic fields of strengths 3.8×10^6 N/C and 4.9×10^{-2} T respectively at right angles to each other and to the direction of motion of the electron. Now the electric field is removed. What will happen to the electron?
A) Continues to move unaffected with a velocity 7.76×10^7 ms^{-1}
B) Continues to move in the same direction with increased velocity
C) Performs circular motion of radius 9.02×10^{-3} m at a speed of 7.76×10^7 ms^{-1}
D) Performs circular motion with increased velocity

33. The skin depth in a copper conductor at 10 GHz is 0.654 m. Its value at 1 MHz will be
A) 654 m
B) 0.654 cm
C) 0.00654 cm
D) 6.54 m

34. The electric field close to the surface of a charged conductor (surface charge density σ):
A) Parallel to the surface and of magnitude σ/ε_0
B) Normal to the surface and of magnitude σ/ε_0
C) Normal to the surface and of magnitude $\sigma/2\varepsilon_0$
D) Parallel to the surface and of magnitude $\sigma/2\varepsilon_0$

35. The total electric charge of either sign in a 1 cm^3 cube of copper is
A) 1 C
B) 1 C
C) Less than 100 C
D) Greater than 1000 C

36. A beam of light is incident on the surface of an optical medium in air at an angle of incidence of 60^o. The refracted beam makes an angle of 15^o with the incident beam. What is the velocity of light in the medium?

A) 3×10^8 ms^{-1} B) 2×10^8 ms^{-1}

C) 3.67×10^8 ms^{-1} D) 2.45×10^8 ms^{-1}

37. A line of force in an electric field is a curve that gives the trajectory of the particle so that

A) The electric force at any point is along the tangent to the curve at that point.

B) The electric force at any point is along the normal to the curve at that point.

C) The electic potential will be a constant along the curve

D) The electic potential increases along the curve in the direction of the line of force

38. Magnetic vector potential of a volume current distribution can be expressed as

A) $\oint_S \frac{\mu_o J \, dV}{4\pi r}$ B) $\oint_S \frac{\mu_o J \, dV}{4\pi r^2}$

C) $\oint_S \frac{\mu_o J \, dV}{2\pi r}$ D) $\oint_S \frac{\mu_o J \, dV}{2\pi r^2}$

39. A coil of wire having an inductance L has a current I passing through it. Now the current is reduced to 0.3I. How much magnetic energy has the coil lost in the process?

A) 30% B) 9% C) 70% D) 91%

40. The magnetic vector of a plane electromagnetic wave is given by the expression

$$\mathbf{B}(y) = \mathbf{j}\, B_o \cos (10y + 3 \times 10^9 t)$$

Where the vector **j** is a unit vector in the Y direction, y is in meters and t is in seconds. What are the values of the wavelength and period of the wave?

A) $\pi/10$ m and $\pi/3$ ns B) $\pi/5$ m and $2\pi/3$ ns

C) 0.1 m and 0.3 ns D) $\pi/5$ nm and $2\pi/3$ ns

41. An air filled rectangular waveguide has internal dimensions of a cm x b cm. Given that a = 2b and the cut off frequency of TE_{02} mode is 6 GHz, what will be the cut off frequency of the dominant mode?

A) 6 GHz B) 4 GHz

C) 3 GHz D) 1.5 GHz

42. The experimental spectrum of a fireball closely resembles that of a black body

whose peak emission occurs at 29 Å. What will be its approximate temperature?

A) 1000 K B) 10000 K C) 100000 Å D) 1 millionK

43. The average kinetic energy of a CO_2 molecule at room temperature will be approximately:
A) 1 eV B) 0.1 eV C) 0.37 eV D) 0.037 eV

44. Let H(S,P) represent the enthalpy of a system expressed as a function of entropy and pressure. Which pair of equations are true for its partial derivatives?

A) $(\partial H/\partial S)_P = T$ and $(\partial H/\partial P)_S = V$

B) $(\partial H/\partial S)_P = P$ and $(\partial H/\partial P)_S = S$

C) $(\partial H/\partial S)_P = V$ and $(\partial H/\partial P)_S = T$

D) $(\partial H/\partial S)_P = S$ and $(\partial H/\partial P)_S = P$

45. A gas with $\gamma = 1.5$ is adiabatically compressed to $1/9^{th}$ of its volume. What will be the ratio of the initial and final temperatures?
A) 1:1 B) 1:3 C) 3:1 D) 1:9

46. The thermodynamical relation $(\partial T/\partial P)_H = (1/Cp)[T(\partial V/\partial T)p - V]$ refers to one of the following effects. Which one is it?
A) Joule heating B) Joule-Thomson effect
C) Peltier effect D) Seebeck effect

47. In the demonstration of uncertainty principle using gamma-ray microscope thought experiment, if X-rays are used instead of gamma rays, the uncertainty in the measurement of position of the electron
A) Increases
B) Decreases
C) Independent of the wavelength of the radiation
D) May increase or decrease

48. Which special functions are part of the radial component of the hydrogenic wave function?
A) Associated Legendre functions
B) Associated Laguerre functions
C) Hermite polynomials
D) Spherical Bessel functions

49. A particle of mass m moving in a cubical box of side a has energy equal to $14h^2/8ma^2$. What is the degeneracy of this energy level (h = Planck's constant)?
A) 1 B) 2 C) 3 D) 4

50. An electron is in an infinite square well of width a. What will be the expectation value of the dipole moment of the electron?
A) 0 B) ea C) 2ea D) ea/2

51. The normalized ground state wave function of the hydrogen atom is given by $\psi(r)$

$= Ae^{(-r/a_o)}$ where a_o is the Bohr radius. The electron will be spending major part of the time at which distance from the nucleus?

A) 0 B) $a_o/2$ C) $a_o/\sqrt{2}$ D) a_o

52. Which of the following quantities is proportional to the electron density at a point?
A) The wave function
B) The absolute square of the wave function
C) The de Broglie wavelength
D) The reciprocal of the de Broglie wavelength

53. A quantum state is specified by its wave function $\sin x\ x_1 + e^{i\phi} \cos x\ x_2$. Here x_1 and x_2 are the spin wave functions for spin up and down cases respectively. Which of the following states will be orthogonal to this state?

A) $\sin x\ x_1 + e^{-i\phi} \cos x\ x_2$ B) $\cos x\ x_1 + e^{-i\phi} \sin x\ x_2$

C) $\sin x\ x_1 - e^{-i\phi} \cos x\ x_2$ D) $\cos x\ x_1 - e^{-i\phi} \sin x\ x_2$

54. A muon can be considered to be a heavy electron with a mass $m = 207m_e$. Imagine replacing the electron in a hydrogen atom with a muon. What are the energy levels E_n for this new form of hydrogen in terms of the binding energy of ordinary hydrogen E_0, the mass of the proton m_p, and the principal quantum number n?
A) $E_n = -(E_0/n^2)\ (m_e/m)$
B) $E_n = -(E_0/n^2)\ (m/m_e)$
C) $E_n = -(E_0/n^2)\ [(m/m_e)(m_p+m_e)/(m_p+m)]$
D) $E_n = -(E_0/n^2)\ [(m_p+m_e)/(m_p+m)]$

55. In the simple variational method one takes a parametrized trial wave function and finds the parameters that make the expectation value of the Hamiltonian
A) Maximum B) Minimum C) Positive D) Negative

56. Which one of the following has the longest wavelength?
A) A 1 MeV gamma ray B) A red light photon
C) A 1 eV electron D) A cricket ball moving at 100 m/s

57. The uncertainty relation is **not** applicable to one of the following pairs of variables. Which one is it?
A) Energy and time
B) Position and corresponding momentum
C) Energy and position
D) Angular position and angular momentum

58. Which relation is satisfied by the angular momentum operators?
A) $L \times L = 0$ B) $L \times L = i\hbar L$
C) $L.L = i\hbar L_z$ D) $[L^2, L_z] = i\hbar L_z$

59. Consider a single electron atom with orbital angular momentum L = $\sqrt{2}\hbar$. Which of the following gives the possible values of a measurement of L_z, the z-component of L?

A) 0 B) 0, $\hbar$ C) 0, $\hbar$,2$\hbar$ D) - $\hbar$, 0, +$\hbar$

60. Considering the Pauli spin matrices σ_x, σ_y, σ_z and the identity matrix I, which of the following is the value of the commutator $[\sigma_x, \sigma_y]$?

A) I B) 2i σ_x C) 2i σ_y D) 2i σ_z

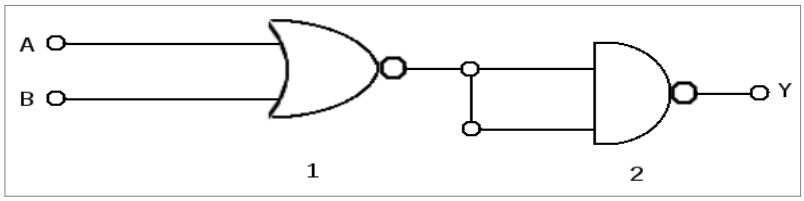
61. The decay constant for an atom making a transition from the first excited state to the ground state is 10^{-10} s^{-1}. If the matrix element connecting the two states is increased by a factor of two, what will be the new decay constant?

A) 4×10^{-10} s^{-1} B) 1.414×10^{-10} s^{-1}
C) 2×10^{-10} s^{-1} D) 0.5×10^{-10} s^{-1}

62. Which of the following best describes a n-type semiconductor?

A) A material with electrons in donor levels which may be thermally promoted to the conduction band.
B) A material with no band gap which conducts with little resistance.
C) A material with a sizeable band gap.
D) A material with empty acceptor levels to which electrons from the valence band may be thermally promoted.

63. The following diagram represents a gate formed by a suitable combination of two other gates. What are the names of the individual gates 1 and 2 and the combination gate?



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

64. The resistivity of pure silicon is 2300 $\Omega\,m^{-1}$. The mobilities of electrons and holes in it are 0.135 and 0.048 $m^2V^{-1}s^{-1}$ respectively for electrons and holes. The electron and hole concentrations are respectively

A) 2.01×10^{-16} m^{-3} and 5.66×10^{-16} m^{-3}
B) 1.49×10^{-16} m^{-3} and 1.49×10^{-16} m^{-3}
C) 1.49×10^{-16} m^{-3} and zero
D) Zero and 1.49×10^{-16} m^{-3}

65. The mid frequency gain of amplifier is 200 without feedback and the band width is 50 kHz. On applying feedback the gain is reduced to 150. Choose from the following the correct combination of the type of feedback, the feedback factor and the new band width :

A) Positive, 1/200, 37.5 kHz B) Positive, 1/600, 66.7 kHz
C) Negative, 1/600, 66.7 kHz D) Negative, 1/200, 37.5 kHz

66. A silicon pn junction diode has a built-in potential barrier of 0.65 Volts. If the acceptor impurity concentration is doubled, the new barrier potential will be (Take kT/e = 0.025 eV)

A) Remains the same 0.65 V B) Reduced to about 0.63 V
C) Increased to about 0.67 V D) Increases by a factor of 2.

67. In the experimental determination of the ratio e/k (e being the electronic charge and k the Boltzmann constant) using a transistor, the current I is measured as a function of temperature. Then

A) A plot of log I vs T is made to get a straight line, the slope of which gives the required ratio
B) A plot of log I vs 1/T is made to get a straight line, the slope of which gives the required ratio
C) A plot of log I vs 1/T is made to get a straight line, the y intercept of which gives the required ratio
D) A plot of log I vs T is made to get a straight line, the y intercept of which gives the required ratio

68. A mod 10 counter requires a minimum of how many flip-flops?

A) 10 B) 5 C) 4 D) 2

69. A source follower is

A) A common source amplifier with very high gain
B) A common source amplifier with very low input impedance
C) A common drain amplifier with unity gain
D) A common source amplifier with unity gain

70. Determine the output frequency for a frequency division circuit that contains 12 flip-flops with an input clock frequency of 20.48 MHz.

A) 20 kHz B) 10 kHz C) 1.706 MHz D) 5 kHz

71. A 12 bit ADC is used to digitize analog signals of amplitudes lying in the range from 0 V to +10 V. What digital output will an analog input of 3.004 V correspond to?

A) 100011001111 B) 010011001111
C) 010011001110 D) 010111001110

72. A Zener diode is usually used

A) To obtain a stable reference voltage
B) As a variable voltage source
C) In an oscillator circuit
D) To reduce the ripple in a voltage regulator

73. One of the following types of filters has a bandwidth equal to its cut off frequency.

Which one is it?

A) Low pass B) High pass
C) Band reject D) Band pass

74. If the value of resistor *Rf* in an averaging amplifier circuit is equal to the value of one input resistor divided by the number of inputs, the output will be equal to

A) Sum of the inputs B) Average of the inputs
C) Inverted sum of the inputs D) Inverted average of the inputs

75. An amplitude modulated waveform has at its maximum 100 V p-p and at the minimum 40 V p-p. What is the modulation percentage?

A) 250% B) 43% C) 25% D) 37.5%

76. Which one of the following optoelectronic devices works under reverse bias conditions?

A) LED B) Photo diode
C) Solar cell D) Diode laser

77. Which of the following statements is **NOT TRUE** of an OPAMP integrator?

A) Its gain increases with increasing frequency of the input
B) It uses capacitive feedback
C) Usually the circuit works well at high frequencies
D) It converts a dc input into a ramp voltage

78. Which one of the following devices has the highest input impedance?

A) BJT B) FET C) MOSFET D) Diode

79. When a positron comes close enough to an electron, a bound system called positronium can be formed. Given that the K-shell energy in hydrogen atom is 13.6 eV, what will be the corresponding energy in a positronium atom?

A) 6.8 eV B) 3.4 eV C) 1.36 eV D) 13.6 eV

80. Which one of the following sets of quantum numbers (n, l, m_l, m_S) is valid for an electron in an atom?

A) 2 3 -3 +1/2 B) 4 3 4 -1/2
C) 3 1 0 +1/2 D) 1 -1 1 +1/2

81. You are supplied with a klystron, a microwave cavity, a suitable magnetic field, a paramagnetic specimen and a microwave detector and associated electronics. What can this equipment be used for?

A) Determination of electric quadrupole moment of the electron
B) Determination of electric dipole moment of the electron
C) Determination of electric dipole moment of the proton
D) Determination of the Lande g factor

82. Raman activity of a molecule is due to

A) Change in the electric dipole moment of the molecule
B) Change in the electric quadrupole moment of the molecule
C) Change in the electric polarizability of the molecule
D) Change in the magnetic polarizability of the molecule

83. A hydrogen atom is subjected to an electric field of strength 1 kV/cm. The observed second order Stark splitting for a given transition is 0.001 eV. If the field strength is increased to 2 kV/cm, what will be the new splitting?
A) 0.001 eV B) 0.002 eV C) 0.004 eV D) 0.006 eV

84. Which of the following statements is **TRUE** regarding the Larmor frequencies of the electron and the proton?
A) Both are the same and lie in the microwave region.
B) The Larmor frequency of the electron lies in the microwave region whereas that of the proton lies in the rf range.
C) The Larmor frequency of the electron lies in the microwave region whereas that of the proton lies in the near infra red range.
D) The Larmor frequency of the electron lies in the rf region whereas that of the proton lies in the near microwave range.

85. The fundamental and first overtone lines of the HCl molecule (reduced mass = 0.9796 amu) occur at 2886 cm^{-1} and 5668 cm^{-1} respectively. What will be the force constant of the molecule?
A) 516 Nm^{-1} B) 498 Nm^{-1} C) 978 Nm^{-1} D) 480 Nm^{-1}

86. A gas having an excited state at 1 eV is in thermal equilibrium at 4000 K. What will be the ratio of the probabilities for spontaneous to stimulated emissions, assuming conditions of black body radiation?
A) 1 : 1 B) 1 : 17.1 C) 0.41 : 1 D) 57 : 3.33

87. A $_{55}Cs^{137}$ decays to an excited level of the daughter nucleus $_{56}Ba^{137}$ at 662 keV. What should be the energy of a gamma ray in order that it can excite a $_{56}Ba^{137}$ nucleus in its ground state to the excited level at 662 keV?
A) Same as 662 keV
B) Less than 662 keV by 1.718 eV
C) Greater than 662 keV by 3.436 eV
D) Greater than 662 keV by 1.718 eV

88. The Morse curve represents
A) The variation of the electronic potential energy of a molecule as a function of internuclear distance.
B) The variation of the vibrational energy of a molecule as a function of internuclear distance
C) The variation of the rotational energy of a molecule as a function of internuclear distance.
D) The variation of kinetic energy of a molecule as a function of internuclear distance.

89. Molecules can absorb energy in the microwave region via one type of transition

given below. Which one is it?

A) Electronic B) Vibrational C) Rotational D) Nuclear

90. For a molecule with centre of symmetry, which among the following statements is correct?

A) The molecule will not have any peak in the IR and Raman spectra
B) Some peaks will be common in IR and Raman spectra
C) All peaks will be common in IR and Raman spectra
D) No peaks will be common in IR and Raman spectra

91. The dielectric constant of a material is given by $\varepsilon = \varepsilon' + i\varepsilon''$, where ε' and ε'' are real, no-zero. This implies that

A) The material is a perfect dielectric.
B) The material is a lossy dielectric.
C) The material is a perfect conductor.
D) The polarizability of the material is zero.

92. The ability of certain materials to generate a temporary voltage when they are heated or cooled

A) Ferroelectricity B) Piezoelectricity
C) Thermoelectricity D) Pyroelectricity

93. In the Einstein model of heat capacity of solids, the characteristic temperature, the Einstein temperature is

A) Proportional to the frequency of the relevant oscillations
B) Inversely proportional to the frequency of the relevant oscillations
C) Independent of the frequency of the relevant oscillations
D) A threshold temperature above which only vibrations can exist inside the solid

94. The work function of a certain metal is 4eV. Light incident on this metal surface will eject photoelectrons provided

A) Its frequency is more than 9.66×10^{14}
B) Its frequency is less than 9.66×10^{14}
C) Its energy is more than 4 keV
D) Its energy is more than 4 MeV

95. The Bravais lattice for CsCl is

A) Base centred cubic B) Body centred cubic
C) Primitive cubic D) Face centred cubic

96. What will be the Miller indices of a plane in a crystal lattice which makes an intercept of 1 on the a-axis, 2 on the b-axis and is parallel to the c-axis?

A) (210) B) (201) C) (120) D) (102)

97. For a thin semiconductor specimen placed in a magnetic field the measured Hall voltage is 100 milli Volts. If the thickness of the specimen were half, what will be the new Hall voltage?

A) 50 mV B) 200 mV C) 141.4 mV D) 70.7 mV

98. The atoms at the centres of the unit cells in a bcc lattice

A) Produce the same X-ray diffraction pattern as that of a simple cubic crystal lattice
B) Result in extra reflections in the X-ray diffraction pattern compared to that of a simple cubic crystal lattice
C) Result in enhanced intensity of the lines in the X-ray diffraction pattern compared to that of a simple cubic crystal lattice
D) Result in missing orders in the X-ray diffraction pattern compared to that of a simple cubic crystal lattice

99. Which of the following statements is TRUE?
A) In the optical mode two adjacent different atoms move against each other, while in the acoustic mode they move together.
B) In the optical mode two adjacent different atoms move together, while in the acoustic mode they move against each other.
C) In both modes the atoms move together.
D) In both modes the atoms move against each other.

100. The Langevin function
A) Gives the magnetic susceptibility of a ferromagnetic material.
B) Gives the magnetic susceptibility of a paramagnetic material.
C) Gives the magnetic susceptibility of a diamagnetic material.
D) Gives the magnetic susceptibility of a ferrimagnetic material.

101. A ferromagnetic specimen is magnetized to saturation by passing a high current through a coil of wire wound around it. It is now required to take the specimen back to its zero magnetization state. Which of the methods listed below can be best used for this?
A) Reduce the current to zero
B) Apply a large negative current
C) Apply a large ac current and then gradually decrease the current strength to zero
D) Apply a large ac current and then switch it off

102. At the superconducting transition temperature, the specific heat of a superconductor
A) Is much more than that of a normal conductor
B) Changes smoothly as the material passes from the normal to the superconducting phase
C) Is much less than that of a normal conductor
D) Is infinity

103. The energy of the pairing interaction in a Cooper pair
A) Is of the order of 1 keV
B) Is of the order of 1 eV
C) Is of such magnitude that they can exist only at very low temperatures
D) Is zero

104. A semiconducting material can absorb all radiations of wavelength below 620.6

nm. This means that its band gap is

A) 1 eV B) 2 eV C) 1 keV D) 2 keV

105. Phonons are

A) Similar to photons but with very high energies
B) Quantized lattice vibrations with energies of about 1 MeV
C) Quantized lattice vibrations with typical energies of 0.1 eV
D) Quanta of vibrations in a liquid

106. The spin and parity of the ground state of $_{20}Ca^{41}$ nucleus is

A) $(7/2)^-$ B) $(5/2)^+$ C) 0^- D) 1^+

107. The ground state of a nucleus has a spin parity of $(3/2)^-$ and has an excited state at 2.5 MeV. When the nucleus makes a transition from the excited level to the ground state, the gamma radiation emitted is predominantly of the type E1. What will be the spin parity of the excited state?

A) $(5/2)^-$ B) $(0)^+$ C) $(1/2)^-$ D) $(1/2)^+$

108. The Yukawa exchange particle must have a finite, no-zero rest mass. This is necessary to explain

A) The spin dependence of the nuclear forces
B) The saturation property of the nuclear forces
C) The short range of the nuclear forces
D) The strength of the nuclear forces

109. A 1 MeV alpha particle incident on a GM counter produces an output pulse of amplitude 2 Volts. If now the energy of the alpha is increased to 5 MeV, what will be the output voltage?

A) 2 Volts B) 5 Volts C) 0.2 Volts D) 10 Volts

110. The total binding energy of the nucleus $_{26}Fe^{55}$ is approximately

A) 125 MeV B) 8 MeV C) 500 MeV D) 100 MeV

111. The radius of the $_{53}I^{125}$ nucleus is given to be 6.5 fermis. In a collision with an incoming aluminium nucleus $_{13}Al^{27}$ the two nuclei have their surfaces just touching each other. What will be the distance between the centres of the two nuclei at this instant?

A) 3.9 fm B) 9.4 fm C) 7.8 fm D) 13.0 fm

112. Identify the radiations which can be detected using silicon surface barrier detector and Si(Li) detector.

A) Gamma rays and X-rays respectively
B) Gamma rays and alpha particles respectively.
C) Alpha particles and gamma rays respectively.
D) Alpha particles and X-rays respectively.

113. In a set of nuclei which are connected via a chain of beta decay processes,

A) All the nuclei will have the same mass number but different atomic numbers
B) All the nuclei will have the same atomic number but different mass numbers
C) All the nuclei will have the same atomic number and the same mass number
D) All the nuclei will have different atomic numbers and different mass numbers

114. Two resonances are found to occur in a given nuclear reaction. The resonance energies are 1.2 MeV and 1.5 MeV and the respective widths are 1 keV and 2 keV. What will be the ratio of the lifetimes of the energy levels of the compound nucleus involved in these resonances?
A) 1.2 : 1.5 B) 1 : 2 C) 2 : 1 D) 1 : 1

115. A neutron is electrically neutral. But it possesses a finite magnetic moment. The reason is:
A) It has an internal charge distribution which integrates to zero net charge.
B) It contains a number of tiny magnetic dipoles inside.
C) It is composed of charged π mesons.
D) It is constantly emitting and re-absorbing charged pions.

116. An alpha particle bombards a ^{30}Si target with a lab energy of 10 MeV. What is the energy of the projectiles in the centre of mass of the system?
A) 10 MeV B) 1.176 MeV
C) 11.333 MeV D) 8.824 MeV

117. Lepton number is conserved in
A) All interactions B) Strong interactions only
C) Weak interactions only D) Electromagnetic interactions only

118. How many up quarks and down quarks are there in the nucleus $_8O^{17}$?
A) 25 u quarks and 26 d quarks B) 26 u quarks and 26 d quarks
C) 25 u quarks and 25 d quarks D) 26 u quarks and 25 d quarks

119. In the following elementary particle interaction, identify the particle a.

$$p + a \rightarrow \sum^- + K^+$$

A) π^- B) n C) e D) $^-$

120. The ground state of the deuteron has a small positive electric quadrupole moment. This is a manifestation of the
A) Extremely small range of the nuclear force
B) Tensor nature of the nuclear force
C) Charge independence of the nuclear force
D) Charge dependence of the nuclear force

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