1. The vector $\mathbf{F} = \mathbf{i}f_1(y,z) + \mathbf{j}f_2(x,z) + \mathbf{k}f_3(x,y)$ is
   A) Both Solenoidal and irrotational
   B) Irrotational, but not solenoidal
   C) Solenoidal but not irrotational
   D) Neither solenoidal nor irrotational

2. The divergence of a vector field at a point will be zero if the field lines are
   A) Parallel B) Converging
   C) Diverging D) Curved

3. Given the arbitrary vector A, which of the following combinations will be skew-Hermitian?
   († denotes conjugate transpose).
   A) $AA^\dagger$ B) $(A - A^\dagger)/2$
   C) $(A + A^\dagger)/2$ D) $A^\dagger A$

4. A is a vector and B is a tensor of rank 2. What is the nature of the quantity A_iB_{ik}?
   A) A vector B) A scalar
   C) A tensor of rank 3 D) A pseudo scalar

5. Which of the following statements is **not true** of Cauchy residue theorem?
   A) It is a powerful tool to evaluate line integrals of analytic functions over closed curves
   B) It generalizes the Cauchy integral theorem and Cauchy's integral formula.
   C) It applies to only to circular contours in the complex plane.
   D) It can be used to evaluate definite integrals of real functions.

6. A student obtains two apparently distinct solutions $y_1(x)$ and $y_2(x)$ for a given second order differential equation. He calculates the Wronskian W and obtains a non-zero value. He will conclude that
   A) $y_1(x)$ and $y_2(x)$ are linearly independent
   B) $y_1(x)$ and $y_2(x)$ are linearly dependent
   C) $y_1(x)$ and $y_2(x)$ are the same function except for an arbitrary multiplicative constant
   D) $ay_1(x) + b\,y_2(x) + c$ can be zero for non-zero values of a, b and c

7. The Frobenius method of solution of a linear differential equation consists of assuming a power series expansion of the solution of the form $y(x) = \sum_{n=0}^{\infty} a_n x^{k+n}$, where a_n's are coefficients in the expansion and k is a constant.
   A necessary condition for applying the method is that
   A) None of the coefficients can be zero
   B) k cannot be zero
   C) a_0 is non-zero
   D) k cannot be a complex number

8. f(x) is a given arbitrary function of x. Another function of x is formed from f(x) using the combination g(x) = 1/2[f(x) + f(-x)]. The Fourier series of expansion of g(x) will be :

A) $y(x) = \sum_{n=0}^{\infty} a_n e^{inx}$

B) $y(x) = \sum_{n=0}^{\infty} a_n \cos(nx)$

C) $y(x) = \sum_{n=0}^{\infty} a_n \sin(nx)$

D) $y(x) = \sum_{n=0}^{\infty} [a_n \sin(nx) + b_n \cos(nx)]$

9. $z = x + iy$ is a complex number having magnitude $r = \sqrt{(x^2 + y^2)}$ and phase angle $\theta = \tan^{-1}(y/x)$. What is the nth root of z? (Take $R = r^{1/n}$ and $\phi = \theta/n$).

A) $R [\cos(\phi + 2k\pi) + i \sin(\phi + 2k\pi)]$, k = 0, 1, 2, 3, ...

B) $R [\cos\phi + i \sin\phi]$

C) $R [\cos^{1/n}\phi + i \sin^{1/n}\phi]$

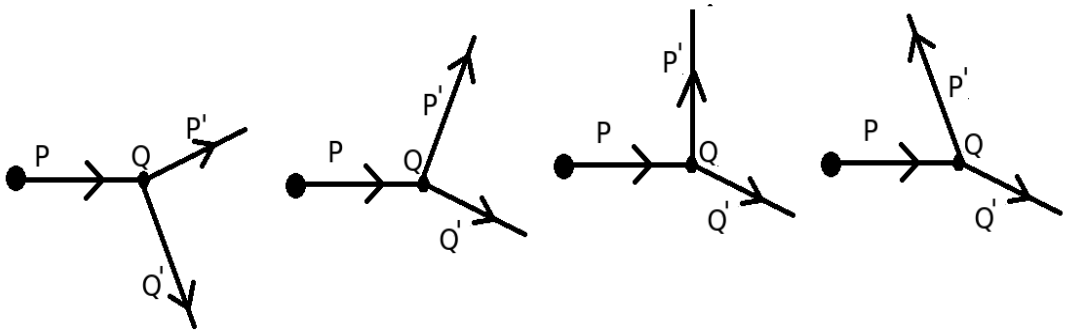
D) $R [\cos(\phi + 2k\pi/n) + i \sin(\phi + 2k\pi/n))]$, k = 0, 1, 2, 3, ...

10. In an experiment to determine the half life of a radioactive material by counting the emitted radiations as a function of time, the recorded counts are 1000000 for 10 seconds at t = 0 and 10000 for the same time period at t = 10 s. The errors in the counts are the usual statistical ones and that in the determination of time is 0.1 s. Choose the correct way to express the half life :

A) (0.460517 ± 0.006529) s B) (0.46 ± 0.01) s

C) (0.4605 ± 0.0065) s D) (0.461 ± 0.007) s

11. An atomic particle P of mass 240 amu collides with another particle Q of mass 16 amu at rest, thereby getting scattered elastically. Which of the following correctly describes this scattering event? (Primes indicate the particles after scattering).



A) B) C) D)

12. For a classical system with Lagrangian L and Hamiltonian H what does the combination (H – L) depend on?

A) T alone B) V alone

C) Both T and V D) Neither T nor V

13. A particle moves subject to the constraint expressed via the equation $x^2+y^2 = 5t$. The particle is said to move under which of the following constraints?
A) Cyclic
B) Scleronomous
C) Non-holonomic
D) Holonomic

14. An atomic electron moving in an orbit of radius 3Å has a velocity of 3×10^5 m/s. What is the total area swept out by a radius vector of the orbit in one second?
A) 9×10^{-5} m^2
B) 9×10^{-15} Å^2
C) $4.5 \times 10^{+15}$ Å^2
D) 4.5×10^{-15} Å^2

15. An electron having rest mass m_e moves with a kinetic energy three times its rest energy. What will be its momentum?
A) $m_e c$
B) $2\sqrt{15} m_e c$
C) $4 m_e c$
D) $\sqrt{15} m_e c$

16. Two simple harmonic motions (SHMs) have the same angular frequency ω = 500 rad/s and equal displacement amplitudes A1 = A2 = A. The phase difference between the SHMs is $\Delta\varphi = 0.55\pi$. The two SHMs are now added together to form a resultant SHM. The displacement amplitude of the resultant SHM is
A) 0.1A
B) 0.5A
C) 0.9A
D) 1.3A

17. A physical system is subjected to a translation in time. It is found to remain invariant. What can be concluded from this observation?
A) The total energy of the system is a conserved quantity
B) The net angular momentum is a constant of the motion of the system
C) The net linear momentum is conserved
D) The kinetic energy of the particles in the system is invariant

18. In a central force field,
A) The force is always inversely proportional to the square of the distance from the centre of the force
B) The force is always directed along the radius vector and depends only on the distance from the centre of the force
C) The force is always directed along the radius vector and inversely proportional to the square of the distance from the centre of the force
D) The force is always directed along the radius vector and depends on the distance as well as on the azymuthal angle

19. The Lagrangian of a system with one degree of freedom q is given by $L = \alpha (dq/dt)^2 + \beta q^2$. Here α and β are constants. If p denotes the canonical momentum conjugate to q then which one of the following statements is CORRECT?
A) $p = 2 \beta q$ and is a conserved quantity
B) $p = 2 \beta q$ and is not a conserved quantity
C) $p = 2 \alpha (dq/dt)$ and is not a conserved quantity
D) $p = 2 \alpha (dq/dt)$ and is a conserved quantity

20. A particle is moving with a velocity of 3 X 10^6 ms^{-1}. What will be the associated phase velocity?

A) 3 X 10^6 m s^{-1} B) 3 X 10^{10} m s^{-1}
C) 6 X 10^6 m s^{-1} D) 30 nm s^{-1}

21. A beam of alpha particles of energy 5 MeV is incident on a gold ($_{79}Au^{197}$) target. Scattering takes place. What is the approximate closest distance of approach of the alpha particle to the gold nucleus?

A) 45 Å B) 45 nm C) 45 fermi D) 90 fermi

22. What does the Poisson bracket {p,H} between the momentum and the Hamiltonian evaluate to?

A) Zero B) - dp/dt C) dq/dt D) dp/dt

23. The mean lifetime of a muon travelling with a velocity 99.9% of the velocity of light as measured in the laboratory frame is 2.2 s. On the average, how far will the muon travel in its own frame of reference before decaying?

A) 14.75 km B) 29.41 m C) 660 m D) Infinite

24. The space time coordinates of two events as measured in a frame S are as follows : $x_1=x_0$, $t = x_0/c$ ($y_1=0$, $z_1=0$); $x_2=2x_0$, $t = x_0/2c$ ($y_2=0$, $z_2=0$). C is the velocity of light. There exists a frame in which these two events occur at the same time. What is the velocity of this new frame?

A) c/2 B) -c/2
C) c/4 D) Not possible to have simultaneity

25. A pair of electric charges of equal magnitude q and opposite sign are separated by a distance d along the X-axis at equal distances from the origin on either side of it, the positive charge being on the negative side of the X-axis. Which of the following gives the approximate magnitude and direction of the electric field set up by the two charges at a point on the axis at a distance r from the origin (r >> d)?

A) $(1/4\pi\varepsilon_0)(2q/r^2)$ towards the positive direction of the Y-axis
B) $(1/4\pi\varepsilon_0)(2q/r^2)$ towards the negative direction of the Y-axis
C) $(1/4\pi\varepsilon_0)(qd/r^3)$ towards the negative direction of the X-axis
D) $(1/4\pi\varepsilon_0)(qd/r^3)$ towards the positive direction of the X-axis

26. Maxwell's equations for the static case are given below. Which one permits us to write the electrostatic field to be written in the form $\mathbf{E} = -\nabla\varphi$?

A) $\nabla . \mathbf{E} = r / \varepsilon_0$ B) $\nabla \times \mathbf{E} = 0$
C) $\nabla . \mathbf{B} = 0$ D) $\nabla \times \mathbf{B} = {}_0\mathbf{J}$

27. A wire of length L m is bent into a circular loop. What is the magnetic moment of the wire loop when a current I ampere flows through it?

A) $L^2/4\pi$ B) $IL/4\pi$
C) $IL^2/4\pi$ D) $4\pi\ IL^2$

28. The magnitude of the magnetic dipole moment due to a circular loop of radius R carrying current:

A) $\pi R^2 I$ B) $2\pi R^2 I$

C) $\pi R^2 I/2$ D) $4\pi R^2 I$

29. A 300 mm long conductor is placed along the X axis carries a current of 10 A along the positive X direction. It is situated in a magnetic field of magnitude 0.8 T along the +Z axis. The conductor experiences a force F. What will be the direction and magnitude of F?

A) 24 N along the positive Y direction

B) 24 N along the negative Y direction

C) 2.4 N along the positive Y direction

D) 2.4 N along the negative Y direction

30. A bar magnet is moved relative to a solenoid. An emf is induced in the solenoid. The magnitude of the induced emf does not depend on

A) The resistance of the wire of the solenoid

B) The speed with which the magnet is moved

C) The pole strength of the magnet

D) The number of turns in the solenoid

31. The lowest cut-off frequency of a rectangular wave guide with inside dimensions (3 × 4.5 cm) operating at 10 GHz is

A) 10 GHz B) 6 GHz C) 10/9 GHz D) 10/3 GHz

32. The electrostatic potential in a certain region of space is given by $\varphi(x) = \varphi_o(x^2 + y^2 + z^2)$ where φ_o is constant. Then the charge density giving rise to the above potential would be :

A) Zero B) $-6\varphi_o \varepsilon_o$ C) $+6\varphi_o \varepsilon_o$ D) $-6\varphi_o / \varepsilon_o$

33. A magnetic field exists in a region of space where there is no conduction current. However, there is a displacement current with a density of 15 A/m^2. What will be the magnitude of the curl of the magnetic vector **B**? (ε_0 and μ_0 are respectively the electric permittivity and magnetic permeability of free space).

A) $15\ \mu_0$ Gauss/m B) $5\ \mu_0\ A/m^2$

C) $5/\mu_0\ A/m^2$ D) $5\ \varepsilon_0$ Gauss/m

34. An optical system consists of two media with refractive indices $n_1 = 1.5$ and $n_2 = 1.33$, separated by an interface. An electromagnetic wave with frequency 5.765×10^5 GHz is incident on the interface in medium 1 at an angle of incidence of 65^0(Given $\sin 65^0 = 0.891$). What will happen to the wave?

A) The wave will be completely transmitted into the second medium with the same frequency and velocity

B) The wave will be completely reflected back with the same frequency and velocity

C) The wave will be completely transmitted into the second medium with the same frequency but a larger velocity

D) The wave will be partially transmitted into the second medium with the same frequency but a larger velocity

35. Which of the following correctly describes the electric fields at the surface of a conductor?
A) They are always normal to the surface
B) They are always zero
C) They are always tangential to the surface
D) They are independent of the surface charge density

36. What are the boundary conditions that the magnetic fields obey on the surface between two materials when there are no free currents on the surface?
A) The field **H** is continuous and the curl of **B** is continuous.
B) Both **B** and **H** approach infinity at boundary surfaces
C) The normal components of **B** are continuous and the tangential components of **H** are continuous
D) The normal components of **H** are continuous and the tangential components of **B** are continuous

37. A hollow rectangular waveguide has its axis along the Z-axis. Waves are propagating along the length of the guide. The TEM component has
A) Only $H_z = 0$ and all other components are non-zero.
B) Only $E_z = 0$ and all other components are non-zero.
C) Both H_z and $E_z = 0$ and all other components are non-zero.
D) All components of the fields are zero.

38. One of Maxwell's equations pertaining to electromagnetic fields can be written as :

$$\oint \vec{E} \cdot d\vec{l} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{S}$$

This equation is based on an important theorem in electromagnetism. Which one is it?
A) Gauss's Law
B) Faraday's Law
C) Ampere's Law
D) Modified Ampere's Law

39. An electromagnetic wave passing through vacuum is governed by the following equations for the electric and magnetic fields : $\mathbf{E} = \mathbf{E_0} \sin(\omega t - kx)$ and $\mathbf{B} = \mathbf{B_0} \sin(kx - \omega t)$. What is the relation between the amplitudes E_0 and B_0? (c = velocity of light)
A) $k E_0 = \omega B_0$
B) $\omega E_0 = k B_0$
C) $E_0 B_0 = \omega k$
D) $cE_0 = B_0$

40. The impedance of an open circuited transmission line is Z_{OC} and that for a short circuited line is Z_{SC}. Its characteristic impedance Z_o in terms of the above two quantities is given by
A) $Z_o = Z_{OC}\ Z_{SC}$
B) $Z_o = \sqrt{(Z_{OC}\ Z_{SC})}$
C) $Z_o = \sqrt{(Z_{OC} / Z_{SC})}$
D) $Z_o = \sqrt{(Z_{SC} / Z_{OC})}$

41. A particle of charge -5 X 10^{-18} Coulombs has a velocity of 3 $m.s^{-1}$ along the X-axis. On its way, it enters a region of space where a magnetic field and an electric field co-exist. The electric field of magnitude 6 X 10^{4} V. m^{-1} is directed along the negative Z axis. On emerging from this region the particle continues to move along its initial direction with no deviation. What should be the magnitude and direction of the applied magnetic field?

A) 2 X 10^{4} Web. m^{-2}, along -Y axis
B) 2 X 10^{4} Web. m^{-2}, along +Y axis
C) 10^{-4} Web. m^{-2}, along -Y axis
D) 10^{-4} Web. m^{-2}, along +Y axis

42. The Gibb's function G in thermodynamics is defined as G = H-TS. In an isothermal, isobaric, reversible process, what happens to G?

A) Varies linearly
B) Varies non linearly
C) Remains zero
D) Remains constant but not zero

43. An ideal gas expands subject to the equation $PV^{\gamma} = C$. Here C and γ are constants characteristic of the gas. The initial and final values of the state parameters V and P are respectively (V_i,P_i) and (V_f,P_f). The work done during this expansion is W. What will be the expression for W?

A) $(V_fP_f - V_iP_i)/(1-\gamma)$
B) $(V_f - V_i)(P_f - P_i)/2$
C) $P_f[V_f^{(1+\gamma)} - V_i^{(1+\gamma)}]/(1+\gamma)$
D) $P_i[V_i^{(1+\gamma)} - V_f^{(1+\gamma)}]/(1-\gamma)$

44. Select the valid thermodynamic relation from the following :

A) $(\partial T / \partial V)_S = -(\partial V / \partial S)P$
B) $(\partial T / \partial V)_S = -(\partial P / \partial S)V$
C) $(\partial T / \partial P)_S = -(\partial V / \partial S)P$
D) $(\partial P / \partial T)V = (\partial V / \partial S)T$

45. The temperature of the surface of the sun is often taken to be 5778 K. The peak emission from the sun occurs at a wavelength of 502 nm. The brightest part of the spectrum of the star Sirius is located at a wavelength of 290 nm. What is the approximate surface temperature of Sirius?

A) 1000 K
B) 3338 K
C) 9000 K
D) 10000 K

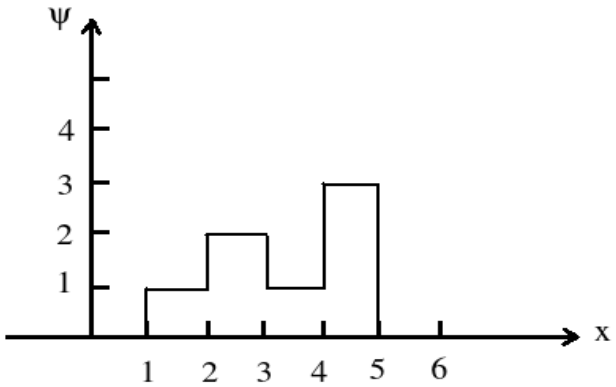
46. Pick the correct statement from the following regarding Bose-Einstein condensation of liquid helium:

A) Liquid Helium-4 being a boson undergoes Bose-Einstein condensation at a temperature of 2.17 K, but liquid He-3 being a fermion can never undergo such a process
B) Liquid Helium-3 can also undergo a similar process by Cooper-like pairing which results in a boson state, but the transition occurs at much higher temperature
C) Liquid Helium-3 can also undergo a similar process by Cooper-like pairing which results in a boson state, but the transition occurs at much lower temperature
D) Liquid Helium-3 being a fermion undergoes a similar condensation process at much higher temperatures

47. The physical meaning of the normalization of a quantum mechanical wave function is

A) The wave function is continuous everywhere in space
B) The wave function is single valued
C) The particle exists somewhere in space
D) The wave function is finite everywhere

48. An approximation to the un-normalized wave function Ψ of a particle moving in one dimension is shown in figure, being zero for $x < 1$ and $x > 5$. What will be the probability of finding the particle between $x = 2$ and $x = 4$?



A) 5 B) 15 C) 0.3333 D) 0.577

49. What is the value of the commutator $[p_x, L_z]$? (p is the momentum operator and L is the angular momentum operator)

A) Zero B) $i\hbar$ C) $i\hbar L_y$ D) $-i\hbar p_y$

50. An electron has a speed of 500 m/s, determined with an accuracy of 0.004%. What is the corresponding accuracy with which the position can be measured?

A) 0.0598 m B) 0.598 m C) 0.289 mm D) 2.89 mm

51. A quantum mechanical harmonic oscillator is in its ground state. Where will its probability density be maximum?

A) At the two ends as in the case of the classical counter part
B) In the middle, unlike in the case of the classical counter part
C) At a distance equal to 2/3rd of the maximum amplitude
D) Near the middle, but displaced from the middle slightly

52. The scalar product of the operators **L** and **S** relevant in spin orbit coupling is given by : ($\mathbf{J} = \mathbf{L} + \mathbf{S}$)

A) $(\mathbf{L} + \mathbf{S}).(\mathbf{L} + \mathbf{S})$ B) $(\mathbf{L} - \mathbf{S}) . (\mathbf{L} - \mathbf{S})$
C) $(\mathbf{J}^2 + \mathbf{L}^2 + \mathbf{S}^2)/2$ D) $(\mathbf{J}^2 - \mathbf{L}^2 - \mathbf{S}^2)/2$

53. In the Heisenberg picture the wave function is time independent but operators are time dependent. For an oprator A which is time independent in the Schroedinger picture, the time evolution in the Heisenberg picture is specified by the equation $A(t) = U^{\dagger}(t)\, A\, U(t)$, U(t) being the time evolution operator. What is the form of this operator? (H is the Hamilton operator and E the eigen value)

A) $U(t) = \exp(-iEt/\hbar)$ B) $U(t) = \exp(iEt/\hbar)$

C) $U(t) = \exp(-iHt/\hbar)$ D) $U(t) = \exp(iHt/\hbar)$

54. The average kinetic energy of a particle described by the wave function $\Psi(x) = \sqrt{(2/a)} \sin(n\pi x/a)$, $0 \le x \le a$, $n = 1,2,3$ ..... is

A) $n^2h^2\pi^2/4ma^2$ B) $n^2h^2\pi^2/2ma^2$

C) $n^2h^2\pi^2/2ma^3$ D) $n^2h^2\pi^2/8ma^2$

55. A spin-half particle is in a linear superposition $0.8|\uparrow\rangle + 0.6|\downarrow\rangle$ of its spin-up and spin-down states, $|\uparrow\rangle$ and $|\downarrow\rangle$ being the eigen states of σ_z. What is the expectation value of the operator $10\,\sigma_z + 5\,\sigma_x$? ($\sigma_x$, σ_y and σ_z are the Pauli spin matrices).

A) 14.8 B) 2.0

C) 7.6 D) 2.8

56. Consider a complete orthonormal basis comprising of the basis vectors $|i\rangle$, i = 0, 1, 2, 3....., what does $\sum_i |i\rangle\langle i|$ represent?

A) Null operator

B) Probabilty for the system being in the i^{th} state

C) The norm of the vector $|i\rangle$

D) Identity operator

57. How does the probability of an electron tunneling through a potential barrier vary with the thickness of the barrier?

A) It decreases inversely with thickness

B) It decreases sinusoidally with thickness

C) It decreases linearly with thickness

D) It decreases exponentially with thickness

58. All quantum mechanical operators can be represented as matrices. Which of the following statements regarding these matrices is TRUE?

A) The matrix elements are independent of the choice of the basis

B) The matrix elements depend very much on the choice of the basis

C) The matrices corresponding to any two arbitrary operators always commute with each other

D) Such matrices are always skew-Hermitian

59. It is known that a given orbital angular momentum level splits into two levels with $j = \ell + 1/2$ and $j = \ell - 1/2$ consequent on the spin orbit coupling. Given that the energy splitting due to this effect is 0.003 eV for $\ell = 2$ in a given atom, what will be the corresponding splitting for $\ell = 4$?

A) 0.006 eV B) 0.012 eV C) 0.0054 eV D) 0.003 eV

60. The variational method can be applied to calculate the ground state energy of the hydrogen atom. What would be the best suited trial wave function for applying the procedure? (A and k are constants)

A) $\psi(r) = A \exp(-kr)$ B) $\psi(r) = A \exp(-kr^2)$

C) $\psi(r) = A \cos(kr)$ D) $\psi(r) = A \exp(-ikr)$

61. Consider a 4-fold degenerate state with orthonormal eigen functions u_1, u_2, u_3 and u_4. A perturbation H acts on the state. This is given by the matrix elements $H_{12} = H_{21} = -g$; $g > 0$, and all the other matrix elements are zero. What are the wave functions of the split levels?

A) u_1, u_2, u_3 and u_4

B) $(u_1 - u_2)/\sqrt{2}$, $(u_1 + u_2)/\sqrt{2}$, u_3 and u_4

C) $(u_1 - 2u_2)/\sqrt{2}$, $(u_1 + 2u_2)/\sqrt{2}$, u_3 and u_4

D) $(u_1 - 3u_2)/\sqrt{2}$, $(u_1 + 3u_2)/\sqrt{2}$, u_3 and u_4

62. The clipping action of a diode is due to

A) Its forward voltage drop being very small

B) Its forward voltage drop being large

C) Its junction capacitance

D) Its depletion region being very thin

63. Thermal runaway is not possible in FET because as the temperature of FET increases

A) The channel resistance decreases

B) The transconductance increases

C) The drain current increases

D) The mobility tends to decrease

64. In an emitter follower

A) The emitter is common to both the input and output sides and the input impedance is low

B) The base is common to both the input and output sides and the input impedance is low

C) The collector is common to both the input and output sides and the input impedance is high

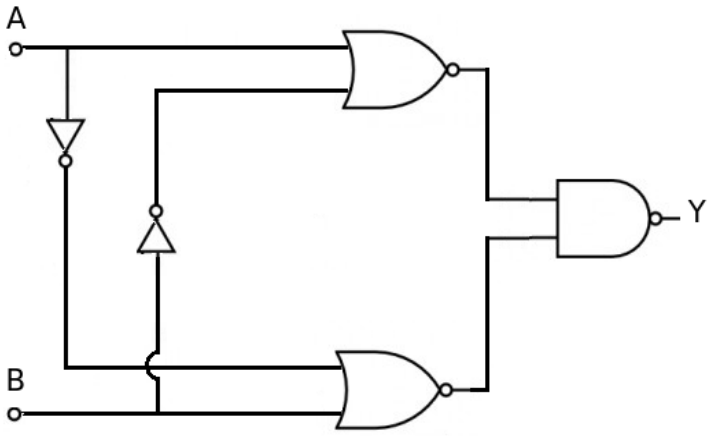
D) The emitter is common to both the input and output sides and the input impedance is high

65. The quoted ripple factor in a regulated power supply is 0.04%. With a DC output of 5 Volts what is the Joule heating power loss due to the ripple alone when the load is a 10 Ω resistor?

A) 4×10^{-7} W B) 2×10^{-4} W

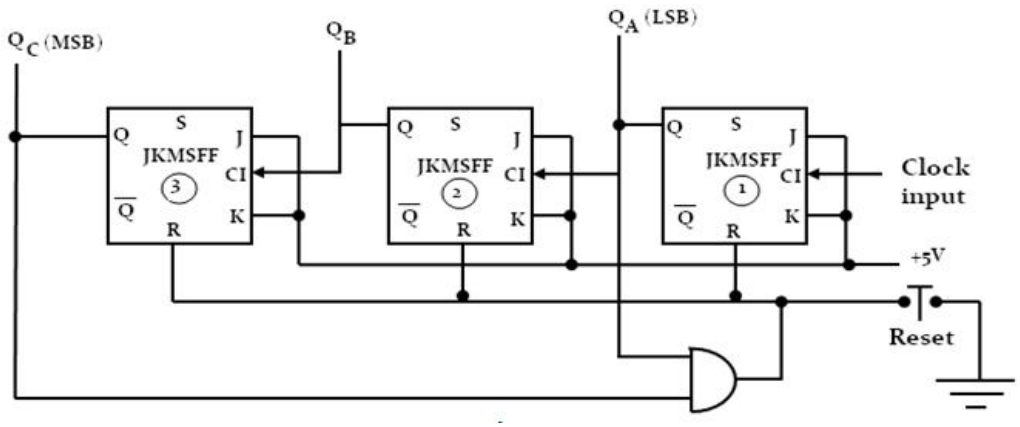
C) 8×10^{-7} W D) 4×10^{-3} W

66. What is the speciality of the following logic circuit in which two inputs are given to terminal A and B?



A) The output Y is always 1, independent of the two inputs A and B.
B) The output Y is always 0, independent of the two inputs A and B.
C) The output is always the same as A, independent of the state of B.
D) The output is always the same as B, independent of the state of A.

67. A simple counter consists of three JK flip-flops connected as shown below. The output is taken from Q_A, Q_B and Q_C, Q_C being the most significant bit (MSB). A train of clock pulses is sent through the circuit after resetting it to zero. After how many pulses will the counter reset again?



A) 8 B) 4 C) 3 D) 5

68. A given logic circuit functions as an XOR gate when positive logic is used, wherein the higher voltage level corresponds to logic 1. How will it function when the logic is changed to negative logic?

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

69. In a solar cell, use is made of which of the following portion(s) of the I-V characteristics?
A) 1 B) 2 C) 4 D) 1 and 4

70. A certain section of an electronic circuit consists of three OP AMPs. One is operated as an inverting amplifier with input resistor R_i = 100 kΩ and feedback resistor R_f = 200 kΩ. The second one is operated as a non-inverting amplifier with same values for R_i and R_f. The outputs of the first two OPAMPs are fed to the two input terminals of the third OPAMP operated as a summing amplifier. The first two amplifiers are fed from the same signal source giving signals of 1 V amplitude. What will be the final output from the summing amplifier?
A) 1 V B) -6 V C) 0 V D) 6 V

71. An n- channel JFET has I_{DSS} = 2 mA,and V_p = - 4 V. Its transconductance g_m for an applied gate to source voltage V_{GS} = -2 V in mA/V is
A) 0.25 B) 0.5 C) 0.75 D) 1.0

72. An OPAMP is used as a differentiator. The output gain will be
A) Directly proportional to the frequency ω.
B) Inversely proportional to the frequency ω.
C) Directly proportional to ω^2.
D) Independent of the frequency ω.

73. In an n channel JFET, the channel becomes pinched off and the drain current reaches a saturation value at a particular applied voltage. This means that
A) The majority carrier concentration within the channel has reached a saturation value
B) The minority carrier concentration within the channel has reached a saturation value
C) The width of the channel near the drain end has reached a maximum possible value, subject to the dimensions of the device
D) The width of the channel near the drain end has reached a minimum possible value

74. An amplifier with feedback has a voltage gain of 20 and a bandwidth of 750 kHz. When the feedback is removed, the bandwidth falls to 500 kHz. What is the type of feedback and the gain without feedback?
A) -ve, 30 B) +ve, 30
C) -ve, 13.33 D) +ve,13.33

75. A multichannel analyzer is used to record the pulse height spectra of radiations detected by suitable detectors. It uses a 12 bit ADC. What will be the resolution of the analyzer?
A) 0.00024% B) 0.0024%
C) 0.024% D) 0.24%

76. The voltage gain of a CE amplifier is

A) $1-\frac{h_{ie}}{R_E}$ B) $\frac{h_{fe}R_L}{h_{ie}}$

C) $-\frac{h_{fe}R_L}{h_{ie}}$ D) None of these

77. When a BJT is used as an amplifier,
A) The EB junction is reverse biased and CB junction is forward biased
B) The EB junction is reverse biased and CB junction is reverse biased
C) The EB junction is forward biased and CB junction is forward biased
D) The EB junction is forward biased and CB junction is reverse biased

78. An amplitude modulated carrier wave is represented by V = [12 + 0.5 cos (5.3 X 10^4 t)] cos (3 X 10^7 t). From the following choose the correct set of values for the frequencies of the carrier wave and the modulating signal and the modulation index.
A) 4.8 MHz, 8.5 kHz, 4.2% B) 60 MHz, 30 kHz, 4.2%
C) 4.8 MHz, 8.5 kHz, 92% D) 60 MHz, 30 kHz, 92%

79. A positronium atom has the proton of a hydrogen atom replaced with a positron. What will be the possible ground state energy of such an atom?
A) -13.6 eV B) -6.8 eV
C) - 3.4 eV D) -27.2 eV

80. The lifetime for the 2p → 1s transition in hydrogen is 1.6×10^{-9} s. The natural line width for the radiation emitted during the transition is approximately
A) 4.11 eV B) 0.411 MeV
C) 0.411 X 10^{-6} eV D) 2.05 eV

81. In the Bohr model of the hydrogen atom, the radius of a stationary orbit is directly proportional to
A) n^{-1} B) n^{-2} C) n D) n^2

82. Which of the following sets of three quantum numbers is **not** allowed for an atomic electron?
A) n = 3 l = 2 $m_l = -1$ B) n = 2 l = 1 $m_l = 1$
C) n = 4 l = 4 $m_l = -2$ D) n = 6 l = 0 $m_l = 0$

83. The magnetic quantum number m of an atomic orbital defines:
A) The energy level of the orbital
B) The shape of the orbital
C) The spatial orientation of the orbital
D) The spin of the electrons in the orbital

84. An NMR experiment consists of measuring the energy associated with one of the following physical phenomena. Choose the appropriate selection.
A) Excitation of a core electron from an atom
B) Flipping the magnetic spin vector of a nucleus (having a non-zero magnetic moment) in a strong magnetic field
C) Activating a molecular vibration
D) Promoting a valence electron from the ground state to the higher state

85. The transition $5^1D_2 \rightarrow 5^1P_1$ in cadmium atom has a wavelength of 643.8 nm. The normal Zeeman effect experiment is carried out in the lab using a spectrometer having a resolution of 0.01 nm. What will be the minimum magnetic field needed to observe the split lines?
A) 0.26 T B) 0.52 T C) 2.6 T D) 5.2 T

86. For an electron in the 4f shell, the total orbital angular momentum will be
A) $\sqrt{2}\,\hbar$ B) $\sqrt{3}\,\hbar$ C) $2\sqrt{3}\,\hbar$ D) $3\,\hbar$

87. Which electronic transition of Li^{2+} will give rise to radiation of the same wavelength as the first line in the Balmer series of the hydrogen atom?
A) $n_2 = 3$ to $n_1 = 2$ B) $n_2 = 6$ to $n_1 = 3$
C) $n_2 = 9$ to $n_1 = 6$ D) $n_2 = 9$ to $n_1 = 8$

88. The Stark effect comprises of the splitting of the energy levels by an electric field. The magnitude of the energy splitting in the lowest non-vanishing order in the case of the ground state of the hydrogen atom for a given electric field is 0.003 eV. What will be the splitting when the electric field is doubled?
A) Remains the same B) 0.012 eV
C) 0.0015 eV D) 0.006 eV

89. The $J' = 1 \rightarrow J'' = 0$ transition in HCl molecule occurs at 20.68 cm^{-1}. If we assume that the molecule can be considered as a rigid rotor, what will be the wavelength of the $J' = 15 \rightarrow J'' = 14$ transition?
A) 3.22 mm. B) 1.66 nm.
C) 322 nm. D) 32.2 m

90. In a given sample, the Raman lines occur at wavelengths of 406.55 nm and 434.1 nm. What will be the wavelength of the exciting radiation and which of the two Raman lines will be most intense?
A) 420.33 nm; 434.1 nm will be more intense
B) 419.85 nm; 434.1 nm will be more intense
C) 420.33 nm; 406.55 nm will be more intense
D) 419.85 nm; 406.55 nm will be more intense

91. Electrons with de Broglie wavelength λ are incident on the target in an X-ray tube. What will be the cut off wavelength λ_o of the emitted X-rays?
A) $\lambda_o = 2mc\,\lambda^2/h$ B) $\lambda_o = 2h/mc$
C) $\lambda_o = 2m^2c^2\lambda^2/h$ D) $\lambda_o = \lambda$

92. In the X-ray diffraction of a set of crystal planes having d equal to 0.18 nm a first order reflection is found to be at an angle of 25°. The wavelength of the X-rays is
A) 0.076 nm B) 0.152 nm
C) 1.52 nm D) 0.326 nm

93. A piece of copper and another of germanium are cooled from room temperature to 80 K. How do the resistances of the two materials vary?
A) The resistance of each of them increases
B) The resistance of Cu increases and that of Ge decreases
C) The resistance of Cu decreases and that of Ge increases
D) The resistance of each of them decreases.

94. Fermi level of intrinsic semiconductor at 0K is
A) Far above near to the conduction band
B) Far below near to the valence band
C) At the top of the valence band
D) Near the middle of the band gap

95. The forbidden energy gap of carbon in diamond structure is
A) 7.0 eV B) 1.0 eV
C) 0.01 eV D) 70 eV

96. The Fermi energy of silver at 0 K is given to be 5 electron volt. What will be the mean energy of electron in silver at this temperature?
A) 6 electron volt B) 12 electron volt
C) 1.5 electron volt D) 3 electron volt

97. Above Curie temperature, the spontaneous polarization for ferro electric materials is
A) Zero. B) 0.5 C) 2 D) Infinity

98. Hall effect cannot be used to measure
A) Mobility of semiconductors
B) Conductivity of semiconductors
C) Resistivity of semiconductors
D) Band gap of semiconductors

99. A ferromagnetic material is one in which neighbouring atomic magnetic moments are predominantly
A) Parallel in small regions of material.
B) Parallel and unequal in small regions of material.
C) Equal and parallel throughout the material.
D) Unequal and parallel throughout the material.

100. A superconductor has a transition temperature T_C of 20 K. A critical field of 100 G is required to destroy its superconductivity at 15 K. What critical field will be required at a temperature of 10 K?
A) 58.3 G B) 100 G C) 200 G D) 171.4 G

101. A Cooper pair consists of two electrons which are
   A) Bound via exchange of photons
   B) Bound via exchange of phonons
   C) Unbound due to the Coulomb repulsion
   D) Bound due to spin-orbit interaction

102. The Bloch function is defined as $\psi(r) = u_k(r)\exp(-i\mathbf{k}.\mathbf{r})$. What does it represent?
   A) The wave function of the core electrons in the atoms of the lattice.
   B) A phonon wave traversing a crystal lattice with amplitude given by the factor $u_k(r)$.
   C) The wave function of electrons moving in a periodic potential and the periodicity is contained in the factor $u_k(r)$.
   D) The passage of an electromagnetic wave through a periodic lattice.

103. The Debye temperatures for lead and silver are respectively 105 K and 225 K. The vibrational contribution to the specific heat capacity of lead at 5 K is given to be 0.291 J / K.mole. What will be the corresponding value for silver?
   A) 0.0296 J / K.mole B) 2.863 J / K.mole
   C) 0.623 J / K.mole D) 0.136 J / K.mole

104. The electrical resistivity of intrinsic germanium at room temperature is 0.47 Ωm. The mobilities of electrons and holes are respectively 0.39 and 0.19 m^2/V.s. What are the intrinsic concentration of electrons and holes?
   A) Both equal to 0.506×10^{19} m^{-3}
   B) Both equal to 2.292×10^{19} m^{-3}.
   C) 1.545×10^{19} m^{-3} for electrons and 0.751×10^{19} m^{-3} for holes.
   D) 0.506×10^{19} m^{-3} for electrons and 2.291×10^{19} m^{-3} for holes.

105. Which is TRUE of a pyroelectric material?
   A) When a point in the middle of the material is heated, a voltage develops across the two ends
   B) When this material is heated, electrons are expelled from it resulting in a net positive charge and a consequent generation of a voltage
   C) When pressure is applied to the material, a voltage develops across the two ends
   D) When this material is heated, a voltage is developed across it, consequent on the movement of atoms resulting in a net polarization

106. According to the shell model including spin orbit interaction for atoms and nuclei, which of the following statements is correct regarding the two split levels $j_1 = l + 1/2$ and $j_2 = l - 1/2$?
   A) In the nuclear case, j_2 lies lower in energy whereas in the atomic case, it is j_1 which lies lower in energy
   B) In the nuclear case, j_1 lies lower in energy whereas in the atomic case, it is j_2 which lies lower in energy
   C) The separation between j_1 and j_2 in nuclei is much smaller than that for atoms
   D) The separation between j_1 and j_2 in both nuclei and atoms decreases as the l value increases

107. An excited state $5/2^+$ of a nucleus decays to another excited state $1/2^+$ emitting a gamma ray of energy $E_1 = 250$ keV. The same excited state also can decay to the ground state $3/2^-$ emitting a gamma ray of energy $E_2 = 500$ keV. What will be the ratio of the intensities of the two gamma ray transitions?

A) $E_1 : E_2 = 7813$ B) $E_1 : E_2 = 0.000128$
C) $E_1 : E_2 = 5 \text{ X } 10^{-7}$ D) $E_1 : E_2 = 2 \text{ X } 10^{6}$

108. A given species of radioactive nuclei has a mean life of 10 hours. What is the probability that a given nucleus in the sample will survive exactly three half lives?

A) 12.5% B) 87.5%
C) 5% D) 95%

109. Pick the correct choice for an experimental evidence for the existence of discrete energy levels for nuclei.

A) Electrons emitted during beta decay have discrete energies
B) The conversion electrons emitted from nuclei have discrete energies
C) The alpha rays emitted from nuclei have discrete energies
D) Nuclear decay is a discrete process

110. Given that the mass of a O^{16} nucleus is $2.66 \text{ X } 10^{-26}$ kg, what will be the approximate value for density of nuclear matter inside the nucleus?

A) 10^3 kg.m^{-3} B) 10^{12} kg.m^{-3}
C) 10^{24} kg.m^{-3} D) 10^{18} kg.m^{-3}

111. A proton is located at a distance of 12 fermis from the centre of an $_{13}Al^{27}$ nucleus. What can be said about the Coulomb force of repulsion and the nuclear force of attraction between the two?

A) The two forces are more or less equal in magnitude
B) The nuclear force is much stronger
C) The nuclear force is completely absent at this distance
D) Both are of similar magnitudes, but the Coulomb force is smaller

112. The atomic mass of helium is 4.0026 amu and that of hydrogen is 1.0078 amu. Neutron mass is 1.0087 amu. (1 amu = 931.5 MeV). What will be the binding energy per nucleon in the helium nucleus?

A) 7.1 MeV B) 28.3 MeV
C) 932.1 MeV D) 938.7 MeV

113. Heavier stable nuclei have a higher value of the neutron to proton ratio than light nuclei have. This is in order to provide

A) More nucleons so that the total binding energy increases
B) A greater magnitude of the weak nuclear interaction
C) More attractive electromagnetic interaction
D) More attractive strong interaction so that the repulsive electromagnetic forces can be overcome

114. In the Compton effect, a photon with energy E scatters through 90° from a stationary electron of mass m_e. The energy of the ejected electron will be

A) $E^2/(E+m_ec^2)$ B) E/2
C) E^2/m_ec^2 D) $m_ec^2E/(E+m_ec^2)$

115. Which equation is an example of artificial transmutation?

A) $_{92}U^{238} \rightarrow {}_2He^4 + {}_{90}Th^{234}$ B) $_{13}AL^{27} + {}_2He^4 \rightarrow {}_{15}P^{30} + {}_0n^1$

C) $_6C^{14} \rightarrow {}_7N^{14} + e^- + \nu$ D) $_{88}Ra^{226} \rightarrow {}_2He^4 + {}_{86}Ra^{222}$

116. According to the liquid drop model, the fission process occurs due to

A) Pairing of nucleons
B) Neutron-proton asymmetry
C) Large oscillations
D) A competition between surface energy and Coulomb energy

117. One of the following properties of a nucleus is decided by the shape of the nucleus. Which one is it?

A) Mass of the nucleus
B) Electric dipole moment
C) Electric quadrupole moment
D) Magnetic moment

118. A sodium iodide detector is used to detect gamma rays of energy 1.022 MeV and the Compton scattered gamma rays at 90^0 to the incident beam. The amplitude of the pulses corresponding to the direct gamma rays is 5.11 Volts. What will be the the amplitude of the pulses corresponding to the scattered gamma rays?

A) 2.56 Volts B) 1.7 Volts

C) 0.22 Volts D) 3.41 Volts

119. Protons and neutrons are fermions and also baryons. Which of the following describes protons and neutrons?

A) They are composed of three quarks and have a half integer spin
B) They are composed of a quark and an antiquark and have a half integer spin
C) They are composed of three quarks and have zero or integer spin
D) They are composed of a quark and an antiquark and have zero or integer spin

120. Identify the principal mode of decay of the positively charged muon $^+$?

A) $^+ \rightarrow \pi^+ + \nu \ + \nu_e$ B) $^+ \rightarrow e^+ + \nu_e + \bar{\nu}$

C) $^+ \rightarrow p + \nu$ D) $^+ \rightarrow n + e^+ + \nu$

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