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1. A spherical body of density ρ and radius r is moving with velocity v in a medium whose coefficient of viscosity is η and density σ. Which one of the following gives the retardation F due to viscous drag?
   (a) $6\pi\eta rv$
   (b) $4\pi r^3\rho g/3$
   (c) $4\pi r^3\sigma g/3$
   (d) $4r^3(\rho - \sigma)g/3$

2. A particle moves under the effect of a force F = cx from x = 0 to x = x_1. What is the work done in the process?
   (a) cd_1^2
   (b) $cx_1^2 / 2$
   (c) $cx_1^3 / 3$
   (d) zero

3. Two planets of masses M_1 and M_2 have satellites of masses m_1 and m_2 respectively, revolving around them at the same radius r. the period of the first satellite (of mass m_1) is twice as that of the second. Which one of the following relations is correct?
   (a) $4M_1 + M_2$
   (b) $2M_1 = M_2$
   (c) $M_1 = 2M_2$
   (d) $m_1M_1 = m_2M_2$

4. The amplitude of a damped harmonic oscillator in successive cycles decreases as
   (a) in an arithmetic progression
   (b) in a geometric progression
   (c) linearly exponentially
   (d) exponentially

5. A photon has energy e. What is its relativistic mass?
   (a) E / c
   (b) E / c^2
   (c) Zero
   (d) Infinity

6. A particle is moving with a constant velocity parallel to the axis of y and a velocity parallel to the axis of x proportional to y. It will describe a
   (a) circle
   (b) parabola
   (c) spiral
   (d) catenary

7. R is the range on a horizontal plane for shot with the same velocity at two different angles of projection. If h and h′ be the greatest heights attained corresponding to these angles of projection, then what is R^2 equal to?
   (a) hh′
   (b) 9hh′
   (c) 16hh′
   (d) 25hh′

8. A particle is executing SHM. If the displacement at any instant is given by x = 3 cos 2t + 4 sin 2t, what is the time period of the particle?
   (a) 1.57 s
   (b) 2 s
   (c) 3.14 s
   (d) 5 s

9. A body of mass 2m is split into two equal parts by an internal explosion which generates a kinetic energy E. If, after the explosion, the parts move in the same line as before then what is their relative speed?
   (a) $\sqrt{E / m}$
   (b) $\sqrt{2E / m}$
   (c) $\sqrt{4E / m}$
   (d) 0

10. A body is rolling down an inclined plane with angle of inclination θ and coefficient of sliding friction μ. What is the acceleration of the body downwards along the plane?
    (a) $\mu g \cos\theta$
    (b) $\mu g \sin\theta$
    (c) $g(\cos\theta - \mu \sin\theta)$
    (d) $g(\sin\theta - \mu \cos\theta)$

11. A body of mass m is released from a height equal to the radius R of the earth. What will be the velocity of the body when it strikes the surface of the earth?
    (a) $\sqrt{gR}$
    (b) $\sqrt{2gR}$
    (c) $2\sqrt{gR}$
    (d) $\sqrt{gR / 2}$

12. A closed organ pipe and an open organ pipe of same length are set into vibrations simultaneously. The beat frequency is 4. If the length of each of them is doubled, then what is the beat frequency?
    (a) 2
    (b) 4
    (c) 6
    (d) 8

13. Consider a satellite going around the earth in a circular orbit at a height of 2R from the surface of the earth, where R is the radius of the earth. What is the speed of the satellite?
    (a) gR / 3
    (b) $(gR / 3)^{1/2}$
    (c) $(gR / 2)^{1/2}$
    (d) gR / 2

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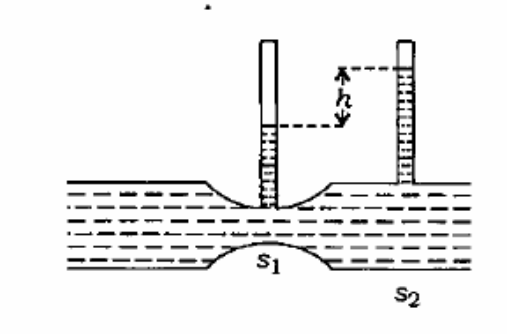
14. Two manometers are mounted on a horizontal pipe carrying water at the positions where the areas of cross-sections of the pipe are s_1 and s_2 as shown in the figure. If the difference in water column at these cross-sections is h, what is the volume of water flowing through the pipe per unit time?



(a) $s_2^2\sqrt{\dfrac{2gh}{s_2^2 - s_1^2}}$

(b) $s_2\sqrt{2gh}$

(c) $(s_2 - s_1)\sqrt{2gh}$

(d) $s_1 s_2\sqrt{\dfrac{2gh}{s_2^2 - s_1^2}}$

15. A clock is moving with a constant speed v = c/2 along the x-axis with respect to an inertial frame of reference F, c being the speed of light. It shows a time t = 0 when it is crossing the origin. What is the time shown by this moving clock when it has moved to a position x = c in frame F?

(a) 1 s (b) $\dfrac{1}{\sqrt{3}}$ s

(c) 2 s (d) $\sqrt{3}$ s

16. A ρ-meson of mass M at rest decays into two pions each of rest mass m. What is the speed of either of these pions in terms of the speed of light c?

(a) $c\left(1 - \dfrac{4m^2}{M^2}\right)^{1/2}$ (b) $c\left(1 - \dfrac{4m^2}{M^2}\right)$

(c) $c\left(1 - \dfrac{2m}{M}\right)^{1/2}$ (d) $c\left(1 - \dfrac{2m}{M}\right)$

17. An object of small size and mass m is attached to a spring of force constant k fixed at one end and is undergoing linear oscillatory motion. If its maximum displacement from the point of equilibrium is x_0, what is its speed when it is at a distance of $x_0/2$ from the equilibrium point?

(a) $x_0\,[3k/(4m)]^{1/2}$ (b) $x_0\,[k/(m)]^{1/2}$

(c) $x_0\,[k/(2m)]^{1/2}$ (d) $x_0\,[k/(3m)]^{1/2}$

18. The following equations represent transverse waves:

$Z_1 = A\cos(kx - \omega t)$

$Z_2 = A\cos(kx + \omega t)$

$Z_3 = A\cos(ky - \omega t)$

Which one of the following combinations represents a wave traveling in a direction making an angle 45° with the positive x and positive y axes?

(a) $z_1 + z_2$ (b) $z_1 + z_3$

(c) $z_2 + z_3$ (d) $z_1 + z_2 + z_3$

19. A sphere of radius r and density p is dropped under gravity through a fluid of viscosityη. If the average acceleration is half of initial acceleration, what is the time required to attain terminal velocity?

(a) $4pr^2 / (9\eta)$ (b) $9pr^2 / (4\eta)$

(c) $4pr^2 / (3\eta)$ (d) pr^2 / η

20. A rod at rest in an inertial frame of reference F is of length l and inclined to the x-axis by an angle of 45°. What is the length of this rod as observed from a frame F′ which is moving with velocity ν in the x-direction with respect to frame F?

(a) $l\left(1 - \dfrac{\nu^2}{c^2}\right)^{1/2}$ (b) $\dfrac{l}{\left(1 - \dfrac{\nu^2}{c^2}\right)^{1/2}}$

(c) $\dfrac{l}{\left(1 - \dfrac{\nu^2}{2c^2}\right)^{1/2}}$ (d) $l\left(1 - \dfrac{\nu^2}{2c^2}\right)^{1/2}$

21. A convex lens makes the real image of a point situated on the optic axis. If the upper-half part of the lens is painted with black colur, what will happen to the image?

(a) The image will be displaced downward.
(b) The image will be displaced upward.
(c) The image will be displaced on the optic axis
(d) The image will not be displaced

22. The telescope uses a parabolic reflector so that it can completely eliminate

(a) chromatic aberration
(b) spherical aberration
(c) astigmatism
(d) distortion

23. At a point P, a distance L from a point source of light, the intensity is measured to I. An aperture is now introduced between the source and the point P such that it blocks all Fresnel zones except the central zone. What is the intensity at P now?

(a) 4I (b) 2I

(c) I / 2 (d) I / 4

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24. In a Michelson interferometer, sharp circular fringes are observed. A very thin plate with optical thickness equal to twenty wavelengths of the light being used is inserted into one of the interferometer arms. What is the number of bright fringes that cross the field of view?
(a) 10 (b) 20
(c) 40 (d) 80

25. When a thin glass wedge of refractive index 1.5 is illuminated by the wavelength of light 600 Å, the fringes of equal thickness are observed with fringe spacing of 1 mm. What is the angle of wedge in radian?
(a) 1×10^{-4} (b) 2×10^{-4}
(c) 4×10^{-4} (d) 6×10^{-4}

26. Keeping the width of transmission grating the same, the number of lines is increased. Which one of the following will happen in the diffraction pattern?
(a) The diffraction pattern will remain unchanged
(b) The principal maxima will increase in height and their width will increase
(c) The principal maxima will decrease in height and their width will decrease
(d) The principal maxima will increase in height but their width will decrease

27. The resolution of an object being observed using a microscope will improve, if light of
(a) higher frequency is used
(b) lower frequency is used
(c) plane polarization is used
(d) higher intensity is used

28. A very small source of light is observed with a microscope. Around the sharply focused image, circular fringes are observed. These diffraction fringes are due to
(a) Fresnel diffraction only
(b) Fraunhofer diffraction only
(c) both Fresnel and Fraunhofer diffractions
(d) neither Fresnel nor Fraunhofer diffraction

29. Q quarter-wave plate is placed on a shiny coin. On the top of the quarter-wave plate, a linear polarizer is placed. When the polarizer is rotated with respect to the quarter-wave plate, the coin appears to darken and then again becomes shiny. What is the angel between the axis of the quarter-wave plate and that of polarizer when the coin appears darkest?
(a) 180°
(b) 90°
(c) 45°
(d) 0°

30. What is the dimension of the quantity 'specific rotation?
(a) $M^{-1}L$ (b) $M^{-1}L^2$
(c) $M^{-1}L^3$ (d) $M^{-1}L^2T$

31. A signal of 100 mw is injected into a fiber. The outcoming signal form the other end is of 10 mw. What is the loss?
(a) 10 dB (b) 20 dB
(c) 100 dB (d) 1000 dB

32. The longitudinal chromatic aberration depends on which one of the following?
(a) Dispersive power of the lens only
(b) Mean focal length of the lens only
(c) Both (a) and (b)
(d) Neither (a) nor (b)

33. What is the additional phase difference caused, if a thin transparent plate of thickness 8 μm and refractive index 1.4 is introduced across one of the beams in a Young's double-silt experiment? [The wavelength of light (in air) used is 4000 Å]
(a) 8π
(b) 11.2π
(c) 6π
(d) None of the above

34. What is the total angular width of the central maximum in diffraction due to a single slit?
(a) λ / a (b) $2\sin^{-1}(\lambda / a)$
(c) $2\cos^{-1}(\lambda / a)$ (d) a / λ

35. A right circularly polarized light is incident normally on a quarter wave plate. The output will be
(a) linearly polarized light
(b) right circularly polarized light
(c) left circularly polarized light
(d) unpolarized light

36. A rectangular coil is rotating in a uniform magnetic field B. The e.m.f. induced in the coil is maximum when the plane of the coil
(a) is parallel to B
(b) makes an angle 30° with B
(c) makes an angle 45° with B
(d) is perpendicular to B

37. A disc rotates at 300 r.p.m. A variable force is applied to it and the speed is reduced according to the law $\alpha = -2\omega$ revolutions per square minute, where ω is in r.p.m. What is the expression for revolutions θ as a function of time t?
(a) $\theta = 150 (1 - e^{-2t})$
(b) $\theta = 150 (1 - e^{2t})$
(c) $\theta = 150 (1 + e^{-2t})$
(d) $\theta = 150 (1 + e^{2t})$

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38. A rigid insulated box is divided into two parts with a partition. One part is occupied by 1 gm mole of ideal gas at temperature T_1 and the other by 2 gm moles of the same ideal gas at temperature T_2. When the partition is removed, what is the final equilibrium temperature of the mixture?
(a) $T = (T_1 + T_2) / 2$
(b) $T = (2T_1 + T_2) / 3$
(c) $T = (T_1 + 2T_2) / 3$
(d) Cannot be determined due to insufficient data

39. The relation $\int T\,dS = \int p\,dV$ is valid for
(a) any process
(b) any cycle
(c) any reversible process
(d) any adiabatic process

40. Consider an ideal gas with molar specific heat $C_V = 3R / 2$. It is at temperature T_0 and has a volume V_0. If it is adiabatically compressed to volume $V_0 / 2$, then what is the final temperature?
(a) $2^{1-\gamma} T_0$ (b) $2^{\gamma-1} T_0$
(c) $2^{\gamma} T_0$ (d) $2 T_0$
Where γ is the ratio between specific heats.

41. What is the maximum amount of work that can be done by extracting 1J of heat energy from a body at temperature 127°C with an environment at temperature 27°C?
(a) 1 / 8 J (b) 1 / 4 J
(c) 1 / 2 J (d) 3 / 4 J

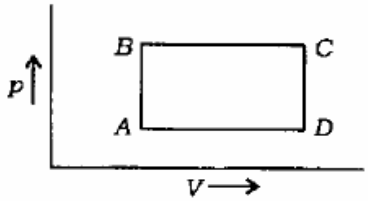
42. What is the change in entropy when 100 gm of water is heated from 27°C to 87°C? [Take specific heat of water to be constant, 4.185 J/(gm K)]
(a) 25110 J/K
(b) 418.5 ln(5) J/K
(c) 418.5 ln(6) J/K
(d) 418.5 ln(1.2) J/K

43. What is the change in entropy of one gram mole of an ideal gas when it expands isothermally from volume V_1 to volume V_2?
(a) $R (V_2 - V_1)$ (b) $R (V_2 / V_1)$
(c) $R \ln(V_1 - V_2)$ (d) $R \ln(V_2 / V_1)$

44. A blackbody with surface area A and temperature 127°C emits an amount of radiation E J/s. What is the radiation emitted by another blackbody with surface area 2A and temperature 327°C
(a) 10.125E (b) 3E
(c) 4.5E (d) 6.75E

45. The radiation emitted per unit wavelength per unit time by a blackbody at temperature T has maximum at wavelength λ. What is the wavelength at which the radiation emitted per unit wave-length per unit time by this blackbody at temperature 2T is maximum?
(a) 2λ (b) 4λ
(c) $\lambda / 2$ (d) $\lambda / 4$

46. The root-mean-square velocity of one molecule at 300 K is four times that of another molecule. If the first molecule is hydrogen, then which one of the following may be the other molecule?
(a) helium (b) Boron
(c) Oxygen (d) Carbon dioxide

47. 

Consider the figure given above. When a system is taken from state A to state B along the path ACB, 80 J of heat flows into the system and the system does 30 J of work. How much heat would flow into the system if the system is taken from state A to state B along the path ADB and the system does 10 J of work?
(a) 30 J (b) 40 J
(c) 50 J (d) 60 J

48. What is the approximate root-mean sped of fine smoke particle of mass 10^{-14} kg at 27°C?
[$k = 1.38 \times 10^{-23}$ J/K]
(a) 2.0×10^{-2} m/s
(b) 2.7×10^{-2} m/s
(c) 3.5×10^{-2} m/s
(d) 4.4×10^{-2} m/s

49. In a gas consisting of n molecules, what is the number of molecular collisions occurring per second?
(a) np
(b) np / 2
(c) 2np
(d) n(n – 1) p / 2

50. The Maxwell thermodynamical relation
$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V$
Can be derived from which one of the following relations?
(a) dU = dQ – pdV
(b) dH = dU + pdV + Vdp
(c) dF = dU – TdS – SdT
(d) dG = dH – TdS – SdT

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51. What is the kinetic energy of a molecule of a diatomic gas at STP?
(a) kT / 2 (b) kT
(c) 3kT / 2 (d) 5kT / 2

52. A Carnot engine working between 300 K and 600 K has a work output of 800 J per cycle. What is the amount of heat energy supplied to the engine from a source in each cycle?
(a) 800 J (b) 1600 J
(c) 3200 J (d) 6400 J

53. A positron is projected into a uniform magnetic field with its velocity vector making an angle of 79° with the field. What is the trajectory of the positron?
(a) Circle (b) Parabola
(c) Straight line (d) Helix

54. Three identical charges each of magnitude q are placed at the corners of an equilateral triangle of side a. What is the magnitude of force on each charge?
(a) $F = q^2 / (4\pi\varepsilon_0 a^2)$
(b) $F = \sqrt{3}\, q^2 / (4\pi\varepsilon_0 a^2)$
(c) $F = q^2 / (4\pi\varepsilon_0 a^2)$
(d) $F = \sqrt{3}\, q^2 / (8\pi\varepsilon_0 a^2)$

55. Consider a spherically symmetric charge distribution with density
$\rho(r) = \rho_0$ for $r < R$ where ρ_0 is constant = 0 for $r \geq R$
What is the magnitude of the electric field at r = R / 2
(a) $\rho_0 R / (6\varepsilon_0)$ (b) $\rho_0 R / (3\varepsilon_0)$
(c) $\rho_0 / (4\pi\varepsilon_0 R)$ (d) $\rho_0 / (4\pi\varepsilon_0 R^2)$

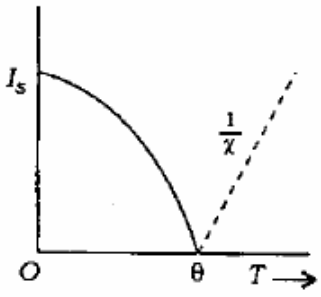
56. A sphere of radius R is made up of uniformly distributed positive change. At a distance r from the centre inside the sphere, the electric field is proportional to which one of the following?
(a) r^{-2}
(b) r^{-1}
(c) r
(d) The electric field does not depend on r

57. What is the electric flux through each of the faces of a cube of side 1 m, if a charge q coulomb is placed at the point of intersection of its diagonals?
(a) q / ε_0
(b) $6q / \varepsilon_0$
(c) $q / (6\varepsilon_0)$
(d) $q / (3\varepsilon_0)$

58. A piece of dielectric of thickness slightly less than the separation between the plates of a charged and isolated parallel-plate condenser is inserted partly between the plates.
Consider the following statements:
1. The energy stored in the condenser decreases.
2. The free charged density on the condenser plates decreases.
Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

59. A capacitor consists of two parallel plates each of area A and separated by a distance d. If it is connected by a battery of voltage V, what is the final charge stored on each plate?
(a) $(\varepsilon_0 A / d))V$
(b) $[\varepsilon_0 A / (2d)]V$
(c) $(2\varepsilon_0 A / d)V$
(d) $(4\varepsilon_0 A / d)V$

60. Copper and iron wires of same length and diameter are in series and connected across a battery. The resistivity of copper is about one-sixth of that of iron. If E_1 and E_2 are the electric fields in the copper and iron wires respectively, then which one of the following is correct?
(a) $E_1 < E_2$
(b) $E_1 = E_2 \neq 0$
(c) $E_1 > E_2$
(d) $E_1 = E_2 = 0$, because electric field cannot exist in metals

61. 

The variation of magnetization with temperature (T) of a magnetic material is shown in the figure. As the temperature increases, the magnetization drops down to zero at Curie temperature θ. Above Curie temperature, $1/\chi$ (where χ is the susceptibility) increases linearly with temperature. What would be the nature of magnetic material?
(a) Ferromagnetism
(b) Paramagnetism
(c) Ferrimagnetism
(d) Antiferromagnetism

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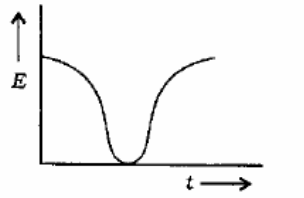
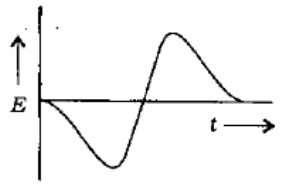
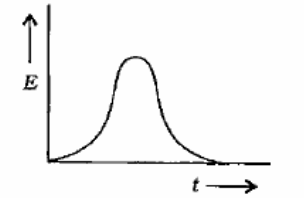
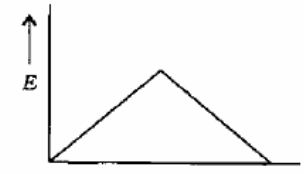
62. For engineering applications (electric motors, loudspeakers, etc.), the magnetic materials with high coercivity, high remanence and large hysteresis loss are desirable. These materials are categorized as
(a) hard magnetic materials
(b) soft magnetic materials
(c) normal magnetic materials
(d) None of the above

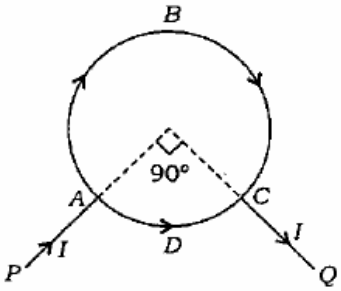
63. A resistor has stripes that read green, blue, brown and silver. What is its nominal resistance and tolerance?
(a) 56 Ω ± 5%
(b) 560 Ω ± 10%
(c) 560 Ω ± 5%
(d) 5600 Ω ± 10%

64. If a short magnet is moved along the axis of a coil with constant velocity, the variation of induced e.m.f. (E) with time (t) is best represented as which one of the following?
(a)


(b)


(c)


(d)


65. A battery is connected between points P and Q such that a current I flows from P to Q. From point A to point c, the current flows through two circular arcs ABC and ADC as shown in the figure above. The arc ADC makes an angle 90° at the centre. The entire circle is made up of the same wire. What is the magnetic induction at the centre of the circle of radius r?


(a) $\mu_0 I / (2r)$
(b) $\mu_0 I / (4r)$
(c) $3\mu_0 I / (8r)$
(d) 0

66. A rectangular frame of wire is moving with constant velocity in a non-uniform magnetic field which is perpendicular to the plane of the frame.
Consider the following statements:
1. The role of the sides of the frame, parallel to the direction of velocity, is only to provide a closed path.
2. Joule heating takes place in the frame.
Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

67. Which one of the following statements is not correct?
In an LCR circuit at resonance
(a) the impedance is purely resistive
(b) the current is maximum and in phase with the applied voltage
(c) quality factor of the circuit is maximum
(d) voltage across the inductance is equal to voltage across the capacitance but out of phase.

68. In a series LCR circuit, the resonant frequency is 1000 Hz. The half-power points are obtained at frequencies 950 Hz and 1050 Hz. What are the quality factor and bandwidth of the circuit respectively?
(a) 100, 100 Hz
(b) 10, 100 Hz
(c) 10, 10 Hz
(d) 100, 10 Hz

69. There is a phase change of 180° when an electromagnetic wave is
(a) reflected from a denser medium
(b) reflected from a rarer medium
(c) transmitted to a denser medium
(d) transmitted to a rarer medium

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70. In a Van de Graaff accelerator, charge is always transferred from the inner shell of radius r to the outer shell of radius R (r << R). The charge is transferred, because
(a) irrespective of potentials, the charge is always transferred whenever two metallic bodies make electric contact
(b) irrespective of the quantity of charge on the outer shell, the potential of the inner shell is higher than that of the outer shell
(c) the outer shell has larger charge-holding capacity (capacitance)
(d) surface charge density is higher on the inner shell

71. Consider the following statements in respect of a cyclotron:
1. In a 50 MeV proton cyclotron with uniform magnetic field, the cyclotron frequency at 10 MeV energy is equal to the cyclotron frequency of the same proton at 50 MeV energy.
2. Relativistically moving particle has higher mass than its rest mass.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

72. Two particles with charges q_1 and q_2 (both positive) are initially at rest at a distance d at t = 0 and are released. What is their total kinetic energy when they are at a distance 3d (taking only coulombic forces into account)?
(a) $q_1q_2 / (12\pi\varepsilon_0 d)$ (b) $q_1q_2 / (6\pi\varepsilon_0 d)$
(c) $q_1q_2 / (4\pi\varepsilon_0 d)$ (d) $q_1q_2 / (3\pi\varepsilon_0 d)$

73. A positronium atom is made up of one electron and one positron. What is the ground-state energy of positronium atom?
(a) –6.8 eV (b) 6.8 eV
(c) –13.6 eV (d) 13.6 eV

74. Projection of angular momentum of a 2p electron on the z-axis has values
(a) $\sqrt{2}h/(2\pi), 0, -\sqrt{2}h/(2\pi)$
(b) $h/(2\pi), 0, h/(2\pi)$
(c) $h/(2\pi), 0, -h/(2\pi)$
(d) h, 0, –h

75. Consider the following statements in respect of Zeeman effect:
1. Atoms are placed in weak electric field.
2. Atoms are placed in weak magnetic field.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

76. X-rays of wavelength λ are incident on a crystal and the second-order reflection from the crystal is observed at an angle 45°. What is the lattice constant of the crystal?
(a) λ (b) 2λ
(c) $\lambda / \sqrt{2}$ (d) $\sqrt{2}\,\lambda$

77. Consider the following statements in respect of Moseley law of x-ray spectra:
1. Plot of square root of the frequency of K_α line and atomic number is a straight line.
2. plot of square root of the frequency of L_α line and atomic number is a straight line.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

78. Which one of the following is correct in respect of an electron and a proton having same de Broglie wavelength of 2 Å?
(a) Both have same kinetic energy
(b) The kinetic energy of proton is more than that of electron
(c) Both have same velocity
(d) Both have same momentum

79. A particle of energy E is incident from the left on a potential step of height V_0 at x = 0. If E < V_0, what is the wave function in the region x > 0?
(a) $C \exp(-i\omega t + kx)$
(b) $C \exp(-i\omega t + ikx)$
(c) $C \exp(i\omega t - ikx)$
(d) $C \exp(-i\omega t - kx)$

80. Approximately how many half-life periods must elapse, if the activity of a radioactive isotope sample is to be reduced to 0.004 of the original value?
(a) 3 (b) 5
(c) 8 (d) 60

81. Consider the following in respect of baryons:
1. They interact strongly.
2. They interact weakly.
3. They possess integral spin.
4. They possess half-integral spin.
Which of the above are correct?
(a) 1 and 3 (b) 1 and 4
(c) 2 and 3 (d) 2 and 4

82. When a neutron is converted into a proton
(a) only an electron is produced
(b) one electron and a neutrino are produced
(c) one electron and an anti-neutrino are produced
(d) one electron and a photon are produced

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83. In a photoelectric effect experiment, the maximum energy of the emitted electrons is 1 eV for incoming radiation of frequency ν_0 and 3 eV for incoming radiation of frequency $3\nu_0 / 2$. What is the maximum energy of the electrons emitted from incoming radiation of frequency $9\nu_0 / 4$?
(a) 8 eV
(b) 6 eV
(c) 4.5 eV
(d) 3 eV

89. For which decay scheme of the original nucleus are the original nucleus and the final nucleus isotopes?
(a) Two gamma decays
(b) An alpha decay followed by two beta decays
(c) A beta decay followed by an alpha decay
(d) A beta decay followed by neutron emission

90. Consider the fission process of decay
$^{236}A \rightarrow {}^{144}B + {}^{89}C + 3n$
If the approximate binding energy per nucleon is 7 MeV for A, 8 MeV for B and 8 MeV for C, what is the energy released in the decay of one nucleus of A?
(a) 236 MeV
(b) 233 MeV
(c) 226 MeV
(d) 212 MeV

91. The decay of $\Lambda \rightarrow p + \pi^-$ through strong interaction is forbidden, because the process violates
(a) charge conservation
(b) angular momentum conservation
(c) parity conservation
(d) strangeness conservation

92. Match List I with List II and select the correct answer using the code given below the lists:

	List I		List II
A.	Electromagnetic interaction	1.	Hadrons
B.	Weak (nuclear) interaction	2.	Photons
C.	Strong (nuclear) interaction	3.	Leptons

Code:

	A	B	C
(a)	1	2	3
(b)	1	3	2
(c)	2	1	3
(d)	2	3	1

93. The Compton wavelength of an electron is about 0.024 Å. If an incoming radiation of wavelength 0.024 Å is scattered at an angle 90° by an electron initially at rest, what is the angle at which the electron comes out?
(a) $-45°$ (b) $-\tan^{-1}2$
(c) $-60°$ (d) $\tan^{-1}(-1/2)$

94. When reverse voltage across silicon diode is charged from 4 V to 8 V, what happens to depletion layer?
(a) It decreases
(b) It increases
(c) It is unaffected
(d) It may increase or decrease

95. In n-type semiconductor when all donor states are filled, then the net charge density in the donor sates becomes
(a) 1 (b) > 1
(c) <1 but not zero (d) 0

96. Two identical Zener diodes having specification 12 v, $\frac{1}{4}$ W are connected in series. If breakdown voltage of each diode is 5 V, then what is the breakdown voltage in the series combination of the diodes?
(a) 2.5 V (b) 5 V
(c) 10 V (d) 12 V

97. Consider the following truth table:

Inputs			Output
A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

What is the simplified Boolean expression for the output X in terms of inputs a, B and C?
(a) $\overline{A}\overline{B} + \overline{A}B\overline{C}$
(b) $A\overline{B} + A\overline{B}C$
(c) $\overline{A}\overline{B} + AB\overline{C}$
(d) $\overline{A}\overline{B} + AB\overline{C}$

98. A BJ having current amplification factor 0.99 is used in a common-base mode. If the load resistance is 4.5 kΩ and dynamic resistance of the emitter junction is 50 Ω, then what is the voltage gain?
(a) 89.1
(b) 79.1
(c) 69.1
(d) 59.1

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99. In an n-type semiconductor, the Fermi level lies 0.3 eV below the conduction lies 0.3 eV below the conduction band at 300 K. If the temperature is increased to 330 K, where does the new position of the Fermi level lie?
(a) 0.55 eV below the conduction band
(b) 0.44 eV below the conduction band
(c) 0.33 eV below the conduction band
(d) 0.27 eV below the conduction band

100. The built-in potential of p-n junction diode is a function of
(a) temperature (b) biased voltage
(c) doping density (d) All of the above

101. In CE mode, the input characteristic of BJT is the variation of
(a) I_B versus V_{BE} at constant V_{CE}
(b) I_C versus V_{CE} at constant V_{BE}
(c) I_C versus V_{CE} at constant I_B
(d) I_B versus V_{CE} at constant V_{BE}

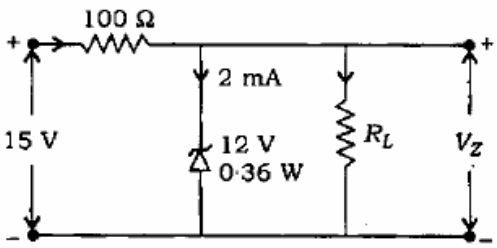
102. At very high frequencies, mica capacitors are used, because
(a) mica has high resistivity at these frequencies
(b) the additional energy for the reversal of particles of the dielectric in a.c. field is small
(c) the retention of charge by mica is negligible
(d) leakage loss in mica does not exist

103. A particle of mass m and charge q is rest at t = 0 in a uniform electric field E in the x-direction and is released. If the particle moves through a distance of 5 m between t = 1s and t = 2s, what is the magnitude of E?
(a) 10m / (3q) (b) m / q
(c) 3m / (10q) (d) q / m

104. Consider a circular charge loop with radius r and total charge Q lying in the xy-plane with centre at the origin. What is the magnitude of the force acting on a point charge q at a point (0, 0, z)?
(a) $qQ / [4\pi\varepsilon_0(r^2 + z^2)]$
(b) $qQ / [4\pi\varepsilon_0(r^2 + z^2)r]$
(c) $qQz / [4\pi\varepsilon_0(r^2 + z^2)^{3/2}]$
(d) $qQz / [4\pi\varepsilon_0(r^2 + z^2)^{1/2}]$

105. In spherical wavefronts, the amplitude of th edistrubance is proportional to
(a) r
(b) r^{-1}
(c) r^2
(d) r^{-2}

106.



In the above circuit, what is the range over which the load resistance can be varied?
(a) $298.6\ \Omega \le R_L < \infty$
(b) $303.7\ \Omega \le R_L < \infty$ only
(c) $408.2\ \Omega \le R_L < \infty$ only
(d) $428.6\ \Omega \le R_L < \infty$ only

107. In Stern-Gerlach experiment, one finds the spin (i.e., total angular momentum) of the charged atom due to splitting on the screen.
Consider the following statements:
1. The splitting is due to magnetic field gradient.
2. The charged atom must travel perpendicular to the field gradient so that splitting occurs.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

108. Which one of the following is correct about wave-particle duality?
(a) Wave-particle duality holds for matter particles but not for light
(b) Wave-particle duality holds for light but not for matter particles
(c) Wave-particle duality holds for electrons but not for protons
(d) Wave-particle duality holds for light as well as for matter particles

109. A whistle of frequency 540 hz rotates in a circle of radius 2m at an angular speed of 15 rad/s. What are the lowest and the highest frequencies respectively heard by listener, a long distance away at rest with respect to the centre of the circle? (Speed of sound = 330 m/s
(a) 495 Hz, 505 Hz
(b) 490 Hz, 505 Hz
(c) 495 Hz, 594 Hz
(d) 490 Hz, 594 Hz

110. The principal quantum number n characterizes the allowed energy levels of hydrogen atom. In which of the following transitions, the emitted photon has the shortest wavelength?
(a) n = 2, n = 1 (b) n = 3, n = 2
(c) n = 4, n = 3 (d) n = 5, n = 4

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111. A rectangular block of mass 5 kg is kept on a horizontal surface. The coefficient of friction between the block and the surface is 0.2. if a force of 20 N is applied to the block at an angle of 30° with the horizontal plane, what is the force of friction on the block? (Take g = 10 m/s^2)

(a) 5 N (b) 10 N
(c) 12 N (d) 20 N

112. In a typical phase transition (such as condensation), which one of the following remains unchanged?

(a) Internal energy
(b) Enthalpy
(c) Helmholtz free energy
(d) Gibbs free energy

113. The electric field associated with a propagating electromagnetic wave is described by the equation
$E = E_0 \sin (4\pi \times 10^6 x - 1.2\pi \times 10^{15} t)$
Where x is in meter and t is second. What is the wavelength?

(a) 10^{-6} m (b) 5×10^{-6} m
(c) 5×10^{-7} m (d) 10^{-7} m

114. What is the ratio of moment of inertia of a thin rod about an axis through midpoint and perpendicular to its length and that about an axis through one end and perpendicular to its length?

(a) 1 / 4 (b) 1 / 3
(c) 1 / 2 (d) 1

115. What is the number of electrons in an atom in which all the states with principal quantum numbers n = 1, 2, 3 and the angular momentum quantum numbers l = 0, 1 states with principal quantum number n = 4 are filled?

(a) 10 (b) 18
(c) 30 (d) 36

Directions:
The following five (5) items consists of two statements, one labeled as 'Assertion (A)' and the other as 'Reason (R)'. You are to examine these two statements carefully and select the answers to these items using the code given below.

Codes:

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

116. **Assertion (A):** When an ultrasonic wave is passed through an oil pot, it can heat a glass rod to a high temperature.

Reason (R): The temperature of the oil increases due to high frequency oscillations

117. **Assertion (A):** Diffusion is the phenomenon of movement of molecules from regions of higher molecular density to regions of lower molecular density.

Reason (R): The mean free path of the molecules of a gas depends on the number of molecules per unit volume and the size of the molecules.

118. **Assertion (A):** A source of light can be temporally coherent but spatially incoherent and vice versa.

Reason (R): Spatial coherence depends on the angular size of the source and temporal coherence on the monochromaticity. The two are therefore not dependent on each other

119. **Assertion (A):** The particle nature of light is prevalent in the photoelectric effect and the wave nature is essential to describe its interference effect.

Reason (R): The apparent paradox, leading to the dual nature of light, may be resolved in a probabilistic description of a particle, where the wave plays the role of a probability amplitude.

120. **Assertion (A):** A nuclear fission is initiated by the capture of thermal neutron by a heavy nucleus and involves release of about 200 MeV per fission.

Reason (R): The energy release occurs because the smaller fission-product nuclei are more tightly bound by about 1 MeV per nucleon than the original heavy nucleus.

End of question paper