PAPER -2003

1. A particle of mass M and charge Q moving with velocity $\vec{v}$ describes a circular path of radius R when subjected to a uniform transverse magnetic field of induction B. The work done by the field when the particle completes one full circle is

(A) $\left(\frac{Mv^2}{R}\right)2\pi R$ (B) zero

(C) $BQ2\pi R$ (D) $BQv2\pi R$

1. **B.**
Since the particle completes one full circle, therefore displacement of particle = 0
Work done = force × displacement = 0

2. A particle of charge -16×10^{-18} coulomb moving with velocity 10 ms^{-1} along the x-axis enters a region where a magnetic field of induction B is along the y –axis, and an electric field of induction B is along the y-axis, and an electric field of magnitude 10^4 V/m is along the negative z-axis. If the charged particle continues moving along the x-axis, the magnitude of B is

(A) 10^3 Wb/m^2 (B) 10^5 Wb/m^2
(C) 10^{16} Wb/m^2 (D) 10^{-3} Wb/m^2

2. **A.**
$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ ...(1)
The solution of this problem can be obtained by resolving the motion along the three coordinate axes namely

$$a_x = \frac{F_x}{m} = \frac{q}{m}(E_x + v_yB_z - v_zB_y)$$

$$a_y = \frac{F_y}{m} = \frac{q}{m}(E_y + v_zB_x - v_xB_z)$$

$$a_z = \frac{F_z}{m} = \frac{q}{m}(E_z + v_xB_y - v_yB_z)$$

For the given problem,

$$E_x = E_y = 0, \quad v_y = v_z = 0 \text{ and } B_x = B_z = 0$$

Substituting in equation (2), we get

$$a_x = a_z = 0 \text{ and } a_y = E_y - v_xB_z$$

If the particle passes through the region undeflected a_y is also zero, then

$$E_y = v_xB_z$$

$$\Rightarrow B_z = \frac{E_y}{v_z} = \frac{10^4}{10} = 10^3\,Wb/m^2$$

3. A thin rectangular magnet suspended freely has a period of oscillation equal to T. Now it is broken into two equal halves (each having half of the original length) and one piece is made to oscillate freely in the same field. If its period of oscillation is T', the ratio T'/T is

(A) $\frac{1}{2\sqrt{2}}$ (B) 1/2

(C) 2 (D) 1/4

3. **B.**
When the magnet is divided into 2 equal parts, the magnetic dipole movement

$M' = \text{pole strength} \times \text{length} = \frac{M}{2}$ and moment of inertia

$$I' = \frac{1}{12} \times \text{mass} \times (\text{length})^2$$

$$= \frac{1}{12} \times \frac{m}{2}\left(\frac{\ell}{2}\right)^2$$

$$\Rightarrow I' = \frac{I}{8}$$

Time period $= 2\pi\sqrt{\frac{I'}{M'B}} = 2\pi\sqrt{\frac{I/8}{\frac{M}{2}B}}$

$$T' = \frac{T}{2}$$

$$\Rightarrow \frac{T'}{T} = \frac{1}{2}$$

4. A magnetic needle lying parallel to a magnetic field requires W units of work to turn it through 60°. The torque needed to maintain the needle in this position will be

(A) $\sqrt{3}$ W
(B) W
(C) $(\sqrt{3}/2)$ W
(D) 2W

4. A.

$W = -MB(\cos\theta_2 - \cos\theta_1)$

Initially magnetic needle is parallel to a magnet field, therefore

$\theta_1 = 0,$

$\theta_2 = 60°$

$\therefore W = -MB(\cos 60° - \cos 0°)$

$= MB$

$e = MB \sin 60° = ZW \times \sqrt{3}/2 = \sqrt{3}W$

5. The magnetic lines of force inside a bar magnet

(A) are from north-pole to south-pole of the magnet
(B) do not exist
(C) depend upon the area of cross-section of the bar magnet
(D) are from south-pole to north-pole of the magnet.

5. D.

The magnetic lines of force inside a bar magnet are from south pole to north pole of the magnet.

6. Curie temperature is the temperature above which

(A) a ferromagnetic material becomes paramagnetic
(B) a paramagnetic material becomes diamagnetic
(C) a ferromagnetic material becomes diamagnetic
(D) a paramagnetic material becomes ferromagnetic.

6. A.

Curie temperature is the temperature above which a ferromagnetic material becomes paramagnetic.

7. A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of 5 m/s^2, the reading of the spring balance will be

(A) 24 N (B) 74 N
(C) 15 N (D) 49 N

7. A.
Reading of spring balance = m(g – a) = 5 × 4.8 = 24 N

8. The length of a wire of a potentiometer is 100 cm, and the e.m.f. of its stand and cell is E volt. It is employed to measure the e.m.f. of a battery whose internal resistance is 0.5 Ω. If the balance point is obtained at ℓ =30 cm from the positive end, the e.m.f. of the battery is

(A) $\frac{30\ E}{100.5}$
(B) $\frac{30\ E}{100-0.5}$
(C) $\frac{30(E-0.5i)}{100}$, where I is the current in the potentiometer wire.
(D) $\frac{30\ E}{100}$

8. A.
$V=\frac{E\ell}{L}=\frac{E\times 30}{100}=\frac{30E}{100}$.

9. A strip of copper and another germanium are cooled from room temperature to 80 K. The resistance of
(A) each of these decreases
(B) copper strip increases and that of germanium decreases
(C) copper strip decreases and that of germanium increases
(D) each of these increases.

9. C.
The temperature coefficient of resistance of copper is positive and that of germanium is negative, therefore when copper and germanium are cooled, resistance of copper strip decreases and that of germanium increases.

10. Consider telecommunication through optical fibres. Which of the following statements is not true?
(A) Optical fibres can be of graded refractive index.
(B) Optical fibres are subject to electromagnetic interference from outside.
(C) Optical fibres have extremely low transmission loss.
(D) Optical fibres may have homogeneous core with a suitable cladding

10. B.
Optical fibres are subject to electromagnetic interference from outside.

11. The thermo e.m.f. of a thermo-couple is 25 μV/°C at room temperature. A galvanometer of 40 ohm resistance, capable of detecting current as low as 10^{-5} A, is connected with the thermocouple. The smallest temperature difference that can be detected by this system is

(A) 16°C (B) 12°C
(C) 8°C (D) 20°C

11. **A.**

$E = 25\ \theta \times 10^{-6}$ V

$IR = 10^{-5} \times 40 = 4 \times 10^{-4}$ V

$$\theta = \frac{4 \times 10^{-4}}{25 \times 10^{-6}} = 16°C$$

12. The negative Zn pole of a Daniell cell, sending a constant current through a circuit, decreases in mass by 0.13 g in 30 minutes. If the electrochemical equivalent of Zn and Cu are 32.5 and 31.5 respectively, the increase in the mass of the positive Cu pole in this time is

(A) 0.180 g (B) 0.141 g
(C) 0.126 g (D) 0.242 g

12. **C.**

$$\frac{m_{Zn}}{m_{Cu}} = \frac{Z_{zx}}{Z_{Cx}}$$

I and t are same for both Cu and Zn electrodes

$$\frac{0.13}{m_{Cu}} = \frac{31.5}{32.5}$$

$$m_{Cu} = \frac{0.13 \times 32.5}{32.5} = 0.126 \text{ g.}$$

13. Dimensions of $\frac{1}{\mu_0 \varepsilon_0}$, where symbols have their usual meaning, are

(A) $[L^{-1}T]$ (B) $[L^{-2}T^{2}]$
(C) $[L^{2}T^{-2}]$ (D) $[LT^{-1}]$

13. **C.**

14. A circular disc X of radius R is made from an iron pole of thickness t, and another disc Y of radius 4R is made from an iron plate of thickness t/4. then the relation between the moment of inertia I_X and I_Y is

(A) $I_Y = 32 I_X$ (B) $I_Y = 16 I_X$
(C) $I_Y = 32\ I_X$ (D) $I_Y = 64\ I_X$

14. **D.**

If t is the thickness and R is the radius of the disc, then mass = $\pi R^2 t\rho$

ρ = density of the material of the disc.

Moment of inertia of disc X,

$$I_x = \frac{1}{2}\pi R^4 t\rho \qquad \text{...(i)}$$

Moment of inertia of disc Y,

$$I_y = 32\ \pi R^4 t\rho \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$I_y = 64\ I_x$$

15. The time period of a satellite of earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, the new time period will become

(A) 10 hours (B) 80 hours
(C) 40 hours (D) 20 hours

15. **C.**

Time period of a satellite T = $\frac{2\pi}{R_e}\sqrt{\frac{r^3}{g}}$

r = distance between satellite and the earth.

$$T \propto r^{3/2}$$

$$\Rightarrow \frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}$$

$$T_2 = 8T_1 = 8 \times 5 = 40 \text{ hours}$$

16. A particle performing uniform circular motion has angular momentum L. If its angular frequency is doubled and its kinetic energy halved, then the new angular momentum is

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

16. A.

Angular momentum of a particle performing uniform circular motion

L = Iω

Kinetic energy, $K = \frac{1}{2}I\omega^2$

Therefore, $L = \frac{2K}{\omega^2}\omega = \frac{2K}{\omega}$

$$\frac{L_1}{L_2} = \frac{K_1\omega_2}{K_2\omega_1}$$

$$\frac{L_1}{L_2} = 2 \times 2 = 4$$

$$L_2 = \frac{L}{4}.$$

17. Which of the following radiations has the least wavelength?

(A) γ-rays (B) β-rays
(C) α-rays (D) X-rays

17. D.

18. When U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed u, the recoil speed of the residual nucleus is

(A) $\frac{4u}{238}$ (B) $-\frac{4u}{234}$
(C) $\frac{4u}{234}$ (D) $-\frac{4u}{238}$

18. B.

According to principle of conservation of linear momentum the momentum of the system remains the same before and after the decay.

Atomic mass of uranium = 238 and after emitting an alpha particle.

= 238 – 4 = 234

$\therefore$ 238 $\times$ 0 = 4u + 234 v

$\therefore$ $v = -\frac{4u}{234}$.

19. Two spherical bodies of mass M and 5M and radii R and 2R respectively are released in free space with initial separation between their centres equal to 12R. If they attract each other

due to gravitational force only, then the distance covered by the smaller body just before collision is

(A) 2.5R
(B) 4.5R
(C) 7.5R
(D) 1.5R

19. **C.**
The two spheres collide when the smaller sphere covered the distance of 7.5 R.

20. The difference in the variation of resistance with temperature in a metal and a semiconductor arises essentially due to the difference in the
(A) crystal structure
(B) variation of the number of charge carries with temperature
(C) type of bonding
(D) variation for scattering mechanism with temperature.

20. **B.**
Variation of the number charge carriers with temperature.

21. A car moving with a speed of 50 km/hr, can be stopped by brakes after at least 6 m. If the same car is moving at a speed of 100 km/hr, the minimum stopping distance is
(A) 12 m
(B) 18 m
(C) 24 m
(D) 6 m

21. **C.**

22. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 m/s at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground?
[$g = 10\ m/s^2$, sin 30° = ½, cos 30° = √3/2]
(A) 5.20 m
(B) 4.33 m
(C) 2.60 m
(d) 8.66 m.

22. **D.**
The ball will be at the height of 10 m from the ground when it cover its maximum horizontal range.

Maximum horizontal range $R = \frac{u^2 \sin 2\theta}{g}$

$$R = \frac{(10)^2 \times 2 \times \frac{\sqrt{3}}{2} \times \frac{1}{2}}{10} = 8.66 \text{ m.}$$

23. An ammeter reads upto 1 ampere. Its internal resistance is 0.81 ohm. To increase the range to 10 A the value of the required shunt is
(A) 0.03 Ω
(B) 0.3 Ω
(C) 0.9 Ω
(D) 0.09 Ω

23. **D.**
$$S = \frac{I_g G}{I - I_g} = \frac{1 \times 0.81}{10 - 1} = 0.09\ \Omega$$

24. The physical quantities not having same dimensions are
(A) torque and work
(B) momentum and Planck's constant

(C) stress and Young's modulus (D) speed and $(\mu_0\varepsilon_0)^{-1/2}$

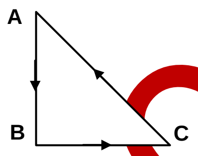
24. **B.**

Dimensions of momentum = kg m/sec = $[MLT^{-2}]$

Dimensions of Planck's constant = joule sec = $[ML^2T^{-1}]$

$\therefore$ Dimensions of momentum $\neq$ dimensions of Planck's constant.

25. Three forces start acting simultaneously on a particle moving with velocity $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC(as shown). The particle will now move with velocity



(A) less than $\vec{v}$

(B) greater than $\vec{v}$

(C) $|v|$ in the direction of the largest force BC

(D) $\vec{v}$, remaining unchanged.

25. **D.**

According to triangle law of vector addition if three vectors addition if three vectors are represented by three sides of a triangle taken in same order, then their resultant is zero. Therefore resultant of the forces acting on the particle is zero, so the particles velocity remains unchanged.

26. If the electric flux entering and leaving an enclosed surface respectively is ϕ_1 and ϕ_2, the electric charge inside the surface will be

(A) $(\phi_2 - \phi_1)\varepsilon_0$ (B) $\dfrac{(\phi_2 + \phi_1)}{\varepsilon_0}$

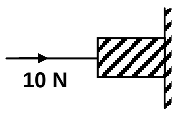
(C) $\dfrac{(\phi_2 - \phi_1)}{\varepsilon_0}$ (D) $(\phi_2 + \phi_1)\varepsilon_0$

26. **A.**

According to Gauss's theorem, charge in flux = $\dfrac{\text{charge enclosed by the surface}}{\varepsilon_0}$

$\therefore\ q = (\phi_2 - \phi_1)\varepsilon_0$.

27. A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2. The weight of the block is



(A) 20 N (B) 50 N

(C) 100 N (D) 2 N

27. **D.**

Weight of the block = $\mu R = 0.2 \times 10 = 2N$.

28. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s, then the coefficient of friction is

(A) 002 (B) 0.03

(C) 0.04 (D) 0.01

28. **C.**

Retardation $= \dfrac{u}{t} = \dfrac{6}{10} = 0.6\ \text{m/sec}^2$

Frictional force = μ mg = ma

$\therefore\ \mu = \dfrac{a}{g} = \dfrac{0.6}{10} = 0.06.$

29. Consider the following two statements.

(1) Linear momentum of a system of particles is zero.
(2) Kinetic energy of system of particles is zero.
(A) A does not imply B and B does not imply A.
(B) A implies B but B does not imply A
(C) A does not imply B but b implies A'
(D) A implies B and B implies A.

29. C.

30. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
(A) the rates at which current are changing in the two coils
(B) relative position and orientation of the two coils
(C) the materials of the wires of the coils
(D) the currents in the two coils

30. C.
The mutual inductance of the pair of coils depends on geometry of two coils, distance between two coils, distance between two coils, relative placement of two coils etc.

31. A block of mass M is pulled along a horizontal friction surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is
(A) $\frac{Pm}{M+m}$ (B) $\frac{Pm}{M-m}$
(C) P (D) $\frac{Pm}{M+m}$

31. D.
Force on block = mass $\times$ acceleration = $\frac{PM}{M+m}$

32. A light spring balance hangs from the hook of the other light spring balance and a block of mass M kg hangs from the former one. Then the true statement about scale reading is
(A) both the scales read M kg each
(B) the scale of the lower one reads M kg and of upper one zero
(C) the reading of the two scales can be anything but sum of the reading will be M kg
(D) both the scales read M/2 kg.

32. A.
Both the scales read M kg each.

33. A wire suspended vertically from one of its ends stretched by attaching weight of 200 N to the lower end. The weight stretches the wire by 1 mm. Then the elastic energy stored in the wire is
(A) 0.2 J (B) 10 J
(C) 20 J (D) 0.1 J

33. D.
The elastic potential energy stored in the wire,

$$U=\frac{1}{2}\times \text{stress}\times \text{strain}\times \text{volume}$$

$$=\frac{1}{2}\times\frac{F}{A}\times\frac{\Delta\ell}{\ell}\times A\ell=\frac{1}{2}F\Delta\ell=\frac{1}{2}\times 200\times 10^{-3}=0.1\text{ J}$$

34. The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/s. If the body is projected at an angle of 45° with the vertical, the escape velocity will be

(A) $11\sqrt{2}$ km/s (B) 22 km/s

(C) 11 km/s (D) $11/\sqrt{2}$ m/s

34. C.

The escape velocity of a body is independent of the angle of projection.

35. A mass M is suspended from a spring of negligible mass. The spring is pulled a little and then released so that the mass executes SHM of time period T. If the mass is increased by m, the time period becomes 5T/3. then the ratio of m/M is

(A) 3/5 (B) 25/9

(C) 16/9 (D) 5/3

35. C.

$$\frac{T}{T'} = \sqrt{\frac{M}{M+m}}$$

$$\Rightarrow \frac{9}{25} = \frac{M}{M+m}$$

$\Rightarrow$ 9M + 9m = 25 M

$$\therefore \frac{m}{M} = \frac{16}{9}$$

36. "Heat cannot by itself flow from a body at lower temperature to a body at higher temperature" is a statement of consequence of

(A) second law of thermodynamics (B) conservation of momentum

(C) conservation of mass (D) first law of thermodynamics.

36. A.

Second law of thermodynamics.

37. Two particles A and B of equal masses are suspended from two massless springs of spring constants k_1 and k_2 respectively. If the maximum velocities, during oscillations, are equal, the ratio of amplitudes of A and B is

(A) $\sqrt{\frac{k_1}{k_2}}$ (B) $\frac{k_2}{k_1}$

(C) $\sqrt{\frac{k_2}{k_1}}$ (D) $\frac{k_1}{k_2}$

37. C.

$$\frac{a_1}{a_2} = \sqrt{\frac{k_2}{k_1}}.$$

38. The length of a simple pendulum executing simple harmonic motion is increased by 21%. The percentage increase in the time period of the pendulum of increased length is

(A) 11% (B) 21%

(C) 42% (D) 10%

38. D.

Time period of simple pendulum is given by.

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

New length $\ell' = \ell + \frac{21}{100}\ell = \frac{121}{199}\ell$

$$\therefore \quad \frac{T'}{T} = \sqrt{\frac{\ell'}{\ell}} = \sqrt{\frac{21}{100}}$$

$$\frac{T'}{T} = \frac{11}{10}$$

$$\Rightarrow \quad T' = T + \frac{1}{10}T$$

$T \neq 10\%$ of T.

39. The displacement y of wave travelling in the x-direction is given by

$y = 10^{-4}\sin\left(600t - 2x + \frac{\pi}{3}\right)$ metres,

where x is expressed in metres and t in seconds. The speed of the wave-motion, in ms^{-1} is

(A) 300 (B) 600
(C) 1200 (D) 200

39. A.

Velocity of wave = $n\lambda = \frac{600}{2\pi} \times \frac{2\pi}{2}$ = 300 m/sec.

40. When the current changes from +2 A to –2 A in 0.05 second, an e.m.f. of 8 V is induced in a coil. The coefficient of self-induction of the coil is

(A) 0.2 H (B) 0.4 H
(C) 0.8 H (D) 0.1 H

40. D.

If e is the induced e.m.f. in the coil, then $e = -L\frac{di}{dt}$

Therefore, $L = -\frac{e}{di/dt}$

Substituting values, we get $L = \frac{-8 \times 0.05}{-4} = 0.1\,H$

41. In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is

(A) Q/2 (B) Q/√3
(C) Q/√2 (D) Q

41. C.

energy stored in capacitor = $E = \frac{1}{2}\frac{Q^2}{C}$

$$\Rightarrow \quad \frac{1}{2} \times \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{q^2}{C}$$

$$\Rightarrow \quad q = \frac{Q}{\sqrt{2}}.$$

42. The core of any transformer is laminated so as to

(A) reduce the energy loss due to eddy currents
(B) make it light weight
(C) make it robust and strong
(D) increase the secondary voltage.

42. A.

43. Let $\vec{F}$ be the force acting on a particle having position vector $\vec{r}$ and $\vec{T}$ be the torque of this force about the origin. Then

(A) $\vec{r}\cdot\vec{T}=0$ and $\vec{F}\cdot\vec{T}\neq 0$
(B) $\vec{r}\cdot\vec{T}\neq 0$ and $\vec{F}\cdot\vec{T}=0$
(C) $\vec{r}\cdot\vec{T}\neq 0$ and $\vec{F}\cdot\vec{T}\neq 0$
(D) $\vec{r}\cdot\vec{T}=0$ and $\vec{F}\cdot\vec{T}=0$

43. D.

Torque = Force × Position vector

$$\vec{T}=\vec{F}\times\vec{r}$$
$$\vec{r}\cdot\vec{T}=\vec{r}\cdot(\vec{F}\times\vec{r})=0$$
$$\vec{F}\cdot\vec{T}=\vec{F}\cdot(\vec{F}\times\vec{r})=0$$

44. A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is

(A) 0.4 In 2
(B) 0.2 In 2
(C) 0.1 In 2
(D) 0.8 In 2.

44. A.

$$\lambda=\frac{2\ln 2}{5}=0.4 \text{ In } 2.$$

45. A nucleus with Z = 92 emits the following in a sequence; α, α, β^-, β^-, α, α, α, α, β^-, β^-, α, β^+, β^+, α. The Z of the resulting nucleus is

(A) 76
(B) 78
(C) 82
(D) 74

45. B.

The Z of resultant nucleus = 92 – 16 + 4 – 2 = 78

46. Two identical photo cathodes receive light of frequencies f_1 and f_2. if the velocities of the photoelectrons (of mass m) coming out are respectively v_1 and v_2, then

(A) $v_1^2-v_2^2=\frac{2h}{m}(f_1-f_2)$
(B) $v_1+v_2=\left[\frac{2h}{m}(f_1+f_2)\right]^{1/2}$
(C) $v_1^2+v_2^2=\frac{2h}{m}(f_1+f_2)$
(D) $v_1-v_2=\left[\frac{2h}{m}(f_1-f_2)\right]^{1/2}$

46. A.

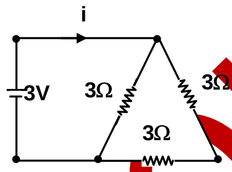
$$\frac{1}{2}m(v_1^2-v_2^2)=h(f_1-f_2)$$
$$\Rightarrow\ v_1^2-v_2^2=\frac{2h}{m}(f_1-f_2).$$

47. Which of the following cannot be emitted by radioactive substance during their decay?

(A) protons (B) neutrinos
(C) helium nuclei (D) electrons

47. **A.**

48. A 3 volt battery with negligible internal resistance is connected in a circuit as shown in the figure. The current I, in the circuit will be



(A) 1 A (B) 1.5 A
(C) 2 A (D) 1/3 A

48. **B.**

The current through the circuit, $I = \frac{V}{R} = \frac{3}{2} = 1.5\ A$

49. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor
(A) decreases (B) remains unchanged
(C) becomes infinite (D) increases.

49. **B.**
When a sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor, the capacitance of capacitor remains unchanged.

50. The displacement of a particle varies according to the relation x = 4(cos πt + sin πt). the amplitude of the particle is
(A) –4 (B) 4
(C) 4√2 (D) 8

50. **C.**
The amplitude of given wave equation = $4\sqrt{2}$.

51. A thin spherical conduction shell of radius R has a charge q. another charge Q is placed at the centre of the shell. The electrostatic potential at a point P at a distance R/2 from the centre of the shell is

(A) $\frac{2Q}{4\pi\varepsilon_0 R}$ (B) $\frac{2Q}{4\pi\varepsilon_0 R} - \frac{2q}{4\pi\varepsilon_0 R}$

(C) $\frac{2Q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0 R}$ (D) $\frac{(q+Q)}{4\pi\varepsilon_0}\frac{2}{R}$

51. **C.**
The total potential at P = $\frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{R}(q+2Q)$

52. The work done in placing a charge of 8 × 10^{-18} coulomb on a condenser of capacity 100 micro-farad is
(A) 16 × 10^{-32} joule (B) 3.2 × 10^{-26} joule
(C) 4 × 10^{-10} joule (D) 32 × 10^{-32} joule

52. **D.**

Required work done is $w = \frac{1}{2}\frac{Q^2}{C^2}$

$= \frac{1}{2} \times \frac{(8 \times 10^{-18})^2}{10^{-4}} = 32 \times 10^{-32}\ J$

53. The co-ordinates of a moving particle at any time t are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed to the particle at time t is given by

(A) $3t\sqrt{\alpha^2+\beta^2}$

(B) $3t^2\sqrt{\alpha^2+\beta^2}$

(C) $t^2\sqrt{\alpha^2+\beta^2}$

(D) $\sqrt{\alpha^2+\beta^2}$

53. B.

Speed = $|\vec{v}| = \sqrt{(3\alpha t^2)^2+(3\beta t^2)^2} = 3t^2\sqrt{\alpha^2+\beta^2}$.

54. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio $\frac{C_p}{C_v}$ for the gas is

(A) 4/3

(B) 2

(C) 5/3

(D) 3/2

54. A.

$\frac{C_P}{C_V} = \frac{4}{3}$.

55. Which of the following parameters does not characterize the thermodynamic state of matter?

(A) temperature

(B) pressure

(C) work

(D) volume

55. C.

The work done does not characterize a thermodynamic state of matter. It gives only a relationship between two different thermodynamic state.

56. A carnot engine takes 3×10^6 cal of heat from a reservoir at 627°C, and gives it to a sink at 27°C. The work done by the engine is

(A) 4.2×10^6 J

(B) 8.4×10^6 J

(C) 16.8×10^6 J

(D) zero.

56. B.

Work done by the engine while taking heat

$Q = 3 \times 10^6$ cal is $W = 2 \times 10^6 \times 4.2 = 8.4 \times 10^6$ J.

57. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch is further by another 5 cm is

(A) 12.50 N-m

(B) 18.75 N-m

(C) 25.00 N-m

(D) 6.25 N-m

57. B.

Required work done = 25 – 6.25 = 18.75 N–m.

58. A metal wire of linear mass density of 9.8 gm is stretched with a tension of 10 kg-wt between two rigid supports 1 metre apart. The wire passes at its middle point between the poles of a per magnet and it vibrates in resonance when carrying an alternating current of frequency n. The frequency n of the alternating source is

(A) 50 Hz

(B) 100 Hz

(C) 200 Hz

(D) 25 Hz

58. A.

Frequency of oscillation n $= \frac{1}{2L}\sqrt{\frac{T}{m}}$

$$= \frac{1}{2L}\sqrt{\frac{10 \times 9.8}{9.8 \times 10^{-3}}} = \frac{1}{2L} \times 10^2 = \frac{1}{2 \times 1} \times 10^2 = 50\text{Hz}$$

59. A tuning fork of known frequency 256 Hz makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was

(A) (256 + 2) Hz (B) (256 – 2) Hz
(C) (256 – 5) Hz (D) (256 + 5) Hz

59. C.

60. A body executes simple harmonic motion. The potential energy (P.E.), the kinetic energy (K.E.) and total energy (T.E.) are measured as function of displacement x. Which of the following statement is true?

(A) K.E. is maximum when x = 0 (B) T.E. is zero when x = 0
(C) K.E. is maximum when x is maximum (D) P.E. is maximum when x = 0.

60. A.

Since at x = 0, the potential energy is minimum, the kinetic energy is maximum.

61. In the nuclear fusion reaction,

$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + n$ given that the repulsive potential energy between the two nuclei is -7.7×10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly [Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K]

(A) 10^{7}K (B) 10^{5} K
(C) 10^{3} K (D) 10^{9} K

61. D.

$$T = \frac{7.7 \times 10^{-14} \times 2}{3 \times 1.38 \times 10^{-23}} = 3.7 \times 10^{-9} \text{ K.}$$

62. Which of the following atoms has the lowest ionization potential?

(A) $^{14}_{7}N$ (B) $^{133}_{55}Cs$
(C) $^{40}_{18}Ar$ (D) $^{16}_{8}O$

62. B.

Since $^{133}_{55}Cs$ has larger size among the four atoms given, thus the electrons present in the outermost orbit will be away from the nucleus and the electrostatic force experienced by electrons due to nucleus will be minimum. Therefore the energy required to liberate electron from outer orbit will be minimum in the case of $^{133}_{55}Cs$.

63. The wavelengths involved in the spectrum of deuterium $(^{2}_{1}D)$ are slightly different from that of hydrogen spectrum, because

(A) size of the two nuclei are different
(B) nuclear forces are different in the two cases
(C) masses of the two nuclei are different
(D) attraction between the electron and the nucleus is different in the two cases.

63. C.

64. In the middle of the depletion layer of a reverse-biased p-n junction, the

(A) electric field is zero (B) potential is maximum
(C) electric field is maximum (D) potential is zero

64. A.

65. If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is

(A) 30.6 eV (B) 13.6 eV
(C) 3.4 eV (D) 122.4 eV.

65. **A.**

The energy of the first excited state of Li^{++} is

$$E_2 = -\frac{Z^2E_0}{n^2} = \frac{3^2 \times 13.6}{2^2} = -30.6 \text{ eV.}$$

66. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time t is proportional to

(A) $t^{3/4}$
(B) $t^{3/2}$
(C) $t^{1/4}$
(D) $t^{1/2}$

66. **B.**

Distance goes as $t^{3/2}$

67. A rocket with a lift-off mass 3.5×10^4 kg is blasted upwards with an initial acceleration of 10 m/s^2. Then the initial thrust of the blast is

(A) 3.5×10^5 N
(B) 7.0×10^5 N
(C) 14.0×10^5 N
(D) 1.75×10^5 N

67. **A.**

68. To demonstrate the phenomenon of interference we require two soruces which emit radiation of

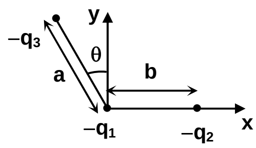
(A) nearly the same frequency
(B) the same frequency
(C) different wavelength
(D) the same frequency and having a definite phase relationship.

68. **A.**

Initial thrust of the blast = $m \times a = 3.5 \times 10^4 \times 10$

$= 3.5 \times 10^5$ N

69. Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in the figure. The x-component of the force on $-q_1$ is proportional to



(A) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\cos\theta$
(B) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta$
(C) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\cos\theta$
(D) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\sin\theta$

69. **B.**

$$F_x \propto \frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta$$

70. A 220 volt, 1000 watt bulb is connected across a 110 volt mains supply. The power consumed will be

(A) 750 watt
(B) 500 watt
(C) 250 watt
(D) 1000 watt

70. **C.**

$$P_{consumed} = \frac{V^2}{R} = \frac{(110)^2}{(220)^2/1000} = 250 \text{ watt.}$$

71. The image formed by an objective of a compound microscope is

(A) virtual and diminished
(B) real and diminished
(C) real and enlarged
(D) virtual and enlarged

71. **C.**

The objective of compound microscope is a convex lens. We know that a convex lens forms real and enlarged image when an object is placed between its focus and lens.

72. The earth radiates in the infra-red region of the spectrum. The spectrum is correctly given by

(A) Rayleigh Jeans law
(B) Planck's law of radiation
(C) Stefan's law of radiation
(D) Wien's law

72. **D.**

73. To get three images of a single object, one should have two plane mirrors at an angle of

(A) 60°
(B) 90°
(C) 120°
(D) 30°

73. **B.**

The number of images formed of two plane mirrors are placed at an angle θ is n = $\frac{360°}{\theta}-1$

Here n = 3

$$\therefore \quad 3=\frac{360°}{\theta}-1$$

$$\Rightarrow \quad \theta=\frac{360°}{4}=90°$$

74. According to Newton's law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\ \theta$ is the difference of the temperature of the body and the surroundings, and n is equal to

(A) two
(B) three
(C) four
(D) one

74. **D.**

According to Newton's law of cooling.

Rate of cooling $\frac{d\theta}{dt}\propto\Delta\theta$

Therefore n = 1.

75. The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be

(A) 200%
(B) 100%
(C) 50%
(D) 300%

75. **D.**

%change = $\frac{3R}{R}\times100\%=300\%$.