DAY THIRTY NINE

Mock Test 2

Instruction

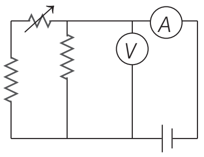
- This question paper contains of 50 Multiple Choice Questions of Physics, divided into two Sections; section A and section B.
- Section A contains 35 questions and all questions are compulsory.
- Section B contains 15 questions out of which only 10 questions are to be attempted.
- Each question carries 4 marks.

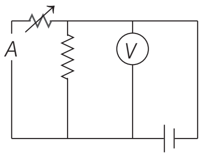
Section-A

1 An electric fan is placed on a stationary boat and air is blown with it on the sail of the boat. Which of the following statements is correct?

(a) The boat will be uniformly accelerated in the direction of the flow of the air
(b) The boat will start moving with uniform speed
(c) The boat will be uniformly accelerated opposite to the direction of flow of air
(d) The boat will remain stationary as before

2 Correct set up to verify Ohm's law is

(a)


(b)


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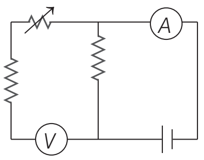
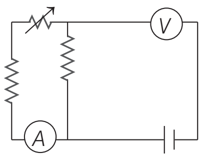
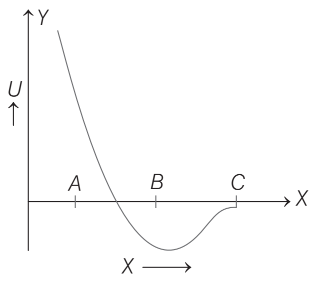


(d)


3 If p represents radiation pressure, c represents speed of light and Q represents radiation energy striking a unit area per second, then non-zero integers x, y and z; such that $p^x Q^y c^z$ is dimension less, are

(a) $x = 1, y = 1, z = -1$
(b) $x = 1, y = -1, z = 1$
(c) $x = -1, y = 1, z = 1$
(d) $x = 1, y = 1, z = 1$

4 The potential energy U between two atoms in a diatomic molecule as a function of the distance x between atoms has been shown in the adjoining figure. The atoms are



(a) attracted when x lies between A and B and are repelled when x lies between B and C
(b) attracted when x lies between B and C and are repelled when x lies between A and B
(c) attracted when they reach B
(d) repelled when they reach B

5 Electrons are accelerated through a potential difference V_0 and protons are accelerated through a potential difference 4 V. The de-Broglie wavelength are λ_e and λ_p for electrons and protons respectively. The ratio of $\frac{\lambda_e}{\lambda_p}$ is given by

(given, m_e is mass of electrons and m_p is mass of proton)

(a) $\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}}$
(b) $\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_e}{m_p}}$
(c) $\frac{\lambda_e}{\lambda_p} = \frac{1}{2}\sqrt{\frac{m_e}{m_p}}$
(d) $\frac{\lambda_e}{\lambda_p} = 2\sqrt{\frac{m_p}{m_e}}$

6 The speed of sound in hydrogen at NTP is 1270 ms^{-1}. Then, the speed in a mixture of hydrogen and oxygen in the ratio 4:1 by volume will be

(a) 317 ms^{-1} (b) 635 ms^{-1} (c) 830 ms^{-1} (d) 950 ms^{-1}

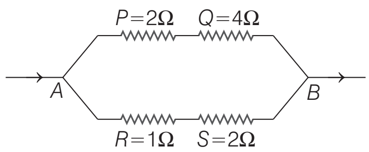
7 A large number of water drops each of the radius r combine to have a drop of radius R. If the surface tension is T and the mechanical equivalent of heat is J, then the rise in temperature will be

(a) $\frac{2T}{rJ}$ (b) $\frac{3T}{RJ}$ (c) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (d) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

8 A train of 150 m length is going towards North direction at a speed of 10 ms^{-1}. A parrot flies at a speed of 5 ms^{-1} towards south direction parallel to the railway track. The time taken by the parrot to cross the train is equal to

(a) 12 s (b) 8 s (c) 15 s (d) 10 s

9 Which of the four resistances P, Q, R and S generate the greatest amount of heat, when a current flows from A to B?



(a) Q (b) S (c) P (d) R

10 A charge Q is uniformly distributed over a large square plate of copper. The electric field at a point very close to the centre of the plate is 10 Vm^{-1}. If the copper plate is replaced by a plastic plate of the same geometrical dimensions and carrying the same charge Q uniformly distributed, then the electric field at the point P will be

(a) 5 Vm^{-1} (b) zero (c) 10 Vm^{-1} (d) 20 Vm^{-1}

11 The speed of electromagnetic waves in vacuum depends upon the source of radiation. It

(a) increases as we move from γ-rays to radio waves
(b) decreases as we move from γ-rays to radio waves
(c) is same for all of them
(d) None of the above

12 Ice starts freezing in a lake with water at 0°C, when the atmospheric temperature is –10°C. If the time taken for 1 cm of ice to be formed is 12 minutes, the time taken for the thickness of the ice to change from 1 cm to 2 cm will be

(a) 12 min
(b) less than 12 min
(c) more than 12 min but less than 24 min
(d) more than 24 min

13 An ideal gas is taken through a cyclic thermodynamical process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J and $Q_4 = 3645$ J, respectively. The corresponding works involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and W_4, respectively. The value of W_4 is

(a) 1315 J (b) 275 J (c) 765 J (d) 675 J

14 A beam of light consisting of red, green and blue colours, is incident on a right-angled prism. The refractive indices of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47, respectively. The prism will

(a) separate part of the red colour from the green and blue colours
(b) separate part of the blue colour from the red and green colours
(c) separate all the three colours from one another
(d) not separate even partially any colour from the other two colours

15 The kinetic energy K of a particle moving along a circle of radius R depends on the distance covered s, as $K = as^2$, where, a is a constant. The force acting on the particle is

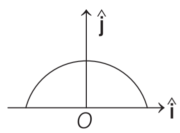
(a) $2a\frac{s^2}{R}$ (b) $2as\left(1+\frac{s^2}{R^2}\right)^{1/2}$

(c) $2as$ (d) $2a\frac{R^2}{s}$

16 A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 ms^{-1}. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1.00 m. The angle made by the rod with track is

(a) zero (b) 30° (c) 45° (d) 60°

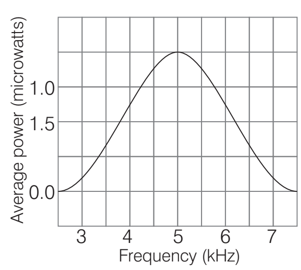
17 A thin semi-circular ring of radius r has a positive charge q distributed uniformly over it. The net field $\mathbf{E}$ at the centre O is



(a) $\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{\mathbf{i}}$ (b) $-\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{\mathbf{j}}$

(c) $-\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{\mathbf{j}}$ (d) $\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{\mathbf{j}}$

18 The plot given below is of the average power delivered to an L-R-C circuit *versus* frequency. The quality factor of the circuit is



(a) 5.0 (b) 2.0 (c) 2.5 (d) 0.4

19 Two identical wires A and B have the same length L and carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side a. If B_1 and B_2 are the values of magnetic induction at the centre of the circle and the centre of the square respectively, then the ratio B_1/B_2 is

(a) $(\pi^2/8)$ (b) $(\pi^2/8\sqrt{2})$ (c) $(\pi^2/16)$ (d) $(\pi^2/16\sqrt{2})$

20 In non-resonant circuit, what will be the nature of the circuit for frequencies higher than the resonant frequency?

(a) Resistive (b) Capacitive
(c) Inductive (d) None of these

21 A particle of mass m is moving in a circular path of constant radius r, such that centripetal acceleration a_c varying with time is $a_c = k^2 r t^2$, where k is a constant. What is the power delivered to the particle by the force acting on it?

(a) $2mkr^2 t$ (b) $mkr^2 t^2$ (c) $mk^2 r^2 t$ (d) $mk^2 r t^2$

22 The maximum height attained by a projectile is increased by 5%. Keeping the angle of projection constant, what is the percentage increase in horizontal range?

(a) 5% (b) 10% (c) 15% (d) 20%

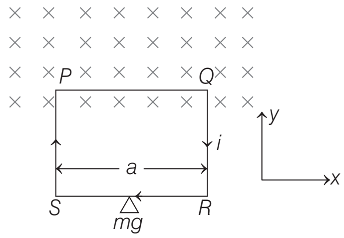
23 A spot of light S rotates in a horizontal plane with a constant angular velocity of 0.1 rads^{-1}. The spot of light P moves along the wall at a distance of 3 m from S. The velocity of spot P, where $\theta = 45°$, is

(a) 0.5 ms^{-1} (b) 0.6 ms^{-1} (c) 0.7 ms^{-1} (d) 0.8 ms^{-1}

24 White light may be considered to be a mixture of wave with λ ranging between 3000 Å to 7800 Å. An oil film of thickness 10000 Å is examined normally by the reflected light. If $\mu = 1.4$, then the film appears bright for

(a) 4308 Å, 5091 Å, 6222 Å
(b) 4000 Å, 5091 Å, 5600 Å
(c) 4667 Å, 6222 Å, 7000 Å
(d) 4000 Å, 4667 Å, 5600 Å, 7000 Å

25 A rectangular loop of wire, supporting a mass m, hangs with one end in uniform magnetic field **B** pointing out of the plane of the paper. A clockwise current is setup, such that $i > mg/Ba$, where a is the width of the loop. Then,



(a) the weight rises due to vertical force caused by the magnetic field but work is done on the system
(b) the weight rises due to vertical force by the no work field and work is extracted shown on the electric field
(c) the weight rises due to vertical force caused by the magnetic field but no work is done on the system
(d) the weight rises due to vertical force caused by the no work field and work is extracted shown on the magnetic field

26 Rain is falling vertically downwards with a velocity of 4 kmh^{-1}. A man walks in the rain with a velocity of 3 kmh^{-1}. The raindrops will fall on the man with a velocity of

(a) 1 kmh^{-1} (b) 3 kmh^{-1} (c) 4 kmh^{-1} (d) 5 kmh^{-1}

27 A machine gun is mounted on a 200 kg vehicle on a horizontal smooth road (friction is negligible). The gun fires 10 bullets per sec with a velocity of 500 ms^{-1}. If the mass of each bullet be 10 g, what is the acceleration produced in the vehicle?

(a) 25 cms^{-2} (b) 35 cms^{-2} (c) 50 cms^{-2} (d) 50 ms^{-2}

28 The displacement of a particle executing periodic motion is given by $y = 4\cos^2(t/2)\sin(1000t)$

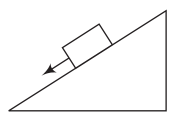
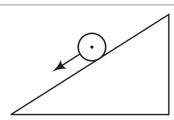
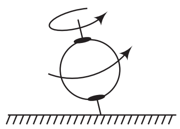
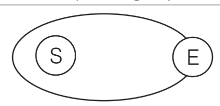
This expression may be considered to be a result of superposition of

(a) two waves (b) three waves
(c) four waves (d) five waves

29 If the series limit wavelength of the Lyman series for hydrogen atom is 912Å, then the series limit wavelength for the Balmer series for the hydrogen atom is

(a) 912 Å (b) 912 × 2 Å (c) 912 × 4 Å (d) $\frac{912}{2}$ Å

30 Match the examples given in Column I with the type of motion they are executing in Column II. There is no information about nature of surfaces of bodies is given.

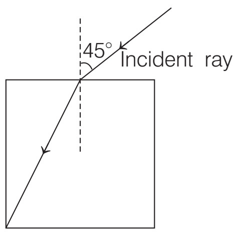
	Column I		Column II
A.	 A block over an inclined plane	1.	Rolling
B.	 A cylinder over an inclined plane	2.	Translation
C.	 A spinning top	3.	Rotation
D.	 Earth-Sun system	4.	Precession

	A	B	C	D
(a)	2	1	3	4
(b)	2	3	1	2
(c)	3	1	2	1
(d)	3	1	2	4

31 Assuming that about 20 MeV of energy is released per fusion reaction ${}_1H^2 + {}_1H^3 \rightarrow {}_0n^1 + {}_2He^4$, then the mass of ${}_1H^2$ consumed per day in a fusion reactor of power 1 MW will approximately be

(a) 0.001 g (b) 0.1 g (c) 10.0 g (d) 1000 g

32 A light ray falls on a square glass slab as shown in the figure. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is equal to



Diagram

(a) $\frac{(\sqrt{2}+1)}{2}$ (b) $\sqrt{\frac{5}{2}}$

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

33 A coil has an inductance of 0.7 H and is joined in series with a resistance of 220 Ω. When an alternating emf of 220 V at 50 cps is applied to it, then the wattless component of the current in the circuit, is

(a) 5 A (b) 0.5 A (c) 0.7 A (d) 7 A

34 Which of the following statements is/are true?

(a) A clock, when taken on a mountain can be made to give correct time, if we change the length of pendulum suitably
(b) An increase in value of g makes a clock go slow
(c) If the length of a pendulum is increased, the clock becomes fast
(d) A clock, when taken to a deep mine or carried to the top of a mountain becomes slow

35 I. Electric field, electric displacement and electric polarisation are related by the relation as $D = \varepsilon_0 E - P$.

II. Electric field vector (**E**), electric displacement vector (**D**) and electric polarisation vector (**P**) are mutually perpendicular to each other.

III. Electric field vector (**E**), electric displacement vector (**D**) and electric polarisation vector (**P**) are mutually parallel to each other.

Which of the following statement(s) is/are correct?

(a) Only I (b) Both II and III
(c) Both I and III (d) Only III

Section-B

36 Electric potential is given by

$$V = 6x - 8xy^2 - 8y + 6yz - 4z^2$$

Then, electric force acting on 2 C on point charge placed on origin will be

(a) 2 N (b) 6N (c) 8 N (d) 20 N

37 There is a current of 40 A in a wire of 10^{-6} m^2 area of cross-section. If the number of free electrons per cubic metre is 10^{29}, then the drift velocity is

(a) 250×10^{-3} ms^{-1} (b) 25.0×10^{-3} ms^{-1}
(c) 2.50×10^{-3} ms^{-1} (d) 1.25×10^{3} ms^{-1}

38 A mixture of n_1 moles of monoatomic gas and n_2 moles of diatomic gas has $\frac{C_p}{C_V} = \gamma = 1.5$. Then,

(a) $n_1 = n_2$ (b) $2n_1 = n_2$ (c) $n_1 = 2n_2$ (d) $2n_1 = 3n_2$

39 A charged particle with some initial velocity is projected in a region where non-zero electric and/or magnetic fields are present. In Column I, information about the existence of electric and/or magnetic field and direction of initial velocity of charged particle are given, while in Column II the probable path of the charged particle is mentioned. Match the entries of Column I with the entries of Column II and select the correct answer from the codes given below.

	Column I		Column II
A.	$\mathbf{E} = 0$, $\mathbf{B} \neq 0$, $\mathbf{E} \neq \mathbf{B}$ and initial velocity is at any angle with $\mathbf{B}$ ($\theta \neq 90°$)	1.	Straight line
B.	$\mathbf{E} = 0, \mathbf{B} \neq 0$ and initial velocity is perpendicular to $\mathbf{B}$	2.	Helical path with uniform pitch
C.	$\mathbf{E} \neq 0, \mathbf{B} \neq 0$, $\mathbf{E} \parallel \mathbf{B}$ and initial velocity is $\perp$ to both	3.	Circular
D.	$\mathbf{E} \neq 0, \mathbf{B} \neq 0, \mathbf{E}$ perpendicular to $\mathbf{B}$ and $\mathbf{v}$ perpendicular to both $\mathbf{E}$ & $\mathbf{B}$	4.	Helical path with non-uniform pitch

	A	B	C	D
(a)	2	3	4	1
(b)	1	3	4	2
(c)	2	3	1	4
(d)	4	1	2	3

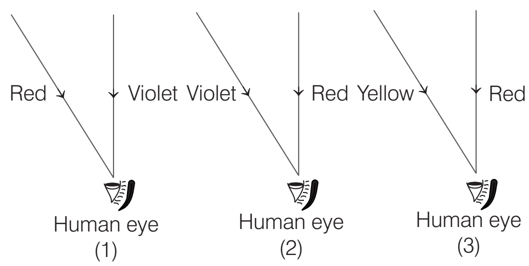
40 A train standing at the outer signal of a railway station blows a whistle of frequency 400 Hz in still air. The train begins to move with a speed of 10 ms^{-1} towards the platform. What is the frequency of the sound for an observer standing on the platform? (sound velocity in air = 330 ms^{-1})

(a) 412.5 Hz (b) 312.6 Hz (c) 500 Hz (d) 616.6 Hz

41 A dip needle arranged to move freely in the magnetic meridian dips by an angle θ. If the vertical plane in which the needle moves is rotated through an angle α to the magnetic meridian, then the needle will dip by an angle

(a) θ (b) α (c) more than θ (d) less than θ

42 The coming rays are forming rainbows



(a) Figure (1) forms primary rainbow
(b) Figure (1) and (3) form primary rainbow
(c) Figure (2) forms secondary rainbow
(d) Figure (1) forms secondary rainbow

43 I. The phenomenon of splitting of light into different colours is known as dispersion.

II. Dispersion takes place because the refractive index of medium for different frequencies (colours) is different.

III. Thin lenses show chromatic aberration due to dispersion of light.

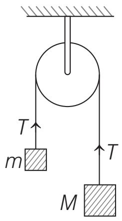
Which of the following statement is incorrect?

(a) Only I (b) Only II
(c) Only III (d) I, II and III

44 A table tennis ball which has been covered with a conducting paint is suspended by a silk thread, so that it hangs between two metal plates. One plate is earthed. When the other plate is connected to a high voltage generator, the ball

(a) is attracted to the high voltage plate and stays there
(b) hangs without moving
(c) swings backward and forward hitting each plate in turn
(d) is repelled to the earthed plate and stays there

45 Two blocks of masses m and M are connected by means of a metal wire of cross-sectional area A passing over a frictionless fixed pulley as shown in the figure. The system is then released. If $M = 2m$, then the stress produced in the wire is



(a) $\frac{2mg}{3A}$ (b) $\frac{4gm}{3A}$
(c) $\frac{gm}{A}$ (d) $\frac{3mg}{4A}$

46 A body is projected with a velocity of 2×11.2 km/s from the surface of earth. The velocity of the body when it escapes the gravitational pull of the earth is

(a) $\sqrt{3} \times 11.2$ km/s (b) 11.2 km/s
(c) $\sqrt{2} \times 11.2$ km/s (d) 0.5×11.2 km/s

47 **Assertion** The detection of neutrino particles is extremely difficult.

Reason Neutrinos interact very weakly with matter.

(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) Assertion is correct but Reason is incorrect.
(d) Assertion is incorrect but Reason is correct.

48 In an adiabatic process, wherein pressure is increased by $\frac{2}{3}$%. If $\frac{C_p}{C_V} = \frac{3}{2}$, then the volume decreases by about

(a) $\frac{4}{9}$ % (b) $\frac{2}{3}$ % (c) 4% (d) $\frac{9}{4}$ %

49 The wavelength of the K_α line for an element of atomic number 43 is λ. Then, the wavelength of the K_α line for an element of atomic number 29, is

(a) $\left(\frac{43}{29}\right)\lambda$ (b) $\left(\frac{42}{28}\right)\lambda$ (c) $\left(\frac{9}{4}\right)\lambda$ (d) $\left(\frac{4}{9}\right)\lambda$

50 For a transistor amplifier, the voltage gain

(a) remains constant for all frequencies
(b) is high at high and low frequencies and constant in the middle frequency range
(c) is low at high and low frequencies and constant at mid-frequencies
(d) None of the above

Answers

1.	(d)	2.	(a)	3.	(b)	4.	(b)	5.	(d)	6.	(b)	7.	(c)	8.	(d)	9.	(b)	10.	(c)
11.	(c)	12.	(d)	13.	(c)	14.	(a)	15.	(b)	16.	(c)	17.	(c)	18.	(d)	19.	(b)	20.	(c)
21.	(c)	22.	(a)	23.	(b)	24.	(a)	25.	(c)	26.	(d)	27.	(a)	28.	(b)	29.	(c)	30.	(a)
31.	(b)	32.	(d)	33.	(b)	34.	(d)	35.	(d)	36.	(d)	37.	(c)	38.	(a)	39.	(a)	40.	(a)
41.	(c)	42.	(d)	43.	(c)	44.	(c)	45.	(b)	46.	(a)	47.	(a)	48.	(a)	49.	(c)	50.	(c)

Hints and Explanations

1 The air blown at the sail will apply forward force but equal and opposite force will be experienced by the fan. As fan is also a part of the boat, hence net force on the boat will be zero, i.e. the boat will remain stationary as before.

2 Ohm's law states that the current (I) flowing through a conductor is directly proportional to the potential difference $(\mathbf{V})$ across the ends of the conductor, provided that physical conditions of the conductor such as temperature, mechanical strain etc., kept constant,

i.e. $\mathbf{I} \propto \mathbf{V}$ or $\mathbf{V} \propto \mathbf{I}$

or $\mathbf{V} = \mathbf{RI}$ [where, R is constant]

3 $[\mathbf{p}] = \dfrac{[\mathbf{F}]}{[\mathbf{A}]} = [\mathbf{ML^{-1}T^{-2}}], [\mathbf{c}] = [\mathbf{LT^{-1}}]$

$[\mathbf{Q}] = \dfrac{[\mathbf{E}]}{[\mathbf{A}][\mathbf{T}]} = [\mathbf{MT^{-3}}]$

As given, $\mathbf{p^x Q^y c^z} = [\mathbf{M^0 L^0 T^0}]$

$[\mathbf{ML^{-1}T^{-2}}]^x[\mathbf{MT^{-3}}]^y[\mathbf{LT^{-1}}]^z = [\mathbf{M^0 L^0 T^0}]$

$\mathbf{M^{x+y}L^{-x+z}T^{-2x-z-3y}} = [\mathbf{M^0 L^0 T^0}]$

$\therefore$ $\mathbf{x + y = 0}$

$\mathbf{-x + z = 0}$

$\mathbf{-2x - z - 3y = 0}$

On solving , we get $\mathbf{x = 1, y = -1}$, $\mathbf{z = 1}$

4 Negative value of potential energy decreases from C to B and there after increases. It shows that kinetic energy increases from C to B and there after it decreases. So, there is attraction from C to B and after which repulsion results.

5 We have, $\mathbf{E = qV}$,

we know that $\mathbf{E} = \dfrac{1}{2}\mathbf{mv^2}$. $\Rightarrow \mathbf{v} = \sqrt{\dfrac{\mathbf{2E}}{\mathbf{m}}}$

As, $\lambda = \dfrac{\mathbf{h}}{\mathbf{mv}} = \dfrac{\mathbf{h}}{\mathbf{m}\sqrt{\dfrac{\mathbf{2E}}{\mathbf{m}}}}$

$\Rightarrow$ $\lambda = \dfrac{\mathbf{h}}{\sqrt{\mathbf{2mqV}}}$ ...(i)

For electron, $\lambda_e = \dfrac{\mathbf{h}}{\sqrt{\mathbf{2m_e qV}}}$ ...(ii)

For proton, $\lambda_p = \dfrac{\mathbf{h}}{\sqrt{\mathbf{2m_p qV}}}$

$\therefore$ $\lambda_p = \dfrac{\mathbf{h}}{\sqrt{\mathbf{2m_p q \cdot 4V}}}$

$[\because \mathbf{V = 4}\ V]$ ...(iii)

On dividing Eq. (ii) by Eq. (iii), we get

$$\frac{\lambda_e}{\lambda_p} = 2\sqrt{\frac{\mathbf{m_p}}{\mathbf{m_e}}}$$

6 As given, the volumes of hydrogen and oxygen in a mixture is 4 : 1, so let $\mathbf{V}$ be the volume of Oxygen. The volume of hydrogen will be 4 V. If ρ_m be the density of mixture, then

$$\rho_m = \frac{\mathbf{4V \times 1 + V \times 16}}{\mathbf{5V}} = \mathbf{4}$$

As, $\mathbf{v} \propto \left(\dfrac{1}{\rho}\right)^{1/2}$

$\therefore$ Velocity in mixture $= \dfrac{\mathbf{1270}}{(\mathbf{4})^{1/2}} = \mathbf{635}$ ms $^{-1}$

7 Rise in temperature, $\Delta\theta = \dfrac{\mathbf{3T}}{\mathbf{JSd}}\left(\dfrac{\mathbf{1}}{\mathbf{r}} - \dfrac{\mathbf{1}}{\mathbf{R}}\right)$

$\therefore$ $\Delta\theta = \dfrac{\mathbf{3T}}{\mathbf{J}}\left(\dfrac{\mathbf{1}}{\mathbf{r}} - \dfrac{\mathbf{1}}{\mathbf{R}}\right)$

[for water, $\mathbf{S = 1}$ and $\mathbf{d = 1}$]

8 Relative velocity of the parrot w.r.t. the train

$= [\mathbf{10 - (-5)}]\ \text{ms}^{-1} = 15\ \text{ms}^{-1}$

Time taken by the parrot to cross the train $= \dfrac{\mathbf{150}}{\mathbf{15}} = \mathbf{10}$ s

9 We know that, $\mathbf{i} \propto \dfrac{\mathbf{1}}{\mathbf{R}}$, $\mathbf{i_2} = \dfrac{\mathbf{6}}{\mathbf{3+6}}\mathbf{i} = \dfrac{\mathbf{2}}{\mathbf{3}}\mathbf{i}$

or $\mathbf{i_1} = \dfrac{\mathbf{3}}{\mathbf{6+3}}\mathbf{i} = \dfrac{\mathbf{1}}{\mathbf{3}}\mathbf{i}$

Power rate in $\mathbf{2}\ \Omega$ of upper series

$= \mathbf{2} \times \left(\dfrac{\mathbf{1}}{\mathbf{3}}\mathbf{i}\right)^2 = \dfrac{\mathbf{2}}{\mathbf{3}}\mathbf{i}^2$

Power rate in $\mathbf{4}\ \Omega$ of upper series

$= \mathbf{4} \times \left(\dfrac{\mathbf{1}}{\mathbf{3}}\mathbf{i}\right)^2 = \dfrac{\mathbf{4}}{\mathbf{9}}\mathbf{i}^2$

Power rate of $\mathbf{1}\ \Omega$ in lower series

$= \mathbf{1} \times \left(\dfrac{\mathbf{2}}{\mathbf{3}}\mathbf{i}\right)^2 = \dfrac{\mathbf{4}}{\mathbf{9}}\mathbf{i}^2$

Power rate of $\mathbf{2}\ \Omega$ in lower series

$= \mathbf{2} \times \left(\dfrac{\mathbf{2}}{\mathbf{3}}\mathbf{i}\right)^2 = \dfrac{\mathbf{8}}{\mathbf{9}}\mathbf{i}^2$

$\therefore$ $\mathbf{P} \to 2/3$, $\mathbf{Q} = 4/9$, $\mathbf{R} \to 4/9$, $\mathbf{S} \to 8/9$

10 Electric field will remain same as charge density σ remain same $(\mathbf{E} = \sigma/\varepsilon_0)$.

11 Speed of electromagnetic waves in vacuum

$= \dfrac{\mathbf{1}}{\sqrt{\mu_0 \varepsilon_0}}$ = constant

Therefore, speed of electromagnetic waves is same for all of them.

12 Time taken by ice to grow a thickness $\mathbf{y}$,

$$\mathbf{t} = \frac{\rho \mathbf{L}}{\mathbf{2K}\theta}\mathbf{y}^2$$

Hence, time intervals to change thickness from 0 to y, from y to $2y$ and so on will be in the ratio

$\Delta\mathbf{t_1} : \Delta\mathbf{t_2} : \Delta\mathbf{t_3} :: (\mathbf{1^2 - 0^2}) : (\mathbf{2^2 - 1^2}) : (\mathbf{3^2 - 2^2})$

or $\Delta\mathbf{t_1} : \Delta\mathbf{t_2} : \Delta\mathbf{t_3} :: \mathbf{1 : 3 : 5}$

According to question, $\Delta\mathbf{t_1}$ = 12 min

Hence, $\Delta\mathbf{t_2} = \mathbf{3}\Delta\mathbf{t_1} = \mathbf{3 \times 12\ min}$

= 36 min

13 $\Delta\mathbf{Q} = \mathbf{Q_1 + Q_2 + Q_3 + Q_4}$

$= \mathbf{5960 - 5585 - 2980 + 3645}$

$= \mathbf{1040}$ J

$\Delta\mathbf{W} = \mathbf{W_1 + W_2 + W_3 + W_4}$

$= \mathbf{2200 - 825 - 1100 + W_4}$

$= \mathbf{275 + W_4}$

For a cyclic process, $\Delta\mathbf{U = 0}$, i.e. $\mathbf{U_f - U_i = 0}$,

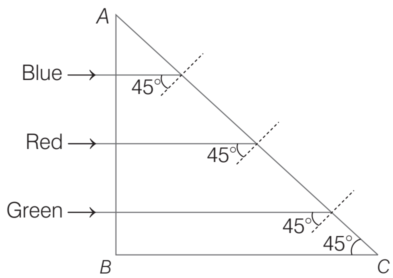
From first law of thermodynamics,

$\Delta\mathbf{Q} = \Delta\mathbf{U} + \Delta\mathbf{W}$

$\mathbf{1040 = 0 + 275 + W_4}$

or $\mathbf{W_4 = 765}$ J

14 The situation is shown in figure



At face **AB**, $\mathbf{i = 0}$. So, $\mathbf{r = 0}$, *i.e.*, light will be incident on face **AC** at an angle of incidence 45°.

The face **AC** will not transmit the light for which $\mathbf{i > C}$.

i.e. $\mathbf{\sin i > \sin C}$

$\Rightarrow$ $\sin \mathbf{45}° > \dfrac{\mathbf{1}}{\mu}$

or $\dfrac{\mathbf{1}}{\sqrt{\mathbf{2}}} > \dfrac{\mathbf{1}}{\mu}$

$\Rightarrow$ $\mu > \sqrt{\mathbf{2}}$

As refractive index for red colour is 1.39 which is less than $\sqrt{\mathbf{2}}$, so red will be transmitted through face **AC** while green and blue will be reflected.

15 According to given problem,

$$\frac{1}{2}mv^2 = as^2$$

$$\Rightarrow \qquad v = s\sqrt{\frac{2a}{m}}$$

So, $$a_R = \frac{v^2}{R} = \frac{2as^2}{mR} \qquad \text{...(i)}$$

Further more as

$$a_t = \frac{dv}{dt} = \frac{dv}{ds}\cdot\frac{ds}{dt} = v\frac{dv}{ds} \qquad \text{...(ii)}$$

[by chain rule]

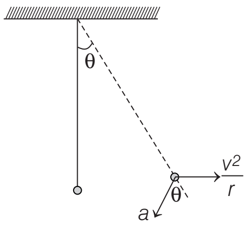
Which in light of Eq. (i), i.e. $v = s\sqrt{\frac{2a}{m}}$

yields

$$a_t = \left[s\sqrt{\frac{2a}{m}}\right]\left[\sqrt{\frac{2a}{m}}\right] = \frac{2as}{m} \qquad \text{...(iii)}$$

So that,

$$a = \sqrt{a_R^2 + a_t^2} = \sqrt{\left[\frac{2as^2}{mR}\right]^2 + \left[\frac{2as}{m}\right]^2}$$



Hence, $$a = \frac{2as}{m}\sqrt{1 + [s/R]^2}$$

$$\therefore \qquad F = ma$$

$$= 2as\sqrt{1 + [s/R]^2}$$

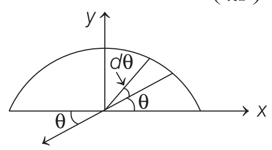
16 $$\tan\theta = \frac{v^2/r}{g} = \frac{v^2}{rg}$$

$$\therefore \qquad \theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$

$$= \tan^{-1}\left(\frac{10\times 10}{10\times 10}\right)$$

$$\therefore \qquad \theta = \tan^{-1}(1) = 45^\circ$$

17 Linear charge density, $\lambda = \left(\frac{q}{\pi r}\right)$



$$E = \int dE\sin\theta(-\hat{j})$$

$$= \int\frac{K\cdot dq}{r^2}\sin\theta(-\hat{j})$$

$$E = \frac{K}{r^2}\int\frac{qr}{\pi r}\,d\theta\sin\theta(-\hat{j})$$

$$= \frac{K}{r^2}\cdot\frac{q}{\pi}\int_0^\pi\sin\theta(-\hat{j})$$

$$\Rightarrow \quad E = \frac{q}{2\pi^2\varepsilon_0 r^2}(-\hat{j})$$

18 As quality factor $Q = \frac{\omega_0}{B}$

where, ω_0 = resonant frequency

B = Bandwidth

From the graph, $B = 2.5$ kHz

$Q = 0.4$

[by observing the curve]

19 $$B_1 = \frac{\mu_0}{4\pi}\times\frac{2\pi I}{R}$$

$$= \frac{\mu_0}{4\pi}\times\frac{2\pi I\times 2\pi}{L} \qquad \text{... (i)}$$

[$\because L = 2\pi R$ for circular loop]

$$B_2 = \frac{\mu_0}{4\pi}\times\frac{I}{(a/2)}[\sin 45^\circ + \sin 45^\circ]\times 4$$

where, $a = L/4$

$$\therefore B_2 = \frac{\mu_0 I}{4\pi L}\times 8\times 4\times\left[\frac{1}{\sqrt{2}}+\frac{1}{\sqrt{2}}\right]$$

$$= \frac{\mu_0 I}{4\pi L}\times\frac{64}{\sqrt{2}} \qquad \text{... (ii)}$$

Hence,

$$\frac{B_1}{B_2} = \left(\frac{\mu_0}{4\pi}\right)\times\frac{4\pi^2 I}{L}\Big/\frac{\mu_0 I}{4\pi L}\times\frac{64}{\sqrt{2}}$$

or $$\frac{B_1}{B_2} = \frac{\pi^2}{8\sqrt{2}}$$

20 At resonant frequency,

$$X_L = X_C \qquad \left[\because \omega L = \frac{1}{\omega C}\right]$$

At frequencies higher than resonance frequencies,

$$X_L > X_C$$

i.e. behaviour is inductive .

21 $$a_c = \frac{v^2}{r} = k^2rt^2 \Rightarrow v^2 = k^2r^2t^2$$

$$KE = \frac{1}{2}mv^2$$

$$= \frac{1}{2}mk^2r^2t^2$$

According to work-energy theorem, change in kinetic energy is equal to work done.

$$\therefore \qquad W = \frac{1}{2}mk^2r^2t^2$$

Thus, power delivered to the particle,

$$P = \frac{dW}{dt} = mk^2r^2t$$

22 Let **h** be the maximum height attained by the projectile. Then,

$$h = \frac{u^2\sin^2\theta}{2g}$$

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

$$\therefore \qquad \frac{R}{h} = \frac{u^2\sin 2\theta}{g}\Big/\frac{u^2\sin^2\theta}{2g}$$

$$= \frac{2\sin\theta\cos\theta}{(\sin^2\theta)/2} = 4\cot\theta$$

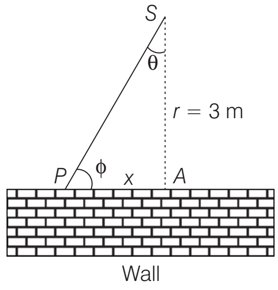
Therefore, $$\frac{\Delta R}{R} = \frac{\Delta h}{h}$$

Hence, percentage increase in **R**

= percentage increase in height **h**

= 5 %

23 The situation is shown in figure.



From figure, $x = r\tan\theta$

∴ Velocity of **P** is

$$v = \frac{dx}{dt} = r\sec^2\theta\left(\frac{d\theta}{dt}\right)$$

where, $\frac{d\theta}{dt}$ = angular velocity of rotation of spot $= \omega$

$$\therefore \qquad v = \omega r\sec^2\theta$$

At $\phi = 45^\circ$, so $\theta = 45^\circ$

Hence, $v = 0.1\times 3\times\sec^2 45^\circ$

$= 0.1\times 3\times 2 = 0.6\ \text{ms}^{-1}$

24 The film appears bright, if the path difference is where,

$$2\mu t\cos r = (2n-1)\frac{\lambda}{2} \quad (n = 1, 2, 3 \ldots)$$

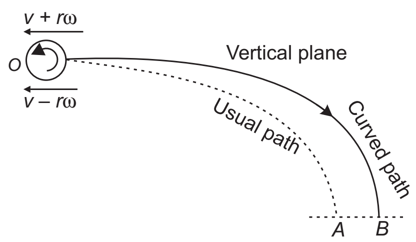
$$\therefore \qquad \lambda = \frac{4\mu t\cos r}{(2n-1)}$$

$$\lambda = \frac{4\times 1.4\times 10000\times 10^{-10}\cos 0^\circ}{(2n-1)}$$

$$= \frac{56000}{(2n-1)}\ \text{Å}$$

∴ λ = **56000** Å, 18666 Å, 11200 Å, 8000 Å, 6222Å, 5091 Å, 4308 Å, 3733 Å

The wavelengths which are not within specified ranges, are to be rejected.



25 The net force on the *RS* is in downward direction which increase the weight attached to it but there is no change in magnetic flux. Hence, there, no induced emf which implies there is no work done on the system.

26 Relative velocity of man w.r.t. rain,

$$v_{rm} = v_r - v_m = 4\hat{j} - 3\hat{i} = -3\hat{i} + 4\hat{j}$$

or $|v_{rm}| = \sqrt{(-3)^2 + (4)^2} = \sqrt{9+16}$

$$= \sqrt{25} = 5 \text{ kmh}^{-1}$$

27 Momentum carried by each bullet $= mv = 0.010 \times 500 = 5$ kg ms^{-1}

Now, force = change in momentum in 1 s

$$= 5 \times 10 = 50 \text{ N}$$

Hence, acceleration, $a = \frac{50}{200}$ ms^{-2}

$$= 25 \text{ cm s}^{-2}$$

28 $y = 4\cos^2(t/2)\sin(1000t)$

$$= 2[2\cos^2(t/2)\sin(1000t)]$$

$$= 2(1+\cos t)\sin(1000t)$$

$$= 2\sin(1000t) + 2\sin(1000t)\cos t$$

$$= 2\sin(1000t) + \sin(1001t) + \sin(999t)$$

Thus, given wave represents the superposition of three waves.

29 For series limit of Balmer series,

$$n_2 = 2,\ n_1 = \infty$$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$$

$$= R\left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2}\right] = \frac{R}{4}$$

$$\therefore \quad \lambda = \frac{4}{R} = \frac{4}{10967800} \text{ m}$$

$$= 4 \times 912 \times 10^{-10} \text{ m}$$

$$= 4 \times 912 \text{ Å}$$

30 *A* — 2; Block is in translation.
B — 1; Cylinder is rolling.
C — 3; Spinning top is in rotational motion
D — 4; Precession

31 Energy produced,

$$U = Pt$$

$$= 10^6 \times 24 \times 36 \times 10^2$$

$$= 24 \times 36 \times 10^8 \text{ J}$$

Energy released per fusion reaction

$$= 20 \text{ MeV}$$

$$= 20 \times 10^6 \times 1.6 \times 10^{-19}$$

$$= 32 \times 10^{-13} \text{ J}$$

Energy released per atom of ${}_1H^2$

$$= 32 \times 10^{-13} \text{ J}$$

Number of ${}_1H^2$ atoms used

$$= \frac{24 \times 36 \times 10^8}{32 \times 10^{-13}}$$

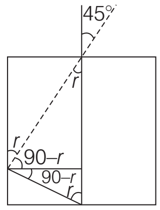
$$= 27 \times 10^{21}$$

Mass of 6×10^{23} atoms = 2 g

$\therefore$ Mass of 27×10^{21} atoms

$$= \frac{2}{6 \times 10^{23}} \times 27 \times 10^{21} = 0.1 \text{ g}$$

32 From figure, we get $r = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$



For critical angle, $\sin C = \frac{1}{\mu}$

Now, by Snell's law, we have

$$\frac{\mu}{1} = \frac{\sin i}{\sin r}$$

$$= \frac{\sin 45°}{\sin\left(\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)\right)} = \frac{1/\sqrt{2}}{1/\sqrt{3}}$$

$$\mu = \sqrt{\frac{3}{2}}$$

33 Wattless component of current

$$= I_v \sin\theta = \frac{E_v}{Z}\sin\theta$$

$$= \frac{220}{\sqrt{R^2 + \omega^2 L^2}} \times \frac{\omega L}{\sqrt{R^2 + \omega^2 L^2}}$$

$$= \frac{220 \times \omega L}{(R^2 + \omega^2 L^2)}$$

$$= \frac{220 \times (2\pi \times 50 \times 0.7)}{(220)^2 + (2\pi \times 50 \times 0.7)^2}$$

$$= \frac{220 \times 220}{(220)^2 + (220)^2} = \frac{1}{2} = 0.5 \text{ A}$$

34 Above or below the earth's surface, value of acceleration due to gravity decreases, so time period $\left(T = 2\pi\sqrt{\frac{l}{g}}\right)$ increases i.e. clock will become slow.

$$\left(\because T \propto \frac{1}{\sqrt{g}}\right)$$

35 The statement III is correct but rest are incorrect and these can be corrected as, Electric field vector $(\mathbf{E})$, electric displacement vector $(\mathbf{D})$ and electric polarisation vector $(\mathbf{P})$ are related as

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P} \qquad \ldots(i)$$

where, ε_0 is permittivity of free space.

From Eq. (i), it is clear that **D**, **E** and **P** are in same direction, i.e. they are mutually parallel to each other.

36 $E_x = -\frac{\partial V}{\partial x} = -(6 - 8y^2)$

$$E_y = -\frac{\partial V}{\partial y} = -(-16xy - 8 + 6z)$$

$$E_z = -\frac{\partial V}{\partial z} = -(6y - 8z)$$

At origin $x = y = z = 0$, so

$$E_x = -6,\ E_y = 8 \text{ and } E_z = 0$$

$$\Rightarrow \quad E = \sqrt{E_x^2 + E_y^2} = 10 \text{ NC}^{-1}$$

Hence, force $F = QE = 2 \times 10 = 20$ N.

37 Drift velocity,

$$v_d = \frac{I}{neA}$$

$$= \frac{40}{10^{29} \times 1.6 \times 10^{-19} \times 10^{-6}}$$

$$= 2.5 \times 10^{-3} \text{ ms}^{-1}$$

38 f_{av}

$$= \frac{\text{total number of degrees of freedom}}{\text{total number of molecules}}$$

$$= \frac{n_1 N_A f_1 + n_2 N_A f_2}{n_1 N_A + n_2 N_A}$$

$$= \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2} = \frac{3n_1 + 5n_2}{n_1 + n_2}$$

Also, $\gamma = 1 + \frac{2}{f_{av}} = 1.5$ or $f_{av} = 4$

$$\therefore \frac{3n_1 + 5n_2}{n_1 + n_2} = 4 \text{ or } n_1 = n_2$$

39

A. Since, $\mathbf{E} = 0$ and $\mathbf{B} \neq 0$ and $\mathbf{E} \neq \mathbf{B}$, the magnetic force act on it and the path will be helical (with uniform pitch) if **v** is at any angle to **B** ($\theta \neq 90°$).

B. Since, $\mathbf{E} = 0$, $\mathbf{B} \neq 0$ and $\mathbf{v} \perp \mathbf{B}$, then a force called Lorentz force, $\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$, acts on charged particle, which provide centripetal force to it and hence the path will be circular.

C. Since, $\mathbf{E} \neq 0$, $\mathbf{B} \neq 0$, $\mathbf{E} \parallel \mathbf{B}$, so path will be helical with non-uniform pitch as both electric and magnetic forces act on it.

D. Since, $\mathbf{E} \neq 0$, $\mathbf{B} \neq 0$, $\mathbf{E} \perp \mathbf{B}$ and **v** is perpendicular to both **E** and **B**, then the particle will move in a straight line due to the resultant force of magnetic and electric fields.

Hence, A $\rightarrow$ 2, B $\rightarrow$ 3, C $\rightarrow$ 4 and D $\rightarrow$ 1.

40 Here, $\nu = \mathbf{400}$ Hz, $\mathbf{v_s} = \mathbf{10}$ m/s, $\mathbf{v} = \mathbf{330}$ m/s.

As the source is moving towards stationary observer, therefore

$$\nu' = \frac{\mathbf{v} \times \mathbf{v}}{\mathbf{v} - \mathbf{v_s}} = \frac{\mathbf{330 \times 400}}{\mathbf{(330 - 10)}} = \mathbf{412.5\ Hz}$$

41 In this question, $\cos\alpha < \mathbf{1}$ i.e. $\dfrac{\mathbf{1}}{\mathbf{\cos\alpha}} > \mathbf{1}$

or $\dfrac{\tan\theta'}{\tan\theta} > \mathbf{1}$ or $\tan\theta' > \tan\theta$

or $\theta' > \theta$

i.e. angle of apparent dip is more than angle of actual dip θ.

42 In secondary rainbow, violet is above and red is below.

43 The statement III is incorrect and it can be corrected as,

Thick lenses show chromatic aberration due to dispersion of light.

Rest statements are correct.

44 When the other plate is connected to the high voltage generator, the negative charge induced on the ball cause attraction. When it strikes the positive plate charge distribution again takes place. This causes repulsion. Hence, the ball swings backward and forward hitting each plate in turn.

45 Tension, $\mathbf{T} = \left(\dfrac{\mathbf{2m_1m_2}}{\mathbf{m_1 + m_2}}\right)\mathbf{g}$,

$$= \left(\frac{\mathbf{2m \times 2m}}{\mathbf{m + 2m}}\right)\mathbf{g}$$

where, $\mathbf{m_1 = m}$ **and** $\mathbf{m_2 = 2m} = \dfrac{\mathbf{4}}{\mathbf{3}}\ \mathbf{mg}$

$\because$ Stress $= \dfrac{\textbf{Force (Tension)}}{\textbf{Area}}$

$$= \frac{\frac{\mathbf{4}}{\mathbf{3}}\ \mathbf{mg}}{\mathbf{A}} = \frac{\mathbf{4mg}}{\mathbf{3A}}$$

46 $\text{KE} = \dfrac{\mathbf{1}}{\mathbf{2}}\ \mathbf{mv_0^2} - \dfrac{\mathbf{1}}{\mathbf{2}}\ \mathbf{m}\ (11.2)^2$

[$\mathbf{v_0} = \mathbf{2} \times 11.2$ km/s]

$$= \frac{\mathbf{1}}{\mathbf{2}}\ \mathbf{m}(\ 2 \times 11.2)^2 - \frac{\mathbf{1}}{\mathbf{2}}\ \mathbf{m}(11.2)^2$$

$$\frac{\mathbf{1}}{\mathbf{2}}\ \mathbf{mv^2} = \mathbf{3} \times \frac{\mathbf{1}}{\mathbf{2}}\ \mathbf{m} \times (11.2)^2$$

$$\mathbf{v} = \sqrt{3} \times 11.2 \text{ km/s}$$

47 Neutrinos are neutral particles with very small mass compared to electrons. They interact very weakly with matter.

Therefore, they are very difficult to detect, since they can even penetrate the large quantity of matter (earth) without any interaction.

Therefore, Assertion and Reason are correct and Reason is the correct explanation of Assertion.

48 For an adiabatic process,
$\mathbf{pV^{\gamma}} = \textbf{constant (say C)}$

Here, $\gamma = \dfrac{\mathbf{C_p}}{\mathbf{C_V}} = \dfrac{\mathbf{3}}{\mathbf{2}}$

$\therefore \quad \mathbf{pV^{3/2} = C}$

$\Rightarrow \quad \log\mathbf{p} + \dfrac{\mathbf{3}}{\mathbf{2}}\log\mathbf{V} = \log\mathbf{C}$

$\Rightarrow \quad \dfrac{\mathbf{\Delta p}}{\mathbf{p}} + \dfrac{\mathbf{3}}{\mathbf{2}}\dfrac{\mathbf{\Delta V}}{\mathbf{V}} = \mathbf{0}$

$\therefore \quad \dfrac{\mathbf{\Delta V}}{\mathbf{V}} = \dfrac{\mathbf{-2}}{\mathbf{3}}\dfrac{\mathbf{\Delta p}}{\mathbf{p}}$

$$\frac{\mathbf{\Delta V}}{\mathbf{V}} \times \mathbf{100} = -\left(\frac{\mathbf{2}}{\mathbf{3}}\right)\left(\frac{\mathbf{\Delta p}}{\mathbf{p}} \times \mathbf{100}\right)$$

$$= -\frac{\mathbf{2}}{\mathbf{3}} \times \frac{\mathbf{2}}{\mathbf{3}}\mathbf{\%} = -\frac{\mathbf{4}}{\mathbf{9}}\mathbf{\%}$$

Thus, volume decreases by $\dfrac{\mathbf{4}}{\mathbf{9}}\mathbf{\%}$,

49 Moseley's law is given by

$$\sqrt{\nu} = \mathbf{a(Z - b)}$$

For $\mathbf{K_\alpha}$ line, $\quad \mathbf{b = 1}$

$$\sqrt{\nu} = \mathbf{a(Z - 1)}$$

On squaring both sides, we get

$$\nu = \mathbf{a^2(Z - 1)^2}$$

or $\quad \dfrac{\mathbf{c}}{\lambda} = \mathbf{a^2(Z - 1)^2}$

$\Rightarrow \quad \lambda = \dfrac{\mathbf{c}}{\mathbf{a^2(Z - 1)^2}}$

For $\mathbf{Z = 43}$, wavelength $= \lambda$

$\therefore \quad \lambda = \dfrac{\mathbf{c}}{\mathbf{a^2(43 - 1)^2}}$

or $\quad \lambda = \dfrac{\mathbf{c}}{\mathbf{a^2(42)^2}} \quad$ ... (i)

For $\mathbf{Z = 29}$, wavelength,

$$\lambda' = \frac{\mathbf{c}}{\mathbf{a^2(29 - 1)^2}}$$

$$= \frac{\mathbf{c}}{\mathbf{a^2(28)^2}} \quad \text{... (ii)}$$

On dividing Eq. (ii) by Eq. (i), we get

$$\frac{\lambda'}{\lambda} = \left(\frac{\mathbf{42}}{\mathbf{28}}\right)^2$$

$$= \left(\frac{\mathbf{3}}{\mathbf{2}}\right)^2$$

$\therefore \quad \lambda' = \left(\dfrac{\mathbf{9}}{\mathbf{4}}\right)\lambda$

50 The voltage gain is low at high and low frequencies and constant at mid-frequency.