JEE (Main) PHYSICS SOLVED PAPER

2023
06th April Shift 2

Section A

Q. 1. The temperature of an ideal gas is increased from 200 K to 800 K. If r.m.s. speed of gas at 200 K is v_0. Then, r.m.s. speed of the gas at 800 K will be:

(1) $4v_0$ **(2)** $2v_0$ **(3)** v_0 **(4)** $\frac{v_0}{4}$

Q. 2. Given below are two statements : one is labelled as assertion A and the other is labelled as Reason R.

Assertion A : The phase difference of two light waves changes if they travel through different media having same thickness, but different indices of refraction.

Reason R : The wavelengths of waves are different in different media.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Both A and R are correct and R is the correct explanation of A
(2) A is not correct but R is correct
(3) A is correct but R is not correct
(4) Both A and R are correct but R is NOT the correct explanation of A

Q. 3. For an amplitude modulated wave the minimum amplitude is 3 V, while the modulation index is 60%. The maximum amplitude of the modulated wave is:

(1) 10 V **(2)** 12 V **(3)** 15 V **(4)** 5 V

Q. 4. The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is :

(1) 1 : 4 **(2)** 1 : 2 **(3)** 1 : 1 **(4)** 4 : 1

Q. 5. A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass 'm' of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance 'l'. If the dipole is placed in a uniform electric field '$\overline{E}$'; in such a way that dipole axis makes a very small angle with the electric field, '$\overline{E}$'. The angular frequency of the oscillations of the dipole when released is given by:

(1) $\sqrt{\frac{4qE}{3ml}}$ **(2)** $\sqrt{\frac{8qE}{ml}}$ **(3)** $\sqrt{\frac{8qE}{3ml}}$ **(4)** $\sqrt{\frac{4qE}{ml}}$

Q. 6. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: When you squeeze one end of a tube to get toothpaste out from the other end. Pascal's principle is observed.

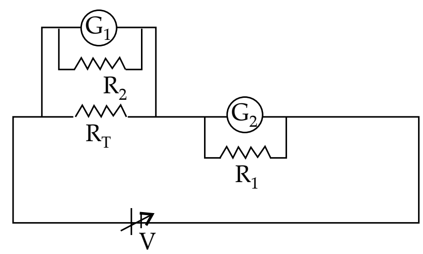
Reason R: A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

In the light of the above statements, choose the most appropriate answer from the options given below

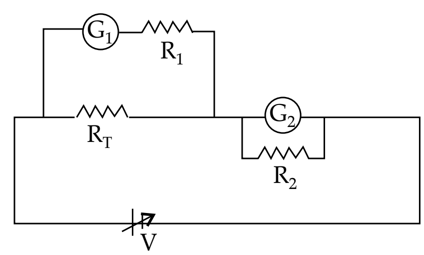
(1) A is correct but R is not correct
(2) Both A and R are correct and R is the correct explanation of A
(3) A is not correct but R is correct
(4) Both A and R are correct but R is NOT the correct explanation of A

Q. 7. A student is provided with a variable voltage source V, a test resistor $R_T = 10\ \Omega$, two identical galvanometers G_1 and G_2 and two additional resistors, $R_1 = 10\ M\Omega$ and $R_2 = 0.001\ \Omega$. For conducting an experiment to verify ohm's law, the most suitable circuit is :

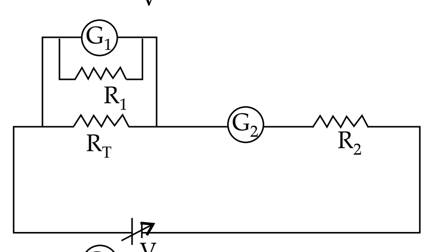
(1)



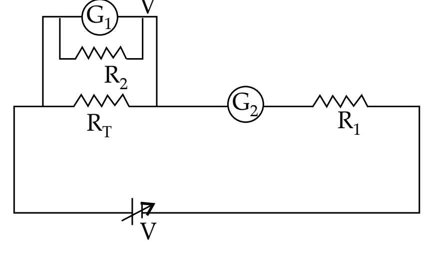
(2)



(3)



(4)



Q. 8. A body cools in 7 minutes from 60°C to 40°C. The temperature of the surrounding is 10°C . The temperature of the body after the next 7 minutes:
(1) 30°C **(2)** 34°C **(3)** 32°C **(4)** 28°C

Q. 9. The energy density associated with electric field $\vec{E}$ and magnetic field $\vec{B}$ of an electromagnetic wave in free space is given by: (ε_0 = permittivity of free space, μ_0 = permeability of free space)

(1) $U_E = \frac{\varepsilon_0 E^2}{2}, U_B = \frac{B^2}{2\mu_0}$

(2) $U_E = \frac{E^2}{2\varepsilon_0}, U_B = \frac{\mu_0 B^2}{2}$

(3) $U_E = \frac{E^2}{2\varepsilon_0}, U_B = \frac{B^2}{2\mu_0}$

(4) $U_E = \frac{\varepsilon_0 E^2}{2}, U_B = \frac{\mu_0 B^2}{2}$

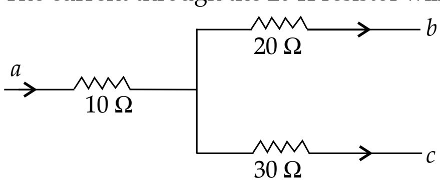
Q. 10. The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height from the surface of earth, equal to one-fourth the radius of the earth is:
(1) 64 N **(2)** 25 N **(3)** 100 N **(4)** 50 N

Q. 11. A capacitor of capacitance 150.0 μF is connected to an alternating source of emf given by $E = 36\sin(120\pi t)$ V. The maximum value of current in the circuit is approximatively equal to:

(1) $\sqrt{2}$A **(2)** $2\sqrt{2}$A **(3)** $\frac{1}{\sqrt{2}}$A **(4)** 2 A

Q. 12. A 2 metre long scale with least count of 0.2 cm is used to measure the locations of objects on an optical bench. While measuring the focal length of a convex lens, the object pin and the convex lens are placed at 80 cm mark and 1 m mark., respectively. The image of the object pin on the other side of lens coincides with image pin that is kept at 180 cm mark. The % error in the estimation of focal length is:
(1) 0.51 **(2)** 1.02 **(3)** 0.85 **(4)** 1.70

Q. 13. Figure shows a part of an electric circuit. The potentials at points a, b and c are 30 V, 12 V and 2 V respectively.
The current through the 20 Ω resistor will be:



(1) 1.0 A **(2)** 0.2 A **(3)** 0.4 A **(4)** 0.6 A

Q. 14. A small particle of mass m moves in such a way that its potential energy $U = \frac{1}{2}m\omega^2 r^2$ where ω is constant and r is the distance of the particle from origin. Assuming Bohr's quantization of momentum and circular orbit, the radius of n^{th} orbit will be proportional to:

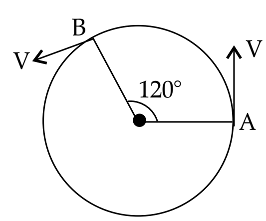
(1) n **(2)** n^2 **(3)** $\frac{1}{n}$ **(4)** $\sqrt{n}$

Q. 15. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : Diffusion current in a p-n junction is greater than the drift current in magnitude if the junction is forward biased.
Reason R: Diffusion current in a p-n junction is from the n-side to the p-side, if the junction is forward biased.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) A is not correct but R is correct
(2) Both A and R are correct and R is the correct explanation of A
(3) Both A and R are correct but R is NOT the correct explanation of A
(4) A is correct but R is not correct

Q. 16. Choose the incorrect statement from the following:
(1) The linear speed of a planet revolving around the sun remains constant.
(2) The speed of satellite in a given circular orbit remains constant.
(3) When a body falls towards earth, the displacement of earth towards the body is negligible.
(4) For a planet revolving around the sun in an elliptical orbit, the total energy of the planet remains constant.

Q. 17. A child of mass 5 kg is going round a merry-go-round that makes 1 rotation in 3.14 s. The radius of the merry-go-round is 2 m. The centrifugal force on the child will be:
(1) 40 N **(2)** 100 N **(3)** 80 N **(4)** 50 N

Q. 18. As shown in the figure, a particle is moving with constant speed π m s^{-1}. Considering its motion from A to B, the magnitude of the average velocity is:



(1) π m s^{-1} **(2)** $2\sqrt{3}$ m s^{-1}
(3) $\sqrt{3}$ m s^{-1} **(4)** $1.5\sqrt{3}$ m s^{-1}

Q. 19. The work functions of Aluminium and Gold are 4.1 e V and 5.1 e V respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is:
(1) 1 **(2)** 2 **(3)** 1.24 **(4)** 1.5

Q. 20. A particle starts with an initial velocity of 10.0 m s^{-1} along x-direction and accelerates uniformly at the rate of 2.0 m s^{-2}. The time taken by the particle to reach the velocity of 60.0 m s^{-1} is :
(1) 3 s **(2)** 6 s **(3)** 25 s **(4)** 30 s

Section B

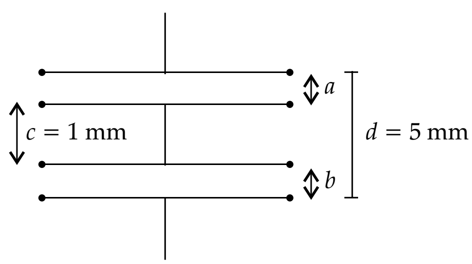
Q. 21. A simple pendulum with length 100 cm and bob of mass 250 g is executing S.H.M. of amplitude 10 cm. The maximum tension in the string is found to be $\frac{x}{40}$ N. The value of x is ________.

Q. 22. Experimentally it is found that 12.8 e V energy is required to separate a hydrogen atom into a proton and an electron. So the orbital radius of the electron in a hydrogen atom is $\frac{9}{x}\times10^{-10}$m. The value of the x is : _______.
(1 e V = 1.6×10^{-19} J, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2/ C^2 and electronic charge = 1.6×10^{-19} C)

Q. 23. A beam of light consisting of two wavelengths 7000 Å and 5500 Å is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the place of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is $n \times 10^{-5}$ m. The value of n is ______.

Q. 24. Two concentric circular coils with radii 1 cm and 1000 cm, and number of turns 10 and 200 respectively are placed coaxially with centers coinciding. The mutual inductance of this arrangement will be _______ $\times 10^{-8}$ H.
(Take, $\pi^2 = 10$)

Q. 25. As shown in the figure, two parallel plate capacitors having equal plate area of 200 cm^2 are joined in such a way that $a \neq b$. The equivalent capacitance of the combination is $x\varepsilon_0$F. The value of x is _______.

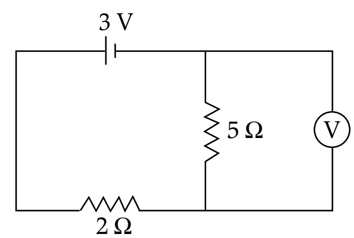


Q. 26. A proton with a kinetic energy of 2.0 e V moves into a region of uniform magnetic field of magnitude $\frac{\pi}{2}\times10^{-3}$ T.
The angle between the direction of magnetic field and velocity of proton is 60°. The pitch of the helical path taken by the proton is ______ cm. (Take, mass of proton = 1.6×10^{-27} kg and Charge on proton = 1.6×10^{-19} C).

Q. 27. A body is dropped on ground from a height 'h_1' and after hitting the ground, it rebounds to a height 'h_2'. If the ratio of velocities of the body just before and after hitting ground is 4, then percentage loss in kinetic energy of the body is $\frac{x}{4}$. The value of x is ________.

Q. 28. A ring and a solid sphere rotating about an axis passing trough their centres have same radii of gyration. The axis of rotation is perpendicular to plane of ring. The ratio of radius of ring to that of sphere is $\sqrt{\frac{2}{x}}$. The value of x is ______.

Q. 29. As shown in the figure, the voltmeter reads 2 V across 5 Ω resistor. The resistance of the voltmeter is ___ Ω



Q. 30. A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is 7×10^5 N m^{-2} . The value of mass m is _____kg.
(Take, g = 9.8 m s^{-2} and $\pi = \frac{22}{7}$)

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(2)	r.m.s. speed of Gas	Kinetic Theory of Gases
2	(1)	Refraction	Ray Optics
3	(2)	Modulation	Communication System
4	(4)	Speed of Sound	Oscillations
5	BONUS	Torque on Electric Dipole Placed in Uniform Electric Field	Electric Charges and Fields
6	(2)	Pascal's Law	Mechanical Properties of Fluids
7	(2)	Moving Coil Galvanometer	Moving Charges and Magnetism
8	(4)	Newton's Law of Cooling	Thermal Properties of Matter
9	(1)	Energy Density	Electromagnetic Waves

10	**(1)**	Varation in Acceleration due to Gravity	Gravitation
11	**(4)**	Alternating Current	Alternating Current
12	**(4)**	Errors in Measurements	Units and Dimesnions
13	**(3)**	Kirchoff's Law	Current Electricity
14	**(4)**	Bohr Model	Atoms
15	**(4)**	p-n Junction Diode	Semiconductor Electronics
16	**(1)**	Planetary Motion	Gravitation
17	**(1)**	Centrifugal Force	Laws of Motion
18	**(4)**	Angular Motion	Motion in a Plane
19	**(1)**	Stopping Potential	Dual Nature of Radiation and Matter
20	**(3)**	Acceleration	Motion in One Dimension
21	**[99]**	Simple Pendulum	Oscillations
22	**[16]**	Bohr Model	Atoms
23	**[462]**	Young's Double Slit Experiment	Wave Optics
24	**[4]**	Mutual Inductance	Electromagnetic Induction
25	**[5]**	Parallel Plate Capacitor	Electrostatic Potential and Capacitance
26	**[40]**	Motion of Charged Particle Inside a Magnetic Field	Moving Charges and Magnetism
27	**[375]**	Kinetic Energy	Work, Energy and Power
28	**[5]**	Radius of Gyration	System of Particles and Rotational Motion
29	**[20]**	Electric Circuit	Current Electricity
30	**[11]**	Young's Modulus of Elasticity	Mechanical Properties of Solids

SOLUTIONS

Section A

1. Option (2) is correct.

Given, $T_1 = 200\text{ K}, T_2 = 800\text{ K}$

$v_1 = v_0, v_2 = ?$

For gas, $v_{\text{rms}} = \sqrt{\dfrac{3RT}{m}} \Rightarrow v_{\text{rms}} \propto \sqrt{T}$

Now, $\dfrac{v_2}{v_1} = \sqrt{\dfrac{T_2}{T_1}} = \sqrt{\dfrac{800}{200}} = 2$

or $v_2 = 2v_0$

2. Option (1) is correct.

Wavelength changes with medium and depends on refractive index as, $\lambda \propto \dfrac{1}{\mu}$

During refraction, $\phi = \dfrac{2\pi}{\lambda}\Delta x$,

we can see phase difference depends upon λ or μ.

Hence reason correctly explains the assertion.

3. Option (2) is correct.

Given, modulation index, $m = 60\%$ or 0.6

$$m = \frac{A_m}{A_c} = 0.6$$

$$\frac{A_m + A_c}{A_m - A_c} = \frac{0.6+1}{0.6-1} = -\frac{1.6}{0.4}$$

$$\frac{A_m + A_c}{-3V} = -4$$

$$\Rightarrow \quad A_m + A_c = 12V$$

4. Option (4) is correct.

Speed of sound is given by,

$$v = \sqrt{\gamma\frac{RT}{m}}$$

At constant temp, $v \propto \sqrt{\dfrac{1}{m}}$

Hence, $\dfrac{v(\text{in } H_2)}{v(\text{in } O_2)} = \sqrt{\dfrac{m_{O_2}}{m_{H_2}}} = \sqrt{\dfrac{32}{2}} = \sqrt{16} = 4:1$

5. None of the given Options (BONUS) is correct.

Here mass of two charges in dipole is not same, hence we need to find its location.

Centre of mass will be at $\dfrac{l}{3}$ from positive charge and $\dfrac{2l}{3}$ from negative charge.

M.I. about axis, $\mathrm{I} = 2m\left(\dfrac{l}{3}\right)^2 + m\left(\dfrac{2l}{3}\right)^2$

$\Rightarrow \quad \mathrm{I} = 2\dfrac{ml^2}{3}$

Now, $pE = I\omega^2$

$$\omega = \sqrt{\frac{pE}{I}} = \sqrt{\frac{qlE}{\frac{2ml^2}{3}}} = \sqrt{\frac{3qE}{2ml}}$$

None of the option matches with the obtained value.

6. Option (2) is correct.

According to Pascal's law pressure applied to an ideal fluid gets transmitted equally in all the directions and to the wall of container as well. Hence, both statements are true and reason correctly explains assertion.

7. Option (2) is correct.

For a galvanometer

Small shunt resistor in parallel ⇒ ammeter

Large shunt resistor in series ⇒ voltmeter

We know ammeter is always connected in series and voltmeter always in parallel. Only option (2) fulfills this criteria.

8. Option (4) is correct.

As per Newton's law of cooling,

$$mc\frac{T_1 - T_2}{t} = k\left(\frac{T_1 + T_2}{2} - T_0\right)$$

Case 1: $T_1 = 60°, T_2 = 40°, T_s = 10°$

$t = 7$ min or 420 s

$$mc\frac{60-40}{420} = k\left(\frac{60+40}{2} - 10\right)$$

$$\frac{mc}{420} \times 20 = 40k \quad \text{...(i)}$$

Case 2: $T_1 = 40°, T_2 = T, T_s = 10°$

$t = 7$ min or 420 s

$$mc\frac{40-T}{420} = k\left(\frac{40+T}{2} - 10\right)$$

From eq. (i), $2k(40 - T) = k\left(\frac{40+T}{2} - 10\right)$

$$\Rightarrow \quad 160 - 4T = 20 + T$$

$$\Rightarrow \quad T = 28°$$

9. Option (1) is correct.

Energy density of EMW, $u_E = \frac{1}{2}\varepsilon_0 E^2$ & $u_B = \frac{B^2}{2\mu_0}$

10. Option (1) is correct.

Acceleration due to gravity at a height h,

$$g_h = g\frac{R^2}{(R+h)^2}$$

$$g_h = g\frac{R^2}{\left(R + \frac{R}{4}\right)^2} = \frac{16}{25}g$$

$$W_h = mg_h$$

$$= \frac{16}{25}mg = \frac{16}{25} \times 100 = 64\,\text{N}$$

11. Option (4) is correct.

Given, $E = 36\sin(120\pi t)$ Volt

Charge in capacitor, $q = CV$

or $q = CE_0 \sin \omega t$

$$i = \frac{dq}{dt} = \omega CE_0 \cos \omega t$$

$$i_0 = \omega CE_0$$

$$= 120\pi \times 150 \times 10^{-6} \times 36$$

$$= 2.03\text{ A}$$

12. Option (4) is correct.

Here, $u = 100 - 80 = 20$ cm

$v = 180 - 100 = 80$ cm

Error in measuring object and image positions,

$$u + \Delta u = (100 \pm 0.2) - (80 \pm 0.2) = 20 \pm 0.4$$

$$v + \Delta v = (180 \pm 0.2) - (80 \pm 0.2) = 80 \pm 0.4$$

Using $$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \text{...(i)}$$

$$\Rightarrow \quad \frac{1}{f} = \frac{1}{80} + \frac{1}{20}$$

$$\Rightarrow \quad f = 16\text{ cm}$$

On differentiating eq.(i), we get

$$-\frac{df}{f^2} = -\frac{dv}{v^2} - \frac{du}{u^2}$$

$$\Rightarrow \quad \frac{\Delta f}{f^2} = \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2} \quad \text{...(ii)}$$

$$\Rightarrow \quad \frac{\Delta f}{f} = 16\left(\frac{0.4}{80^2} + \frac{0.4}{20^2}\right)$$

$$\Rightarrow \quad \%\frac{\Delta f}{f} = \frac{16}{80^2}(0.4 + 6.4) = 1.7$$

13. Option (3) is correct.

Let the potential at junction be V and current in three branches be i_a, i_b, i_c

Using Kirchhoff's junction law,

$$i_a + i_b + i_c = 0$$

$$\Rightarrow \quad \frac{V - V_a}{R_a} + \frac{V - V_b}{R_b} + \frac{V - V_c}{R_c} = 0$$

$$\Rightarrow \quad \frac{V-30}{10} + \frac{V-12}{20} + \frac{V-2}{30} = 0$$

$$\Rightarrow \quad \frac{6V - 180 + 3V - 36 + 2V - 4}{60} = 0$$

$$\Rightarrow \quad 11V = 220 \text{ or } V = 20\,V$$

Now, $$i_b = \frac{20-12}{20} = \frac{8}{20} = 0.4\text{ A}$$

14. Option (4) is correct.

As per bohr's model,

$$KE = \frac{1}{2}PE$$

$$\Rightarrow \quad mv^2 = \frac{1}{2}\left(\frac{1}{2}m\omega^2 r^2\right) \quad \text{...(i)}$$

As per Bohr's quantization rule for angular momentum,

$$\Rightarrow \quad mvr = \frac{nh}{2\pi} \quad \text{...(ii)}$$

On squaring both the sides,

$$v^2 = \frac{n^2h^2}{4\pi^2 m^2 r^2} \quad \text{...(iii)}$$

From equation (i) and (iii),

$$\frac{n^2h^2}{4\pi^2m^2r^2} = \frac{1}{2}\left(\frac{1}{2}\omega^2r^2\right)$$

$$\Rightarrow \quad r^4 = \frac{n^2h^2}{\pi^2m^2\omega^2}$$

$$\Rightarrow \quad r \propto \sqrt{n}$$

15. Option (4) is correct.

When p-n junction is forward biased, diffusion current is from p region to n region.

Hence statement II is wrong. Drift current is always due to minority charge carriers and opposite to the direction of diffusion current, hence in forward bias drift current is always lesser.

16. Option (1) is correct.

Mass of earth is extremely high as compare to object, displacement in earth is negligible.

For a planet revolving around sun, speed, energy and momentum remains conserved, but since its path is not linear hence linear speed cannot remain constant. So statement I is wrong.

17. Option (1) is correct.

Given, $m = 5$ kg, $r = 2$ m

Time period of rev,

$$t = 3.14 \text{ s or } \pi\, s$$

$$\omega = \frac{\theta}{t} = \frac{2\pi}{\pi} = 2 \text{ rad}\, s^{-1}$$

$$F_{centrifugal} = rm\omega^2$$

$$\Rightarrow \quad F = 2 \times 5 \times 2^2 = 40 \text{ N}$$

18. Option (4) is correct.

Given, $v = \pi \text{ m s}^{-1}$

$$\Rightarrow \quad \omega = \frac{v}{R} = \frac{\pi}{R}$$

Angular displacement, $\theta = 120° \text{ or } \frac{2\pi}{3}$

Time taken, $t = \frac{\theta}{\omega} = \frac{\frac{2\pi}{3}}{\frac{\pi}{R}} = \frac{2R}{3}$

Linear displacement, $d = 2R\sin\frac{120°}{2}$

$$d = 2R \times \sin 60° = \sqrt{3}R$$

Average velocity, $v' = \frac{d}{t}$

$$\frac{\sqrt{3}R}{\frac{2R}{3}} = 1.5\sqrt{3} \text{ m s}^{-1}$$

19. Option (1) is correct.

In graph between stopping potential *vs.* frequency, slope does not depend upon type of metal and is always constant with the slope $\frac{h}{e}$.

$$V_s = \frac{h}{e}v - \frac{\phi}{e}$$

Comparing with $y = mx + C$, we get $m = \frac{h}{e}$

20. Option (3) is correct.

Here, $u = 10 \text{ m s}^{-1}$, $a = 2 \text{ m s}^{-2}$, $v = 60 \text{ m s}^{-1}$

We know that, $a = \frac{v-u}{t}$

$$\Rightarrow \quad t = \frac{60-10}{2}$$

$$= \frac{50}{2} = 25 \text{ s}$$

Section B

21. The correct answer is (99).

Given, $L = 1$ m, $m = 0.25$ kg, $A = 10$ cm

From FBD at mean position

$$T_{max} = mg + \frac{mv^2}{L}$$

For SHM, $KE_{max} = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2A^2$

$$\Rightarrow \quad T_{max} = mg + \frac{m\omega^2A^2}{L} \quad ...(i)$$

Time period of simple pendulum,

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

$$\Rightarrow \quad \omega = \frac{2\pi}{T} = \sqrt{\frac{g}{L}} \quad ...(ii)$$

Substituting value from (ii) in (i),

$$\Rightarrow \quad T_{max} = mg + \frac{mgA^2}{L^2}$$

$$\Rightarrow \quad T_{max} = \frac{9.8}{4}\left(1 + \frac{0.1^2}{1}\right)$$

$$= \frac{9.898}{4} = \frac{98.98}{40}$$

$\Rightarrow$ Comparing above with $\frac{x}{40}$, we get

$$x = 98.98 \approx 99$$

22. The correct answer is (16).

Total energy of electron in a hydrogen atom,

$$E = \frac{e^2}{8\pi\varepsilon_0 r}$$

$$\Rightarrow \quad r = \frac{1 \times 9 \times 10^9 (1.6 \times 10^{-19})^2}{2 \times 12.8 \times 1.6 \times 10^{-19}}$$

$$\Rightarrow \quad r = \frac{9}{16} \times 10^{-10} \text{ m}$$

on comparing, we get $x = 16$

23. The correct answer is (462).

Point of maxima is given by,

$$y = \frac{n\lambda D}{d}$$

Let m^{th} bright fringe of 7000 Å coincides with n^{th} fringe of 5500 Å. So

$$\Rightarrow \frac{m \times 7000\,\text{Å} \times 150\,\text{cm}}{d} = \frac{n \times 5500\,\text{Å} \times 150\text{ cm}}{d}$$

$$\Rightarrow \frac{m}{n} = \frac{55}{70} = \frac{11}{14}$$

Least distance of coincidence,

$$y = m \times \frac{7000\,\text{Å} \times 150\text{ cm}}{d}$$

$$\Rightarrow y = \frac{11 \times 7000 \times 10^{-10} \times 150 \times 10^{-2}}{2.5 \times 10^{-3}}$$

$$\Rightarrow y = 462 \times 10^{-5}\text{ m}$$

On comparison, $n = 462$

24. The correct answer is (4).

Given, $r_1 = 1000$ cm or 10 m

$r_2 = 1$ cm or 0.01 m

Number of turns in inner coil, $N_1 = 10$

Number of turns in outer coil, $N_2 = 200$

Since, $r_1 > r_2$

Magnetic flux, $\phi = BA = \frac{\mu_0 i_1 N_1}{2r_1} \times \pi r_2^2 N_2$

Mutual inductance, $M = \frac{\phi}{i_1}$

$$\Rightarrow M = \frac{4\pi \times 10^{-7} \times 200}{2 \times 10} \times \pi \times 0.01 \times 0.01 \times 10$$

$\Rightarrow M = 4\pi^2 \times 10^{-9}$

$\Rightarrow M = 4 \times 10^{-8}$ [given, $\pi^2 = 10$]

25. The correct answer is (5).

Here, $b = 5 - 1 - a = (4 - a)$ mm

Capacitance, $C = \frac{\varepsilon_0 A}{d}$

In series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$$\Rightarrow \frac{1}{C} = \frac{a}{\varepsilon_0 A} + \frac{4-a}{\varepsilon_0 A}$$

$$\Rightarrow C = \frac{\varepsilon_0 A}{4} = \frac{200 \times 10^{-4}}{4 \times 10^{-3}}\varepsilon_0$$

$\Rightarrow C = 5\varepsilon_0$

On comparing with $C = x\varepsilon_0$, we get, $x = 5$

26. The correct answer is (40).

Given, $B = \frac{\pi}{2} \times 10^{-3} T, K = 2\ eV$

Kinetic energy, $k = \frac{1}{2}mv^2$

$$\Rightarrow v = \sqrt{\frac{2k}{m}}$$

Velocity in the direction of magnetic field = $v\cos 60°$

Pitch = $v\cos 60° \times$ time period of one rotation

$$\Rightarrow \sqrt{\frac{2 \times 2 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-27}}} \times \frac{1}{2} \times \frac{2\pi m}{qB}$$

$$\Rightarrow 2 \times 10^4 \times \frac{1}{2} \times \frac{2 \times \pi \times 1.6 \times 10^{-27}}{1.6 \times 10^{-19} \times \frac{\pi}{2} \times 10^{-3}}$$

$\Rightarrow$ 0.4 m or 40 cm

27. The correct answer is (375).

Let, velocity before hitting ground = u

Velocity after hitting ground = v

Given, $\frac{u}{v} = 4$ or $v = \frac{u}{4}$

Loss in KE = ΔKE = $\frac{\frac{1}{2}mu^2 - \frac{1}{2}mv^2}{\frac{1}{2}mu^2}$

$$\Rightarrow \Delta KE = \frac{\frac{1}{2}mu^2 - \frac{1}{2 \times 16}mu^2}{\frac{1}{2}mu^2} \Rightarrow 1 - \frac{1}{16} = \frac{15}{16}$$

$$\Rightarrow \%\Delta KE = \frac{15}{16} \times 100 = \frac{375}{4} = \frac{x}{4}$$

On comparing, $x = 375$

28. The correct answer is (5).

M.I. of ring = MR^2

M.I. of sphere = $\frac{2}{5}MR^2$

Radius of gyration is given by,

$$k = \sqrt{\frac{I}{M}}$$

Given, $k_{ring} = k_{sphere}$

$$\Rightarrow \frac{R_{ring}}{R_{sphere}} = \sqrt{\frac{2}{5}} = \sqrt{\frac{2}{x}}$$

On comparing, $x = 5$

29. The correct answer is (20).

Voltage drop across 2 Ω resistor = 3 – 2 = 1 volt

Current, $i = \frac{V}{2} = \frac{1}{2}$A

Let current through 5 Ω resistor be i_1 and through voltmeter be i_2, then

$i_1 = \frac{V_1}{5} = \frac{2}{5}A$ and $i_2 = \frac{V_2}{R} = \frac{2}{R}A$

$$i_1 + i_2 = i$$

$$\Rightarrow \frac{2}{5} + \frac{2}{R} = \frac{1}{2}$$

$\Rightarrow R = 20\ \Omega$

30. The correct answer is (11).

Given, stress = 7×10^5 Nm^{-2}

Diameter of wire, $d = 14$ mm or 14×10^{-3} m^3

Force = Stress × Area

$$mg = 7 \times 10^5 \times \pi \times \frac{14}{2} \times \frac{14}{2} \times 10^{-6}$$

$$\Rightarrow m = \frac{107.8}{9.8} = 11\text{kg}$$

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