JEE Main 2023 (2nd Attempted)
(Shift - 02 Physics Paper) 06.04.2023

PHYSICS | **TEST PAPER WITH SOLUTION**

SECTION-A

31. A 2 meter 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 lm 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) 1.02 (2) 0.85

(3) 1.70 (4) 0.51

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Least count = 0.2 cm

$$u=(100\pm0.2)-(80\pm0.2)=(20\pm0.4)\text{cm}$$

$$v=(180\pm0.2)-(100\pm0.2)=(80\pm0.4)\text{cm}$$

From lens formula,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{1}{f}=\frac{1}{80}-\frac{1}{-20}$$

f = 16 cm

Also $\frac{\Delta v}{v^2}+\frac{\Delta u}{u^2}=\frac{\Delta f}{f^2}$

$$\Rightarrow\frac{\Delta f}{f}\times100=\left(\frac{\Delta v}{v^2}+\frac{\Delta u}{u^2}\right)\times f\times100$$

$$\Rightarrow\%f=\left(\frac{0.4}{400}+\frac{0.4}{6400}\right)\times16\times100$$

=1.70

32. A capacitor of capacitance 150.0 μF is connected to an alternating source of emf given by E = 36 sin(120πt) V. The maximum value of current in the circuit is approximately equal to :

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

(3) $\sqrt{2}$A (4) $2\sqrt{2}$A

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $I_0=\frac{E_0}{x_c}=\frac{E_0}{\frac{1}{\omega_c}}=E_0\omega_c$

$$\Rightarrow I_0=36\times120\pi\times150\times10^{-6}$$

$$\Rightarrow I_0=2.03$$

$\simeq 2A$

33. 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 not correct but **R** is correct

(2) **A** is correct but **R** is not correct

(3) Both **A** and **R** are correct and R is the correct explanation of **A**

(4) Both **A** and **R** are correct but **R** is **NOT** the correct explanation of **A**

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. (R) is the statement of Pascal's principle & which explains the assertion (S)

34. 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 change 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 but **R** is **NOT** the correct explanation of **A**

(2) **A** is correct but **R** is not correct

(3) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(4) **A** is not correct but **R** is correct

Official Ans. by NTA (3)

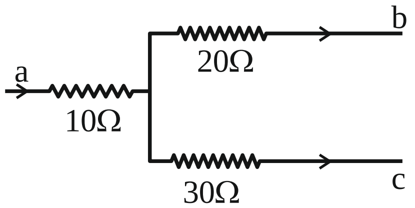
Allen Ans. (3)

Sol. As medium changes, optical path changes.

Also, $\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$

Hence phase difference changes.

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



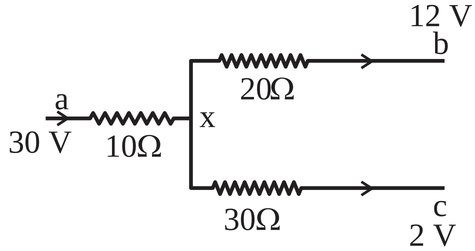
(1) 0.4 A (2) 0.2 A

(3) 0.6 A (4) 1.0 A

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Sum of current at junction point will be zero :



$$\frac{x-30}{10} + \frac{x-12}{20} + \frac{x-2}{30} = 0$$

$$\Rightarrow x\left(\frac{1}{10} + \frac{1}{20} + \frac{1}{30}\right) = \frac{30}{10} + \frac{12}{20} + \frac{2}{30}$$

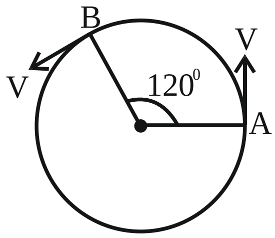
$$\Rightarrow x\left(\frac{6+3+2}{60}\right) = \frac{180+36+4}{60}$$

$$\Rightarrow \text{x} = \frac{220}{11} = 20\text{V}$$

$\therefore$ Current through $20\Omega = \frac{x-12}{20}$

$$= \frac{20-12}{20} = \frac{2}{5} = 0.4A$$

36. As shown in the figure, a particle is moving with constant speed π m/s. Considering its motion from A to B, the magnitude of the average velocity is:



(1) π m/s (2) $\sqrt{3}$ m/s

(3) $2\sqrt{3}$ m/s (4) $1.5\sqrt{3}$ m/s

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $|\langle \vec{v} \rangle| = \frac{|\vec{r}_f - \vec{r}_i|}{\Delta t}$

$$= \frac{2R\cos\left[\frac{\pi-\theta}{2}\right]}{\frac{2\pi R}{3v}} = 3\cos 30^0$$

$1.5\sqrt{3}\ m/s$

Correct option is (4)

37. The work functions of Aluminium and Gold are 4.1 eV and 5.1 eV respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is

(1) 1.24 (2) 2

(3) 1 (4) 1.5

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $eV_s = k_{max}$

$$V_s = \left\{\frac{h}{e}\right\} f + \left\{\frac{-\phi}{e}\right\}$$

Slope is independent of nature of metal

$$slope(V_s)^{Gold} = slope(V_s)^{Aluimiun}$$

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

(1) 4 : 1 (2) 1 : 2

(3) 1 : 4 (4) 1 : 1

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $$C = \sqrt{\frac{\gamma RT}{M}}$$

$$C \propto \frac{1}{\sqrt{M}}$$

$$\frac{C_{H_2}}{C_{O_2}} = \sqrt{\frac{32}{2}} = 4:1$$

Correct option (1)

39. 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) 80 N (2) 50 N

(3) 100 N (4) 40 N

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $$\omega = \frac{2\pi}{3.14} = 2\ rad/s$$

$$\left|\bar{f}_{centrifugal}\right| = \left|-m\bar{a}_{\text{Re}f.}\right|$$

$$= M\omega^2 R$$

= 40 N

Correct option (4)

40. A particle starts with an initial velocity of $10.0ms^{-1}$ along x-direction and accelerates uniformly at the rate of $2.0\ ms^{-2}$. The time taken by the particle to reach the velocity of $60.0\ ms^{-1}$ is______.

(1) 6s (2) 3s

(3) 30s (4) 25s

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. v = u + at

60 = 10 + 2t

t = 25 sec.

Correct option (4)

41. Choose the incorrect statement from the following:

(1) The speed of satellite in a given circular orbit remains constant.

(2) For a planet revolving around the sun in an elliptical orbit, the total energy of the planet remains constant.

(3) When a body fall towards earth, the displacement of earth towards the body is negligible.

(4) The linear speed of a planet revolving around the sun remains constant.

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Planets revolve in elliptical paths around sun. Thus their linear speed is not constant

42. 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) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(2) Both **A** and **R** are correct but **R** is **NOT** the correct explanation of **A**

(3) **A** is correct but **R** is not correct

(4) **A** is not correct but **R** is correct

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. In forward biased condition, diffusion of majority charge carriers takes place from p-side to n-side which constitute the diffusion current.

43. 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 '$\vec{E}$'; such a way that dipole axis makes a very small angle with the electric field, '$\vec{E}$'. The angular frequency of the oscillations of the dipole when released is given by:

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

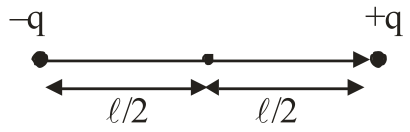
(3) $\sqrt{\frac{4qE}{3ml}}$ (4) $\sqrt{\frac{8qE}{ml}}$

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. **Note:** Dipole will rotate about COM but no option is matching with this calculation.

If we assume dipole to oscillate about midpoint



$\tau = -PE.\theta$

$\Rightarrow \left[m\frac{l^2}{4} + 2m\frac{l^2}{4}\right]\alpha = -qlE.\theta$

$\Rightarrow \frac{3ml^2}{4}\alpha = -qlE.\theta \quad \Rightarrow \alpha = -\frac{4qE}{3ml}\theta$

$\omega = \sqrt{\frac{4qE}{3ml}}$

Correct Ans. is (3)

44. 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) $U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{B^2}{2\mu_0}$

(2) $U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{\mu_0 B^2}{2}$

(3) $U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{\mu_0 B^2}{2}$

(4) $U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{B^2}{2\mu_0}$

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $U_E = \frac{1}{2}\epsilon_0 E^2, U_B = \frac{B^2}{2\mu_0}$

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

(1) v_0 (2) $4v_0$

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

Official Ans. by NTA (4)

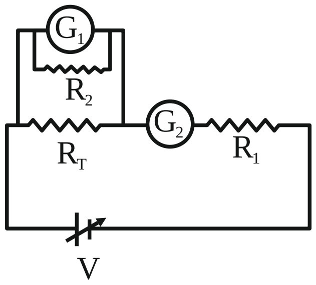
Allen Ans. (4)

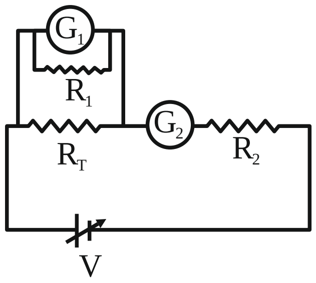
Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

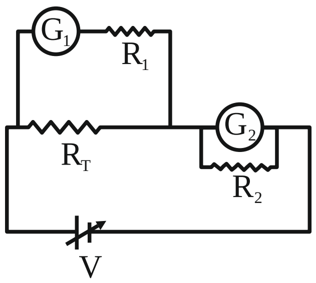
$\Rightarrow V_{rms} \propto \sqrt{T}$

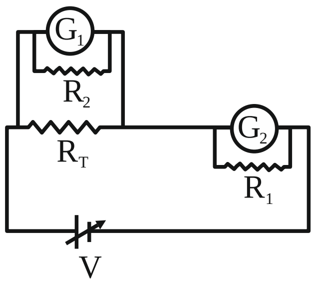
Increasing temperature 4 times, rms speed gets doubled.

46. A student is provided with a variable voltage source V, a test resistor R_r = 10Ω, two identical galvanometers G_1 and G_2 and two additional resistors, R_1 = 10MΩ and R_2 = 0.001Ω. For conducting an experiment to verify ohms law, the most suitable circuit is:

(1)


(2)


(3)


(4)


Official Ans. by NTA (3)

Allen Ans. (3)

Sol. To convert galvanometer into ammeter low resistances should be added into parallel & for voltmeter conversion, a very high resistance should be added in series.

47. 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 will be:

(1) 32°C (2) 30°C

(3) 28°C (4) 34°C

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. using average rate of Newton's law of cooling

$$\frac{T_1 - T_2}{t} = K\left(\frac{T_1 + T_2}{2} - T_s\right)$$

Given $\frac{60-40}{7} = K(50-10)$ … (i)

& $\frac{40-T}{7} = K\left(\frac{40+T}{2} - 10\right)$ … (ii)

From (i) & (ii)

T = 28°C

48. 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) $\sqrt{n}$ (2) n

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

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $U = \frac{1}{2}m\omega^2 r^2$

$$F = -\frac{dv}{dr} = -m\omega^2 r$$

Now $m\omega^2 r = \frac{mv^2}{r} \Rightarrow v = \omega r$ …(i)

& $mvr = \frac{nh}{2\pi}$ …(ii)

From (i) & (ii)

$$m\omega r^2 = \frac{nh}{2\pi}$$

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

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

(1) 15V

(2) 12V

(3) 10V

(4) 5V

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. Modulation index $= \frac{A_m}{A_c} = 0.6$

Minimum amplitude of modulated wave $= A_c - A_m = 3$

$\therefore A_C - 0.6A_c = 3 \Rightarrow 0.4A_c = 3$

$A_c = \frac{3}{0.4} = \frac{15}{2} = 7.5V$

$A_m = 0.6A_c = 4.5V$

$\therefore$ Maximum amplitude = $A_c + A_m$

= 7.5 + 4.5 = 12V

$\therefore$ Correct option is (2)

50. 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) 100 N

(2) 64 N

(3) 50 N

(4) 25 N

Official Ans. by NTA (2)

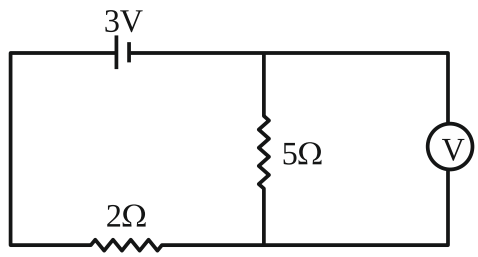
Allen Ans. (2)

Sol. $\Rightarrow g' = \frac{gR^2}{r^2} = \frac{gR^2}{\left(R+\frac{R}{4}\right)^2} = \frac{16g}{25}$

$\therefore Weight = \frac{16}{25} \times 100 = 64N$

SECTION-B

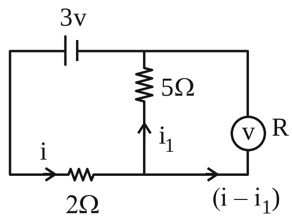
51. As shown in the figure, the voltmeter reads 2V across 5 Ω resistor. The resistance of the voltmeter is________Ω.



Official Ans. by NTA (20)

Allen Ans. (20)

Sol. $i_1 = \frac{2V}{5\Omega} = \frac{2}{5}A$



$i = \frac{1V}{2\Omega} = \frac{1}{2}A$

$\therefore$ Current through voltmeter = $i - i_1$

$= \frac{1}{2} - \frac{2}{5} = \frac{5-4}{10} = \frac{1}{10}A$

$\therefore$ For voltmeter

$2 = \left(\frac{1}{10}\right)R \Rightarrow R = 20\Omega$

52. 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 Nm^{-2}. The value of mass m is _______ kg.

(Take, $g = 9.8\ ms^{-2}$ and $\pi = \frac{22}{7}$)

Official Ans. by NTA (11)

Allen Ans. (11)

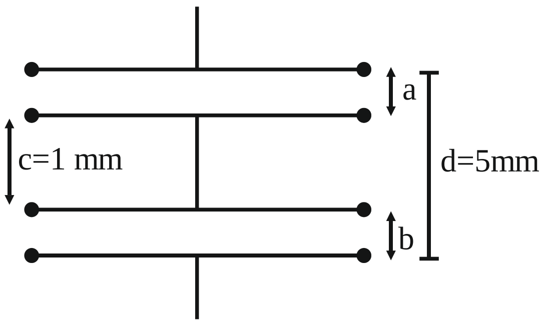
Sol. Tensile stress, $\sigma = \frac{F}{A} = \frac{4mg}{\pi D^2}$

$$\therefore m = \frac{\pi D^2 \sigma}{4g}$$

$$= \frac{22}{7} \times \frac{(14\times10^{-3})^2 \times 7\times10^5}{4\times9.8}$$

= 11 kg

53. 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 $\in_0$ F. The value of x is______.



Official Ans. by NTA (5)

Allen Ans. (5)

Sol. $c = \frac{\varepsilon_0 A}{(d-c)}$

$$= \frac{\varepsilon_0 \times 200\times10^{-4}}{4\times10^{-3}}$$

$\therefore x = 5$

The situation is equivalent to a conducting slab placed between the plates

54. A ring and a solid sphere rotating about an axis passing through their centers 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 _______

Official Ans. by NTA (5)

Allen Ans. (5)

Sol. For ring $I = mR_1^2 = mK_1^2$

$\therefore$ Radius of gyration $K_1 = R_1$

For solid sphere

$$I' = \frac{2}{5}m'R_2^2 = m'K_2^2$$

$\therefore$ Its radius of gyration $= K_2 = \sqrt{\frac{2}{5}}R_2$

$\because K_1 = K_2$

$$\therefore R_1 = \sqrt{\frac{2}{5}}R_2$$

$$\therefore \frac{R_1}{R_2} = \sqrt{\frac{2}{5}}$$

$\therefore x = 5$

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

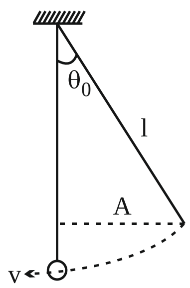
Official Ans. by NTA (99)

Allen Ans. (99)

Sol. $\sin\theta_0 = \frac{A}{l} = \frac{10}{100} = \frac{1}{10}$

From conservation of energy

$$\frac{1}{2}mv^2 = mgl(1-\cos\theta)$$



Maximum tension occurs at mean position.

$$\therefore T - mg = \frac{mv^2}{l}$$

$$\Rightarrow T = mg + \frac{mv^2}{l}$$

$\therefore T = mg + 2mg(1-\cos\theta)$

$= mg\left[1+2\left(1-\sqrt{1-\sin^2\theta}\right)\right]$

$= mg\left[3-2\sqrt{1-\frac{1}{100}}\right]$

$= \frac{250}{1000}\times 9.8\left[3-2\left(1-\frac{1}{200}\right)\right] = \frac{99}{40}$

$\therefore\ x = 99$

56. 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.

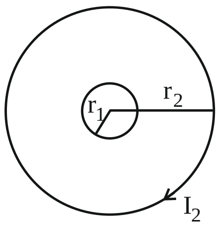
(Take, $\pi^2=10$)

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $r_1 = 1cm,\ N_1 = 10$

$r_2 = 1000cm,\ N_2 = 200$



$\phi_{1,2} = MI_2$

$N_2\vec{B}_2\cdot N_1\vec{A}_1 = MI_2$

$\Rightarrow N_1N_2\frac{\mu_0 I_2}{2r_2}\cdot\pi r_1^2 = MI_2$

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

$\Rightarrow M = 4\times 10^{-8}$

57. 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 plane 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 × 10^{-5} m. The value of n is_________.

Official Ans. by NTA (462)

Allen Ans. (462)

Sol. d = 2.5 mm, D = 150 cm

Fringe width $\beta = \frac{\lambda D}{d}$

Let n[th] bright tringle of λ_1 match with m[th] bright triangle of λ_2

$\Rightarrow n\beta_1 = m\beta_2$

$\Rightarrow n\lambda_1 = m\lambda_2 \Rightarrow \frac{n}{m} = \frac{\lambda_2}{\lambda_1} = \frac{5500}{7000}$

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

Distance where bright fringe will match

$= n\beta_1 = \frac{11\times 7000A^0\times 150\ cm}{0.25\ cm}$

$= 462\times 10^{-5}$

58. 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______.

Official Ans. by NTA (375)

Allen Ans. (375)

Sol. Let V_1 and V_2 are velocity just before and just after hitting the floor.

$$\frac{V_1}{V_2}=4\Rightarrow V_1=4V_2$$

$$KE_{before}=\frac{1}{2}mV_1^2$$

$$KE_{after}=\frac{1}{2}mV_2^2=\frac{1}{2}\frac{m.V_1^2}{16}$$

$$\Delta KE=\frac{1}{2}mV_1^2\left(\frac{1}{16}-1\right)=\frac{-15}{32}mV_1^2$$

$$\%\text{ change}=\frac{\Delta KE}{KE_{before}}\times100\%$$

$$=\frac{-15}{16}\times100=\frac{-375}{4}\%$$

59. Experimentally it is found that 12.8 eV 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 ________.

(1eV = 1.6 × 10^{-19}J, $\frac{1}{4\pi\epsilon_0}=9\times10^9\,Nm^2/C^2$ and electronic charge = 1.6 × 10^{-19}J C)

Official Ans. by NTA (16)

Allen Ans. (16)

Sol. Binding energy of system $=\frac{ke^2}{2r}$ joule and

$$\frac{ke^2}{2r}=12.8\ ev$$

$$\frac{9\times10^9\times\left(1.6\times10^{-19}\right)^2}{2r}=12.8\times1.6\times10^{-19}$$

$$\Rightarrow r=\frac{9\times10^9\times1.6\times10^{-19}}{12.8\times2}$$

$$\Rightarrow r=\frac{9\times10^{-10}}{16}$$

60. A proton with a kinetic energy of 2.0 eV 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).

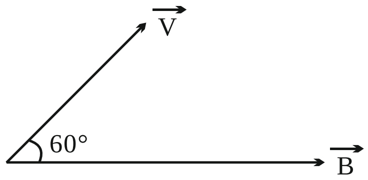
Official Ans. by NTA (40)

Allen Ans. (40)

Sol. $B=\frac{\pi}{2}\times10^{-3}$

$$K.E.=\frac{1}{2}mV^2$$

$$\Rightarrow V=\sqrt{\frac{2KE}{m}}$$



Pitch = v cos 60° × time period of one rotation

$$=v\cos60^0\times\frac{2\pi m}{eB}$$

$$=\sqrt{\frac{2\times2\times1.6\times10^{-19}}{1.6\times10^{-27}}}\times\cos60^0\times\frac{2\pi\times1.6\times10^{-27}}{1.6\times10^{-19}\times\frac{\pi}{2}\times10^{-3}}$$

$$=2\times10^4\times\frac{1}{2}\times4\times10^{-5}$$

$$=4\times10^{-1}m=40cm$$