28/06/2022
Morning

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Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2022 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R**.

   Assertion A : Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

   Reason R : Coefficient of viscosity

   $$= \frac{\text{Force}}{\text{Velocity gradient}}$$

   Choose the correct answer from the options given below.

   (A) Both **A** and **R** true, and **R** is correct explanation of **A**.

   (B) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.

   (C) **A** is true but **R** is false.

   (D) **A** is false but **R** is true.

Answer (C)

Sol. $[\text{Pressure}][\text{Time}] = \left[\frac{\text{Force}}{\text{Area}}\right]\left[\frac{\text{Distance}}{\text{Velocity}}\right]$

$[\text{Coefficient of viscosity}] = \left[\frac{\text{Force}}{\text{Area}}\right]\left[\frac{\text{Distance}}{\text{Velocity}}\right]$

Statement 'A' is true

But statement R is false are coefficient of viscosity

$$= \frac{\text{Force}}{\text{Area} \times \text{Velocity gradient}}$$

2. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is given as

   (A) Zero (B) $mk^2r^2t^2$

   (C) mk^2r^2t (D) mk^2rt

Answer (C)

Sol. $a_r = k^2rt^2 = \frac{v^2}{r}$

$\Rightarrow \; v^2 = k^2r^2t^2$ or $v = krt$

and $\frac{d|v|}{dt} = kr$

$\Rightarrow \; a_t = kr$

$\Rightarrow \; |\bar{F}\cdot\bar{v}| = (mkr)(krt)$

$= mk^2r^2t$ = power delivered

3. Motion of a particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ m and $y = 4\sin(\omega t)$ m. The path of the particle will be

   (A) Circular (B) Helical

   (C) Parabolic (D) Elliptical

Answer (A)

Sol. $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$

$= 4\cos(\omega t)$

$y = 4\sin(\omega t)$

$\Rightarrow \; x^2 + y^2 = 4^2$

$\Rightarrow$ The particle is moving in a circular motion with radius of 4 m.

4. Match List-I with List-II

	List-I		List-II
A.	Moment of inertia of solid sphere of radius R about any tangent	I.	$\frac{5}{3}MR^2$
B.	Moment of inertia of hollow sphere of radius (R) about any tangent.	II.	$\frac{7}{5}MR^2$
C.	Moment of inertia of circular ring of radius (R) about its diameter.	III.	$\frac{1}{4}MR^2$
D.	Moment of inertia of circular disc of radius (R) about any diameter.	IV.	$\frac{1}{2}MR^2$

Choose the correct answer from the options given below.

(A) A-II, B-I, C-IV, D-III (B) A-I, B-II, C-IV, D-III

(C) A-II, B-I, C-III, D-IV (D) A-I, B-II, C-III, D-IV

Answer (A)

Sol. (A) Moment of inertia of solid sphere of radius R about a tangent $=\frac{2}{5}MR^2+MR^2=\frac{7}{5}MR^2$

$\Rightarrow$ A – (II)

(B) Moment of inertia of hollow sphere of radius R about a tangent $=\frac{2}{3}MR^2+MR^2=\frac{5}{3}MR^2$

$\Rightarrow$ B – (I)

(C) Moment of inertia of circular ring of radius (R) about its diameter $=\frac{\left(MR^2\right)}{2}$

$\Rightarrow$ C – (IV)

(D) Moment of inertia of circular ring of radius (R) about any diameter

$$=\frac{MR^2/2}{2}=\frac{MR^2}{4}$$

$\Rightarrow$ D – (III)

5. Two planets A and B of equal mass are having their period of revolutions T_A and T_B such that $T_A = 2T_B$. These planets are revolving in the circular orbits of radii r_A and r_B respectively. Which out of the following would be the correct relationship of their orbits?

(A) $2r_A^2 = r_B^3$

(B) $r_A^3 = 2r_B^3$

(C) $r_A^3 = 4r_B^3$

(D) $T_A^2 - T_B^2 = \frac{\pi^2}{GM}\left(r_B^3 - 4r_A^3\right)$

Answer (C)

Sol. $T_A = 2T_B$

Now $T_A^2 \propto r_A^3$

$$\Rightarrow \left(\frac{r_A}{r_B}\right)^3=\left(\frac{T_A}{T_B}\right)^2$$

$$\Rightarrow r_A^3 = 4r_B^3$$

6. A water drop of diameter 2 cm is broken into 64 equal droplets. The surface tension of water is 0.075 N/m. In this process the gain in surface energy will be

(A) 2.8×10^{-4} J   (B) 1.5×10^{-3} J

(C) 1.9×10^{-4} J   (D) 9.4×10^{-5} J

Answer (A)

Sol. $r' = \frac{r}{4}$

$\Rightarrow \Delta E = T(\Delta S)$

$= T \times 4\pi(nr'^2 - r^2)$, $n = 64$

$= T \times 4\pi \times (4 - 1)r^2$

$\Rightarrow \Delta E = 0.075 \times 4 \times 3.142\ (3) \times 10^{-4}$ J

$= 2.8 \times 10^{-4}$ J

7. Given below are two statements

Statement-I: When μ amount of an ideal gas undergoes adiabatic change from state (P_1, V_1, T_1) to state (P_2, V_2, T_2), then work done is $W=\frac{\mu R(T_2-T_1)}{1-\gamma}$, where $\gamma == \frac{C_p}{C_v}$ and R = universal gas constant.

Statement-II: In the above case, when work is done on the gas, the temperature of the gas would rise.

Choose the correct answer from the options given below

(A) Both statement-I and statement-II are true

(B) Both statement-I and statement-II are false

(C) Statement-I is true but statement-II is false

(D) Statement-I is false but statement-II is true

Answer (A)

Sol. $W=\frac{\mu R(T_2-T_1)}{1-r}$ for a polytropic process for adiabatic process $r = \gamma$

$\Rightarrow$ Statement I is true

In an adiabatic process

$\Delta U = -\Delta W$

$\Rightarrow$ If work is done on the gas

$\Rightarrow$ ΔW is negative

$\Rightarrow$ ΔU is positive or temperature increases

$\Rightarrow$ Statement II is true

8. Given below are two statements

Statement-I: A point charge is brought in an electric field. The value of electric field at a point near to the charge may increase if the charge is positive.

Statement-II: An electric dipole is placed in a non-uniform electric field. The net electric force on the dipole will not be zero.

Choose the correct answer from the options given below

(A) Both statement-I and statement-II are true

(B) Both statement-I and statement-II are false

(C) Statement-I is true but statement-II is false

(D) Statement-I is false but statement-II is true

Answer (A)

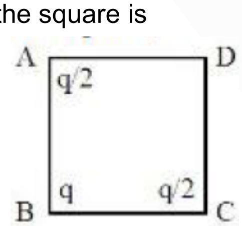
Sol. As one moves closer to a positive charge (isolated) the density of electric field line increases and so does the electric field intensity

$\Rightarrow$ Statement I is true

As opposite poles of an electric dipole would experience equal and opposite forces so net force on a dipole in a uniform electric field will be zero

$\Rightarrow$ Statement II is true

9. The three charges $\frac{q}{2}$, q and $\frac{q}{2}$ are placed at the corners A, B and C of a square of side 'a' as shown in figure. The magnitude of electric field (E) at the corner D of the square is



(A) $\frac{q}{4\pi\epsilon_0 a^2}\left(\frac{1}{\sqrt{2}}+\frac{1}{2}\right)$ (B) $\frac{q}{4\pi\epsilon_0 a^2}\left(1+\frac{1}{\sqrt{2}}\right)$

(C) $\frac{q}{4\pi\epsilon_0 a^2}\left(1-\frac{1}{\sqrt{2}}\right)$ (D) $\frac{q}{4\pi\epsilon_0 a^2}\left(\frac{1}{\sqrt{2}}-\frac{1}{2}\right)$

Answer (A)

Sol. $|E_0| = \frac{kq/2}{a^2}\sqrt{2}+\frac{kq}{(a\sqrt{2})^2}$

$= \frac{kq}{\sqrt{2}a^2}+\frac{kq}{2a^2}$

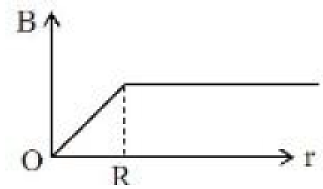
$= \frac{kq}{a^2}\left(\frac{1}{\sqrt{2}}+\frac{1}{2}\right), k = \frac{1}{4\pi\varepsilon_0}$

$\Rightarrow$ Option A is correct

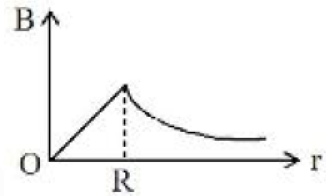
10. An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface.

Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder.

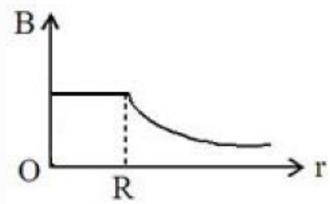
(A)



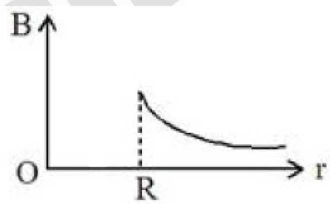
(B)



(C)



(D)



Answer (D)

Sol. Inside a hollow cylindrical conductor with uniform current distribution net magnetic field is zero in hollow space.

But outside the cylindrical conductor $B \propto \frac{1}{r}$

$\Rightarrow$ Graph in option D would be a correct one

11. A radar sends an electromagnetic signal of electric field (E_0) = 2.25 V/m and magnetic field (B_0) = 1.5×10^{-8} T which strikes a target on line of sight at a distance of 3 km in a medium. After that, a part of signal (echo) reflects back towards the radar with same velocity and by same path. If the signal was transmitted at time $t = 0$ from radar, then after how much time echo will reach to the radar?

(A) 2.0×10^{-5} s (B) 4.0×10^{-5} s

(C) 1.0×10^{-5} s (D) 8.0×10^{-5} s

Answer (B)

Sol. $E_0 = 2.25$ V/m

$B_0 = 1.5 \times 10^{-8}$ T

$\Rightarrow \dfrac{E_0}{B_0} = 1.5 \times 10^8$ m/s

$\Rightarrow$ Refractive index = 2

Distance to be travelled = 6 km

Time taken = $\dfrac{6 \times 10^3}{1.5 \times 10^8} = 4 \times 10^{-5}$ s

$\Rightarrow$ Option (B) is correct

12. The refracting angle of a prism is A and refractive index of the material of the prism is cot (A/2). Then the angle of minimum deviation will be :

(A) 180 – 2A (B) 90 – A

(C) 180 + 2A (D) 180 – 3A

Answer (A)

Sol. $\mu = \dfrac{\sin\left(\dfrac{\delta_m + A}{2}\right)}{\sin(A/2)} = \cot A/2$

$\Rightarrow \cos A/2 = \sin\left(\dfrac{\delta_m + A}{2}\right)$

$\Rightarrow \dfrac{\pi}{2} - \dfrac{A}{2} = \dfrac{\delta_m + A}{2}$

$\Rightarrow \pi - 2A = \delta_m$

Option (A) is correct

13. The aperture of the objective is 24.4 cm. The resolving power of this telescope, if a light of wavelength 2440 Å is used to see the object will be:

(A) 8.1×10^6

(B) 10.0×10^7

(C) 8.2×10^5

(D) 1.0×10^{-8}

Answer (C)

Sol. R.P. = $\dfrac{1}{1.22\,\lambda/a}$

$= \dfrac{24.4 \times 10^{-2}}{1.22 \times 2440 \times 10^{-10}}$

$= 8.2 \times 10^5$

Option (C) is correct

14. The de Broglie wavelengths for an electron and a photon are λ_e and λ_p respectively. For the same kinetic energy of electron and photon, which of the following presents the correct relation between the de Broglie wavelengths of two?

(A) $\lambda_p \propto \lambda_e^2$

(B) $\lambda_p \propto \lambda_e$

(C) $\lambda_p \propto \sqrt{\lambda_e}$

(D) $\lambda_p \propto \sqrt{\dfrac{1}{\lambda_e}}$

Answer (A)

Sol. $\lambda_p = \dfrac{h}{p} = \dfrac{hc}{E}$ ...(i)

$\lambda_e = \dfrac{h}{\sqrt{2mE}}$ ...(ii)

From (i) and (ii)

$\lambda_p \propto \lambda_e^2$

$\Rightarrow$ Option A is correct

15. The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as :

(A) $Q = K_p$ (B) $(K_p + Q) < 0$

(C) $Q < K_p$ (D) $(K_p + Q) > 0$

Answer (D)

Sol. $K_p > 0$

If Q is released $\Rightarrow Q > 0$

$\Rightarrow K_p + Q > 0$

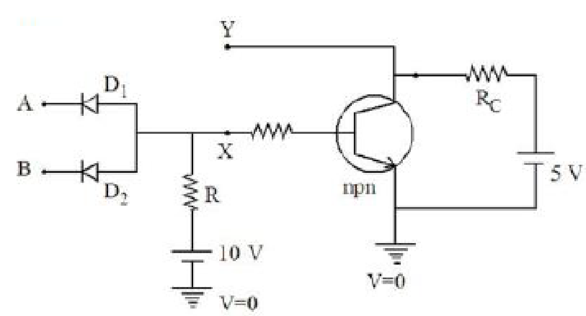
If Q is absorbed $\Rightarrow Q < 0$

Even then particle has to be given kinetic energy greater than magnitude of Q to maintain momentum conservation.

$\Rightarrow K + Q > 0$

$\Rightarrow$ Option D is correct

16. In the following circuit, the correct relation between output (Y) and inputs A and B will be:

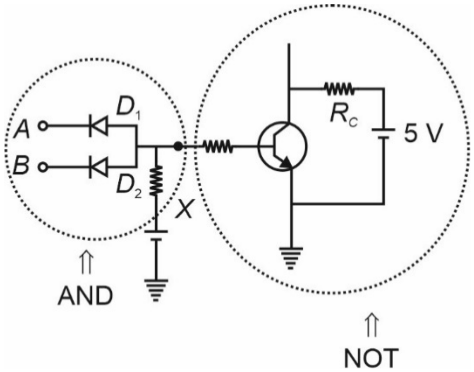


(A) $Y = AB$ (B) $Y = A + B$

(C) $Y = \overline{AB}$ (D) $Y = \overline{A+B}$

Answer (C)

Sol. The shown circuit is a combination of AND gate and a NOT gate



$\Rightarrow Y = \overline{AB}$

Option (C) is a correct option.

17. For using a multimeter to identify diode from electrical components, choose the correct statement out of the following about the diode:

(A) It is two terminal device which conducts current in both directions.

(B) It is two terminal device which conducts current in one direction only

(C) It does not conduct current gives an initial deflection which decays to zero.

(D) It is three terminal device which conducts current in one direction only between central terminal and either of the remaining two terminals.

Answer (B)

Sol. A diode is a two terminal device which conducts current in forward bias only

$\Rightarrow$ Option (B) is correct.

18. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A : n-p-n transistor permits more current than a p-n-p transistor.

Reason R: Electrons have greater mobility as a charge carrier.

Choose the correct answer from the options given below:

(A) Both **A** and **R** are true, and **R** is correct explanation of **A**.

(B) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.

(C) **A** is true but **R** is false.

(D) **A** is false but **R** is true.

Answer (A)

Sol. (A) is true as n-p-n transistor permits more current than p-n-p transistor as electrons which are majority charge carriers in n-p-n have higher mobility than holes which are majority carriers in p-n-p transistor

$\Rightarrow$ Statement R is correct explanation of statement A

19. Match List-I with List-II

	List-I		List-II
(A)	Television signal	I.	03 KHz
(B)	Radio signal	II.	20 KHz
(C)	High Quality Music	III.	02 MHz
(D)	Human speech	IV.	06 MHz

Choose the correct answer from the options given below:

(A) A-I, B-II, C-III, D-IV

(B) A-IV, B-III, C-I, D-II

(C) A-IV, B-III, C-II, D-I

(D) A-I, B-II, C-IV, D-III

Answer (C)

Sol. Television signal $\Rightarrow$ 6 MHz

Radio signal $\Rightarrow$ 2 MHz

High Quality music $\Rightarrow$ 20 kHz

Human speech $\Rightarrow$ 3 kHz

$\Rightarrow$ Option (C) is correct.

20. The velocity of sound in a gas, in which two wavelengths 4.08 m and 4.16 m produce 40 beats in 12 s, will be:

(A) 282.8 ms^{-1}

(B) 175.5 ms^{-1}

(C) 353.6 ms^{-1}

(D) 707.2 ms^{-1}

Answer (D)

Sol. $\frac{v}{4.08} - \frac{v}{4.16} = \frac{40}{12}$

$v = \frac{40}{12} \times \frac{4.08 \times 4.16}{0.08}$

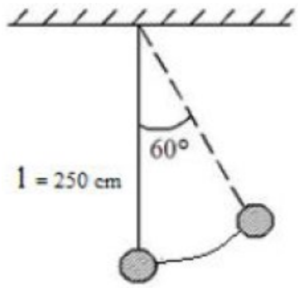
$= 707.2$ m/s

$\Rightarrow$ Option (D) is correct.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

1. A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200 g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob, the maximum velocity attained by the bob will be ___ ms^{-1}. (if g = 10 m/s^2)



Answer (5)

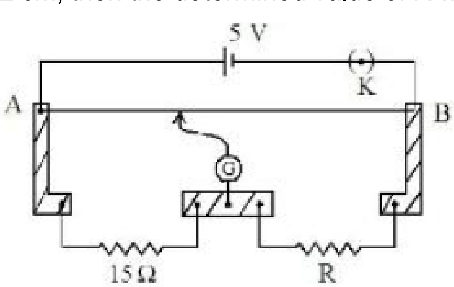
Sol. $\frac{1}{2}mv^2 = mgl(1-\cos\theta)$

$\Rightarrow \quad v = \sqrt{2gl(1-\cos\theta)}$

$= \sqrt{2\times 10\times 2.5\times \frac{1}{2}}$

= 5 m/s

2. A meter bridge setup is shown in the figure. It is used to determine an unknown resistance R using a given resistor of 15 Ω. The galvanometer (G) shows null deflection when tapping key is at 43 cm mark from end A. If the end correction for end A is 2 cm, then the determined value of R will be ___ Ω.

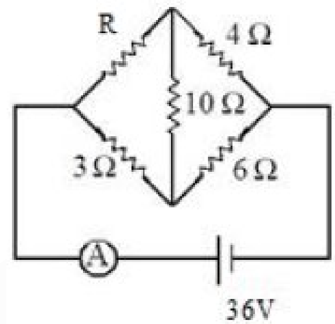


Answer (19)

Sol. $\frac{43+2}{15} = \frac{57}{R}$

$R = \frac{57\times 15}{45} = 19\ \Omega$

3. Current measured by the ammeter Ⓐ in the reported circuit when no current flows through 10 Ω resistance, will be ___ A.



Answer (10)

Sol. For $I_{10} = 0$

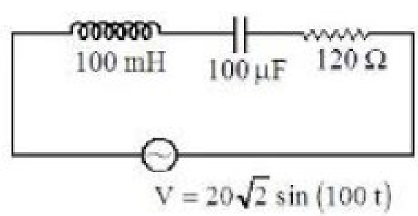
$\frac{R}{3} = \frac{4}{6}$

$\Rightarrow \quad R = 2\ \Omega$

$\Rightarrow \quad I_A = \frac{36\times(6+9)}{6\times 9}$

$= \frac{36\times 15}{6\times 9} = 10$ A

4. An AC source is connected to an inductance of 100 mH, a capacitance of 100 μF and a resistance of 120 Ω as shown in figure. The time in which the resistance having a thermal capacity 2 J/°C will get heated by 16°C is ___ s.



Answer (15)

Sol. $L = 100 \times 10^{-3}$ H

$C = 100 \times 10^{-6}$ F

$R = 120\ \Omega$

$\omega L = 10\ \Omega$

$\frac{1}{\omega C} = \frac{1}{10^4\times 10^{-6}} = 100\ \Omega$

$\Rightarrow\ X_C - X_L = 90\ \Omega$

$\Rightarrow\ Z = \sqrt{90^2 + 120^2} = 150\ \Omega$

$\Rightarrow\ I_{rms} = \frac{20}{150} = \frac{2}{15}$ A

For heat resistance by 16°C heat required = 32 J

$\Rightarrow\ \left(\frac{2}{15}\right)^2 \times (120) \times t = 32$

$t = \frac{32 \times 15 \times 15}{4 \times 120}$

= 15

5. The position vector of 1 kg object is $\vec{r} = \left(3\hat{i} - \hat{j}\right)$ m and its velocity $\vec{v} = \left(3\hat{j} + \hat{k}\right)$ ms^{-1}. The magnitude of its angular momentum is $\sqrt{x}$ Nm where x is

Answer (91)

Sol. $\left|\vec{l}\right| = \left|\vec{r} \times (m\vec{v})\right|$

$= \left|\left(3\hat{i} - \hat{j}\right) \times \left(3\hat{j} + \hat{k}\right)\right|$

$= \left|-\hat{i} - 3\hat{j} + 9\hat{k}\right|$

$= \sqrt{91}$

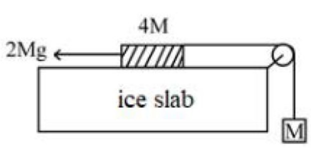
6. A man of 60 kg is running on the road and suddenly jumps into a stationary trolly car of mass 120 kg. Then, the trolly car starts moving with velocity 2 ms^{-1}. The velocity of the running man was _____ ms^{-1}, when he jumps into the car.

Answer (6)

Sol. $v_m = \frac{(120 + 60)v_T}{60}$

$= \frac{180 \times 2}{60}$ = 6 m/s

7. A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement, as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by 2 Mg force. In this situation, tension in the string is $\frac{x}{5}$ Mg for x = __________. Neglect mass of the string and friction of the block (bigger mass) with ice slab. (Given g = acceleration due to gravity)



Answer (6)

Sol. $a = \frac{Mg}{4M + M} = \frac{g}{5}$ (in upward direction)

$T = M\left(g + \frac{g}{5}\right) = \frac{6Mg}{5}$

$\Rightarrow\ x = 6$

8. The total internal energy of two mole monoatomic ideal gas at temperature T = 300 K will be _____ J. (Given R = 8.31 J/mol.K)

Answer (7479)

Sol. $U = 2\left(\frac{3}{2}R\right)300$

= 3 × 8.31 × 300

= 7479 J

9. A singly ionized magnesium atom (A = 24) ion is accelerated to kinetic energy 5 keV, and is projected perpendicularly into a magnetic field B of the magnitude 0.5 T. The radius of path formed will be ________ cm.

Answer (10)

Sol. $R = \frac{mv}{qB}$

$R = \frac{\sqrt{2mKE}}{qB}$

$= \frac{\sqrt{2 \times 24 \times 1.67 \times 10^{-27} \times 5 \times 1.6 \times 10^{-16}}}{1.6 \times 10^{-19} \times 0.5}$

= 10.009 cm = 10 cm

10. A telegraph line of length 100 km has a capacity of 0.01 μF/km and it carries an alternating current at 0.5 kilo cycle per second. If minimum impedance is required, then the value of the inductance that needs to be introduced in series is_______ mH. (if $\pi = \sqrt{10}$)

Answer (100)

Sol. Total capacitance = 0.01 × 100 = 1 μF

ω = 500 × 2π = 1000π rad/s

$\omega L = \frac{1}{\omega C}$

$\Rightarrow\ L = \frac{1}{\omega^2 C} = \frac{1}{10^6 \pi^2 \times 10^{-6}} = \frac{1}{10}$H = 100 mH