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. For a solid rod, the Young's modulus of elasticity is 3.2×10^{11} Nm^{-2} and density is 8×10^3 kg m^{-3}. The velocity of longitudinal wave in the rod will be

   (1) 18.96×10^3 ms^{-1} (2) 3.65×10^3 ms^{-1}

   (3) 145.75×10^3 ms^{-1} (4) 6.32×10^3 ms^{-1}

Answer (4)

Sol. $v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{3.2 \times 10^{11}}{8 \times 10^3}}$

$= 2 \times 10^3 \sqrt{10}$

$= 6.32 \times 10^3$ m/s

2. A microscope is focused on an object at the bottom of a bucket. If liquid with refractive index $\frac{5}{3}$ is poured inside the bucket, then microscope have to be raised by 30 cm to focus the object again. The height of the liquid in the bucket is

   (1) 12 cm (2) 18 cm

   (3) 75 cm (4) 50 cm

Answer (3)

Sol. Shift $= \left(d - \frac{d}{\mu}\right) = 30$ cm

$d\left[1 - \frac{1}{\frac{5}{3}}\right] = 30$

$d = \frac{30 \times 5}{2} = 75$ cm

3. Match List I with List II:

	List I		List II
A.	Microwaves	I.	Physiotherapy
B.	UV rays	II.	Treatment of cancer
C.	Infra-red light	III.	Lasik eye surgery
D.	X-ray	IV.	Aircraft navigation

Choose the correct answer from the options given below:

(1) A-IV, B-I, C-II, D-III (2) A-III, B-II, C-I, D-IV

(3) A-II, B-IV, C-III, D-I (4) A-IV, B-III, C-I, D-II

Answer (4)

Sol. (Theoretical)

A. Microwave $\rightarrow$ IV B. UV rays $\rightarrow$ III

C. Infra-red $\rightarrow$ I D. X-ray $\rightarrow$ II

4. A body is moving with constant speed, in a circle of radius 10 m. The body completes one revolution in 4 s. At the end of 3[rd] second, the displacement of body (in m) from its starting point is:

   (1) 30 (2) 15π

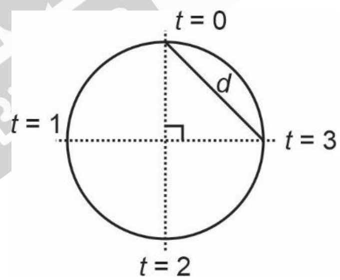
   (3) 5π (4) $10\sqrt{2}$

Answer (4)

Sol. $r = 10$ m

$T = 4$ sec

$d = \sqrt{2}(10)$ m



5. If the two metals A and B are exposed to radiation of wavelength 350 nm. The work functions of metals A and B are 4.8 eV and 2.2 eV. Then choose the correct option.

   (1) Metals B will not emit photo-electrons

   (2) Both metals A and B will not emit photo-electrons

   (3) Both metals A and B will emit photo-electrons

   (4) Metals A will not emit photo-electrons

Answer (4)

Sol. $\phi = \frac{hc}{\lambda} = \frac{1240}{350}$ eV $= 3.54$ eV

$\therefore$ Only metal B will emit photoelectron.

6. A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient of friction is (Take acceleration due to gravity g = ms^{-2})

(1) 0.2 (2) 0.4

(3) 0.3 (4) 0.5

Answer (2)

Sol. $a = -\mu g$

$\because\ v = u + at$

$0 = 20 + (-\mu \times 10) \times 5$

$50\mu = 20$

$\mu = \frac{2}{5} = 0.4$

7. A hypothetical gas expands adiabatically such that its volume changes from 08 litres to 27 litres. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then the ratio of $\frac{C_p}{C_v}$ will be

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

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

Answer (1)

Sol. Let γ be the ratio of $\frac{C_p}{C_v}$

Then for adiabatic process

PV^{γ} = Constant

$$\frac{P_i}{P_f} = \left(\frac{V_f}{V_i}\right)^{\gamma}$$

$$\frac{81}{16} = \left(\frac{27}{8}\right)^{\gamma}$$

$$\gamma = \frac{4}{3}$$

8. An alternating voltage source V = 260 sin (628t) is connected across a pure inductor of 5 mH. Inductive reactance in the circuit is

(1) 0.318 Ω (2) 6.28 Ω

(3) 0.5 Ω (4) 3.14 Ω

Answer (4)

Sol. $X_L = L\omega$

$= 5\text{ mH} \times 628$

$= 3.14\ \Omega$

9. Under the same load, wire A having length 5.0 m and cross-section 2.5×10^{-5} m^2 stretches uniformly by the same amount as another wire B of length 6.0 m and a cross-section of 3.0×10^{-5} m^2 stretches. The ratio of the Young's modulus of wire A to that of wire B will be

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

(3) 1 : 10 (4) 1 : 1

Answer (4)

Sol. $\Delta\ell = \frac{F\ell}{SY}$

F is same for both wire and $\Delta\ell$ is also same

$$\frac{\Delta\ell}{F} = \frac{\ell}{SY} \Rightarrow \frac{\ell_A}{S_A Y_A} = \frac{\ell_B}{S_B Y_B}$$

$$\Rightarrow \frac{5}{2.5 \times Y_A} = \frac{6}{3 \times Y_B}$$

$$\Rightarrow \frac{Y_A}{Y_B} = 1$$

10. Considering a group of positive charges, which of the following statements is correct?

(1) Net potential of the system cannot be zero at a point but net electric field can be zero at that point.

(2) Both the net potential and the net field can be zero at a point.

(3) Net potential of the system at a point can be zero but net electric field can't be zero at that point.

(4) Both the net potential and the net electric field cannot be zero at a point.

Answer (1)

Sol. $V = \frac{\sum KQ_i}{r_i}$

Here, Q_i & r_i are positive

$\therefore\ V > 0$

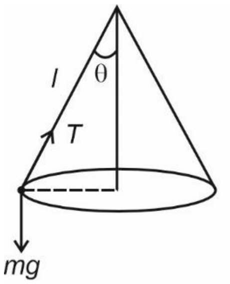
11. A stone of mass 1 kg is tied to end of a massless string of length 1m. If the breaking tension of the string is 400 N, then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is:

(1) 40 ms^{-1} (2) 10 ms^{-1}

(3) 20 ms^{-1} (4) 400 ms^{-1}

Answer (3)

Sol.



$T\cos\theta = mg$

$$T\sin\theta = \frac{mv^2}{l^2\sin\theta}$$

$$\cos\theta = \frac{mg}{T} \quad ...(1)$$

$$\sin 2\theta = \frac{mv^2}{Tl^2} \quad ...(2)$$

From (1) & (2)

$$l = \left(\frac{mg}{T}\right)^2 + \frac{mv^2}{Tl^2}$$

$$l = \left(\frac{10}{400}\right)^2 + \frac{v^2}{400}$$

$v^2 = 399.78$

$v = 20$ m/s

12. The number of turns of the coil of a moving coil galvanometer is increased in order to increase current sensitivity by 50%. The percentage change in voltage sensitivity of the galvanometer will be:

(1) 0% (2) 100%

(3) 75% (4) 50%

Answer (1)

Sol. Current sensitivity = Voltage sensitivity × R

Current sensitivity is made 1.5 times.

R also increase 1.5 times.

$$\text{Hence voltage sensitivity} = \frac{1.5\times\text{current sensitivity}}{1.5\times R}$$

= no change

13. Given below are two statements:

Statement I: In a typical transistor, all three regions emitter, base and collector have same doping level.

Statement II: In a transistor, collector is the thickest and base is the thinnest segment.

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

(1) **Statement I** is correct but **Statement II** is incorrect

(2) Both **Statement I** and **Statement II** are incorrect

(3) **Statement I** is incorrect but **Statement II** is correct

(4) Both **Statement I** and **Statement II** are correct

Answer (3)

Sol. In transistor, emitter collector and base have different doping levels and collector is the thickest while base is thinnest segment.

14. The radius of electron's second stationary orbit in Bohr's atom is R. The radius of 3rd orbit will be

(1) $\frac{R}{3}$ (2) $2.25R$

(3) $9R$ (4) $3R$

Answer (2)

Sol. $r \propto \frac{n^2}{Z}$

$$\frac{r_{2nd}}{r_{3rd}} = \left(\frac{n_2}{n_3}\right)^2$$

$$\Rightarrow \frac{R}{r_{3rd}} = \left(\frac{2}{3}\right)^2$$

$$\Rightarrow r_{3rd} = \frac{9}{4}R$$

$= 2.25R$

15. A long conducting wire having a current I flowing through it, is bent into a circular coil of N turns. Then it is bent into a circular coil of n turns. The magnetic field is calculated at the centre of coils in both the cases. The ratio of the magnetic field in first case to that of second case is:

(1) $n^2 : N^2$ (2) $N : n$

(3) $N^2 : n^2$ (4) $n : N$

Answer (3)

Sol. $l = (2\pi r)n$

$$r \propto \left(\frac{l}{n}\right)$$

$$B = n\left(\frac{\mu_0 i}{2r}\right) \propto \left(\frac{\mu_0 i}{2L}\right)n^2$$

$$\frac{B_1}{B_2} = \left(\frac{N^2}{n^2}\right)$$

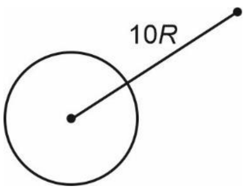
16. A body weight W, is projected vertically upwards from earth's surface to reach a height above the earth which is equal to nine times the radius of earth. The weight of the body at that height will be:

(1) $\frac{W}{91}$ (2) $\frac{W}{3}$

(3) $\frac{W}{100}$ (4) $\frac{W}{9}$

Answer (3)

Sol.



$$g' = \frac{GM}{(10R)^2} = \left(\frac{g}{100}\right)$$

$$W' = \left(\frac{W}{100}\right)$$

17. Given below are two statements :

Statement I : For transmitting a signal, size of antenna (l) should be comparable to wavelength of signal (at least $l = \frac{\lambda}{4}$ in dimension)

Statement II : In amplitude modulation, amplitude of carrier wave remains constant (unchanged).

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

(1) Both Statement I and Statement II are correct

(2) Statement I is incorrect but Statement II is correct

(3) Both Statement I and Statement II are incorrect

(4) Statement I is correct but Statement II is incorrect

Answer (4)

Sol.
- In amplitude modulation frequency of carrier wave remains unchanged.
- Minimum size of antenna should be $\frac{1}{4}$th of wavelength.

18. The H amount of thermal energy is developed by a resistor in 10 s when a current of 4 A is passed through it. If the current is increased to 16 A, the thermal energy developed by the resistor in 10 s will be:

(1) H (2) 16H

(3) 4H (4) $\frac{H}{4}$

Answer (2)

Sol. $H \propto i^2$ for t = constant

$$\frac{H}{H'} = \left(\frac{4}{16}\right)^2$$

$H' = 16H$

19. Match List I with List II

	List I		List II
A.	Angular momentum	I.	$[ML^2T^{-2}]$
B.	Torque	II.	$[ML^{-2}T^{-2}]$
C.	Stress	III.	$[ML^2T^{-1}]$
D.	Pressure gradient	IV.	$[ML^{-1}T^{-2}]$

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

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

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

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

Answer (4)

Sol. $\vec{L} = \vec{r} \times \vec{p} \Rightarrow [L] = [M^0L^1T^0]\,[M^1L^1T^{-1}]$

$= [M^1L^2T^{-1}]$

$\vec{\tau} = \vec{r} \times \vec{F} \Rightarrow [\tau] = [L^1]\,[MLT^{-2}]$

$= [ML^2T^{-2}]$

Stress $\equiv$ Pressure $= \frac{F}{A} \Rightarrow$ [Stress] $= [ML^{-1}T^{-2}]$

Pressure Gradient $= \frac{dP}{dx} \Rightarrow$ [Pressure Gradient]

$= [ML^{-2}T^{-2}]$

20. Heat energy of 735 J is given to a diatomic gas allowing the gas to expand at constant pressure. Each gas molecule rotates around an internal axis but do not oscillate. The increase in the internal energy of the gas will be:

(1) 572 J (2) 525 J

(3) 441 J (4) 735 J

Answer (3)

Sol. $\Delta Q = nC_P\Delta T = 735$ J

$$\Rightarrow \frac{5nR\Delta T}{2} = 735 \text{ J}$$

$$\Delta U = nC_V\Delta T = \frac{3}{2}(nR\Delta T) = \frac{3}{2} \times \frac{2}{5} \times 735$$

$= 441$ J

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.

21. A water heater of power 2000 W is used to heat water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. The efficiency of heater is 70%. Time required to heat 2 kg of water from 10°C to 60°C is_____________ s.

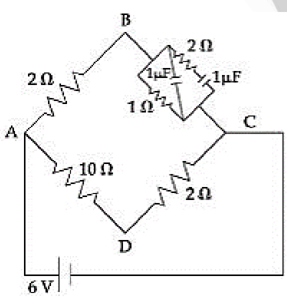
(Assume that the specific heat capacity of water remains constant over the temperature range of the water).

Answer (300)

Sol. $\eta \times P \times \Delta t = M \times s \times \Delta T$

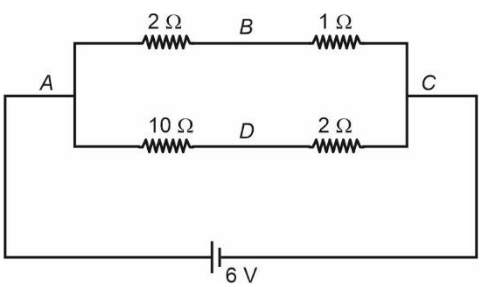
$$\Rightarrow \quad \Delta t = \frac{2 \times 4200 \times (60-10)}{0.7 \times 2000} \text{ s} = 300 \text{ s}$$

22. For the given circuit, in the steady state, $|V_B - V_D| =$ ___________________ V.



Answer (1)

Sol. In steady state, capacitor behaves as an open circuit. Circuit is:



$$\Rightarrow \quad i_{AB} = \frac{6}{3} = 2\text{A} \qquad \& \qquad i_{AD} = \frac{6}{12} = 0.5 \text{ A}$$

$\Rightarrow \quad V_B + 2 \times 2 - 10 \times 0.5 = V_D$

$\Rightarrow \quad V_B - V_D = 1$ volt

23. A ball is dropped from a height of 20 m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a height of ______________ m.

Answer (5)

Sol. We know $h' = e^2 h$

$h' = (0.5)^2 \times 20 \text{ m} = 5 \text{ m}$

24. Two bodies are projected from ground with same speeds 40 ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60°, with horizontal then sum of the maximum heights, attained by the two projectiles, is ___________m. (Given g = 10 ms^{-2})

Answer (80)

Sol. Since range is same.

$\Rightarrow \quad \theta_1 + \theta_2 = 90°$

$\Rightarrow \quad \theta_2 = 30°$

$$\Rightarrow \quad (H_{max})_1 + (H_{max})_2 = \frac{U^2 \sin^2 \theta_1}{2g} + \frac{U^2 \sin^2 \theta_2}{2g}$$

$$= \frac{40^2}{20}\left(\frac{1}{4} + \frac{3}{4}\right) = 80 \text{ m}$$

25. Two parallel plate capacitors C_1 and C_2 each having capacitance of 10 μF are individually charged by a 100 V D.C. source. Capacitor C_1 is kept connected to the source and a dielectric slab is inserted between it plates. Capacitor C_2 is disconnected from the source and then a dielectric slab is inserted in it. Afterwards the capacitor C_1 is also disconnected from the source and the two capacitors are finally connected in parallel combination. The common potential of the combination will be __________ V.

(Assuming Dielectric constant = 10)

Answer (55)

Sol. Charge on C_1 = KCE

And charge on C_2 = CE

When they are connected in parallel charge will be equally divided so charge on one capacitor is

$$q=\frac{K+1}{2}CV$$

So $V=\frac{q}{KC}=\frac{K+1}{2K}=55$ V

26. If the binding energy of ground state electron in a hydrogen atom is 13.6 eV, then, the energy required to remove the electron from the second excited state of Li^{2+} will be $x \times 10^{-1}$ eV. The value of x is __________.

Answer (136)

Sol. E_H = 13.6

$$E_{Li^{2+}}=13.6\frac{Z^2}{n^2}=13.6\times\frac{9}{9}=13.6\text{ eV}$$

= 136 × 10^{-1} eV

27. Two discs of same mass and different radii are made of different materials such that their thickness are 1 cm and 0.5 cm respectively. The densities of materials are in the ratio 3 : 5. The moment of inertia of these discs respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of x is ________.

Answer (05)

Sol. $m = \rho\pi R^2 t$

so $R^2=\frac{m}{\rho\pi t}$

$$I=\frac{mR^2}{4}=\frac{m^2}{4\rho\pi t}$$

so $\frac{I_1}{I_2}=\frac{\rho_2 t_2}{\rho_1 t_1}=\frac{5}{3}\times\frac{0.5}{1}=\frac{5}{6}$

so $x = 5$

28. A series LCR circuit consists of R = 80 Ω, X_L = 100 Ω, and X_C = 40 Ω. The input voltage is 2500 cos(100 πt) V. The amplitude of current, in the circuit, is __________ A.

Answer (25)

Sol. ω = 100π

so $Z=\sqrt{R^2+(X_L-X_C)^2}$

$=\sqrt{80^2+(100-40)^2}$

= 100 Ω

$$i_0=\frac{V_0}{Z}=\frac{2500}{100}\text{A}=25\text{ A}$$

29. The displacement equations of two interfering waves are given by $y_1=10\sin\left(\omega t+\frac{\pi}{3}\right)$ cm, $y_2=5\left[\sin\omega t+\sqrt{3}\cos\omega t\right]$ cm respectively. The amplitude of the resultant wave is __________ cm.

Answer (20)

Sol. $y_2=5(\sin\omega t+\sqrt{3}\cos\omega t)$

$=10\sin\left(\omega t+\frac{\pi}{3}\right)$

Thus the phase difference between the waves is 0.

so A = A_1 + A_2 = 20 cm

30. Two light waves of wavelengths 800 and 600 nm are used in Young's double slit experiment to obtain interference fringes on a screen placed 7 m away from plane of slits. If the two slits are separated by 0.35 mm, then shortest distance from the central bright maximum to the point where the bright fringes of the two wavelength coincide will be __________ mm.

Answer (48)

Sol. $\omega_1=\frac{\lambda_1 D}{d}$ & $\omega_2=\frac{\lambda_2 D}{d}$

ω_1 = 16 mm & ω_2 = 12 mm

so LCM (ω_1, ω_2) = 48 mm

so at 48 mm distance both bright fringes will be found.