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. 'n' polarizing sheets are arranged such that each makes an angle 45° with the preceeding sheet. An unpolarized light of intensity I is incident into this arrangement. The output intensity is found to be $\frac{I}{64}$. The value of n will be

(1) 3 (2) 4

(3) 6 (4) 5

Answer (3)

Sol. $I_{\text{final}} = \frac{I}{2}\left(\frac{1}{2}\right)^{n-1}$

$\frac{I}{6^4} = \frac{I}{2^n}$

$n = 6$

2. A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30 N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10 s. Coefficient of kinetic friction is (given, g = 10 ms^{-2})

(1) 0.50 (2) 0.60

(3) 0.75 (4) 0.25

Answer (1)

Sol. $a = \frac{30 - 50\mu}{5}$

$\because \quad s = ut + \frac{1}{2}at^2$

$50 = \frac{1}{2}\left(\frac{30 - 50\mu}{5}\right) \times 100$

$5 = 30 - 50\mu$

$\mu = \frac{25}{15} = 0.5$

3. Given below are two statements:

Statement I: Acceleration due to gravity is different at different places on the surface of earth.

Statement II: Acceleration due to gravity increases as we go down below the earth's surface.

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

(1) Statement I is false but Statement II is true

(2) Statement I is true but Statement II is false

(3) Both statement I and statement II are false

(4) Both statement I and statement II are true

Answer (2)

Sol. Statement-I is correct as $g' = g - \omega^2 R\cos^2\phi$

Statement-II is clearly incorrect.

4. Match List I with List II:

	List I		List II
A.	Intrinsic semiconductor	I.	Fermi-level near the valance band
B.	n-type semiconductor	II.	Fermi-level in the middle of the valence and conduction band
C.	p-type semiconductor	III.	Fermi-level near the conduction band
D.	Metals	IV.	Fermi-level inside the conduction band

Choose the ***correct*** answer from the options given below:

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

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

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

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

Answer (1)

Sol. (Theoretical)

(A) Intrinsic semiconductor → II

(B) n-type semiconductor → III

(C) p-type semiconductor → I

(D) Metals → IV

5. $\left(P+\frac{\alpha}{V^2}\right)(V-b)=RT$ represents the equation of state of some gases. Where P is the pressure, V is the volume, T is the temperature and a, b, R are the constants. The physical quantity, which has dimensional formula as that of $\frac{b^2}{a}$, will be

(1) Compressibility (2) Energy density

(3) Modulus of rigidity (4) Bulk modulus

Answer (1)

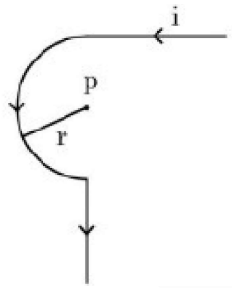
Sol. $[a] = [ML^5T^{-2}]$

$[b] = [L^3]$

$$\left[\frac{b^2}{a}\right]=\left[\frac{L^6}{ML^5T^2}\right]=[M^{-1}LT^{-2}]$$

= [Compressibility]

6. Find the magnetic field at the point P in figure. The curved portion is a semicircle connected to two long straight wires.



(1) $\frac{\mu_0 i}{2r}\left(1+\frac{2}{\pi}\right)$ (2) $\frac{\mu_0 i}{2r}\left(1+\frac{1}{\pi}\right)$

(3) $\frac{\mu_0 i}{2r}\left(\frac{1}{2}+\frac{1}{2\pi}\right)$ (4) $\frac{\mu_0 i}{2r}\left(\frac{1}{2}+\frac{1}{\pi}\right)$

Answer (3)

Sol. $B_P=\frac{\mu_0 i}{4\pi r}+\frac{1}{2}\left(\frac{\mu_0 i}{2r}\right)$

$$\frac{\mu_0 i}{4r}\left[\frac{1}{\pi}+1\right]$$

7. A steel wire with mass per unit length 7.0×10^{-3} kg m^{-1} is under tension of 70 N. The speed of transverse waves in the wire will be

(1) 200π m/s (2) 100 m/s

(3) 50 m/s (4) 10 m/s

Answer (2)

Sol. Speed of transverse wave = $\sqrt{\frac{T}{M}}$

$$=\sqrt{\frac{70}{7\times10^{-3}}}=100 \text{ m/s}$$

8. A sample of gas at temperature T is adiabatically expanded to double its volume. The work done by the gas in the process is $\left(\text{given, } \gamma=\frac{3}{2}\right)$

(1) $W=\frac{T}{R}[\sqrt{2}-2]$

(2) $W=RT[2-\sqrt{2}]$

(3) $W=TR[\sqrt{2}-2]$

(4) $W=\frac{R}{T}[2-\sqrt{2}]$

Answer (2)

Sol. $\gamma=\frac{3}{2}$

$$\omega=\frac{nR\Delta T}{1-\gamma}=\frac{nRT_f-nRT_i}{1-\gamma}$$

$$=\frac{(PV)_f-(PV_i)}{1-\gamma} \quad ...(1)$$

PV^γ = constant

$$P_iV_i^\gamma=P_f(2V_i)^\gamma \Rightarrow P_f=\frac{P_i}{2^\gamma}=\frac{P_i}{2\sqrt{2}} \quad ...(2)$$

From (1) and (2)

$$\omega=\frac{\frac{P_i}{2\sqrt{2}}2V_i-P_iV_i}{1-\gamma}=\frac{P_iV_i}{-1/2}\left(\frac{1}{\sqrt{2}}-1\right)$$

$$=-nRT(\sqrt{2}-2)$$

$$=nRT(2-\sqrt{2})$$

9. The average kinetic energy of a molecule of the gas is

(1) dependent on the nature of the gas

(2) proportional to volume

(3) proportional to absolute temperature

(4) proportional to pressure

Answer (3)

Sol. Average kinetic energy of a molecule of gas

$$=\frac{f}{2}k_BT$$

f is degree of freedom.

10. Match List I with List II

List I		List II	
A.	AC generator	I.	Presence of both L and C
B.	Transformer	II.	Electromagnetic Induction
C.	Resonance phenomenon to occur	III.	Quality factor
D.	Sharpness of resonance	IV.	Mutual Induction

Choose the correct answer from the options given below

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

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

Answer (2)

Sol. AC generator works on EMZ principle (A-II)
Transformer uses Mutual induction (B-IV)

Resonance occurs when both L and C are present (C–Z) and quality factor determines sharpness of resonance (D-III)

11. Which of the following frequencies does not belong to FM broadcast.

(1) 99 MHz (2) 64 MHz

(3) 89 Mhz (4) 106 MHz

Answer (2)

Sol. FM broadcast varies from 89 Hz to 108 Hz

12. If earth has a mass nine times and radius twice to that of a planet P. Then $\frac{\upsilon_e}{3}\sqrt{x}ms^{-1}$ will be the minimum velocity required by a rocket to pull out of gravitational force of, P, where υ_e is is escape velocity on earth. The value of x is

(1) 2 (2) 18

(3) 1 (4) 3

Answer (1)

Sol. $M_E = 9M_P$

$R_E = 2R_P$

Escape velocity $= \sqrt{\frac{2mG}{R}}$

For earth $v_e = \sqrt{\frac{2GM_E}{R_E}}$

For P, $v_e = \sqrt{\frac{\frac{2GM_E}{9}}{\frac{R_E}{2}}} = \sqrt{\frac{2GM_E}{R_E} \times \frac{2}{9}}$

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

13. The mass of proton, neutron and helium nucleus are respectively 1.0073u, 1.0087u and 4.0015u. The binding energy of helium nucleus is

(1) 56.8 MeV (2) 28.4 MeV

(3) 7.1 MeV (4) 14.2 MeV

Answer (2)

Sol. Mass defect = 2 (Mass of p + mass of n) – mass of He nucleus

$\Delta m = 0.0305u$

B.E = 931.5 × Δm = 931.5 × 0.0305

= 28.4 MeV

14. A proton moving with one tenth of velocity of light has a certain de Broglie wavelength of λ. An alpha particle having certain kinetic energy has the same de-Brogle wavelength λ. The ratio of kinetic energy of proton and that of alpha particle is

(1) 1 : 4

(2) 1 : 2

(3) 2 : 1

(4) 4 : 1

Answer (4)

Sol. For same λ_1 momentum should be same,

$(P)_P = (P)_\alpha$

$\Rightarrow \sqrt{2k_P m_P} = \sqrt{2k_\alpha m_\alpha}$

$\Rightarrow k_P m_P = k_\alpha m_\alpha$

$\frac{k_P}{k_\alpha} = \left(\frac{m_\alpha}{m_P}\right) = \frac{4}{1} = 4:1$

15. A mercury drop of radius 10^{-3} m is broken into 125 equal size droplets. Surface tension of mercury is 0.45 Nm^{-1}. The gain in surface energy is

(1) 17.5×10^{-5} J (2) 28×10^{-5} J

(3) 5×10^{-5} J (4) 2.26×10^{-5} J

Answer (4)

Sol. Initial volume = Final volume

So, $\boxed{R = 5r}$

Gain in surface energy = $[125 \times 4\pi r^2 \times T - 4\pi R^2 T]$

$= 4\pi T\,[125r^2 - R^2]$

$= 16\pi R^2 T$

$= 16\pi \times (10^{-3})^2 \times 0.45$

$= 22.6 \times 10^{-6}$ J

$= 2.26 \times 10^{-5}$ J

16. Match List I with List II:

List I	List II
A. Microwaves	I. Radio active decay of the nucleus
B. Gamma rays	II. Rapid acceleration and deceleration of electron in aerials
C. Radio waves	III. Inner shell electrons
D. X-rays	IV. Klystron valve

Choose the ***correct*** answer from the options given below:

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

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

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

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

Answer (2)

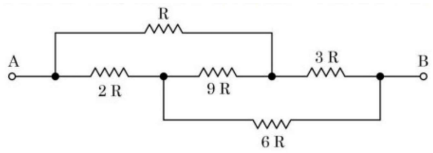
Sol. 1. Klystron valve used to produce Microwave

2. Gamma ray $\rightarrow$ Radioactive decay

3. Radio wave $\rightarrow$ Rapid acceleration and deacceleration of electrons in aerials

4. X-ray $\rightarrow$ Inner shell electrons

17. The equivalent resistance between A and B of the network shown in figure:



(1) $\frac{8}{3}$R

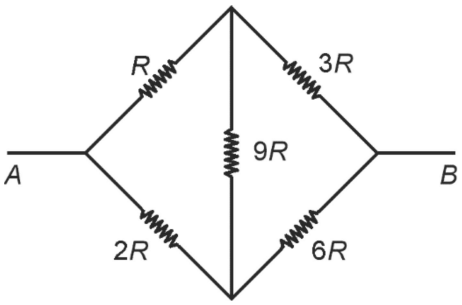
(2) 21 R

(3) 14 R

(4) $11\frac{2}{3}$R

Answer (1)

Sol.



This is balanced Wheatstone bridge,

$$R_{eq} = \frac{4R \times 8R}{12R} = \left(\frac{8R}{3}\right)$$

18. A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 ms^{-1}. Neglecting the air resistance, the speed with which the stone hits the ground will be ____ ms^{-1}

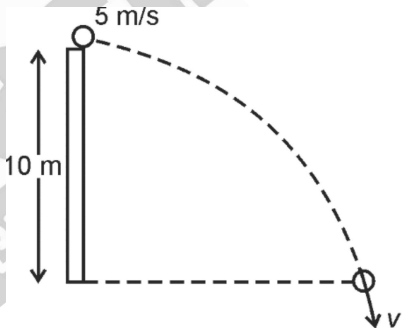
(given, g = 10 ms^{-2}).

(1) 15 (2) 25

(3) 30 (4) 20

Answer (1)

Sol.

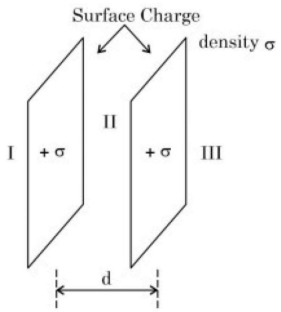


$$v = \sqrt{u^2 + 2gh}$$

$$= \sqrt{25 + 2 \times 10 \times 10}$$

$$= \sqrt{225} = 15 \text{ m/s}$$

19. Let σ be the uniform surface charge density of two infinite thin plane sheets shown in figure. Then the electric fields in three different region E_I, E_{II} and E_{III} are :



(1) $\vec{E}_I = 0, \vec{E}_{II} = \frac{\sigma}{\epsilon_0}\hat{n}, E_{III} = 0$

(2) $\vec{E}_I = -\frac{\sigma}{\epsilon_0}\hat{n}, E_{II} = 0, \vec{E}_{III} = \frac{\sigma}{\epsilon 0}\hat{n}$

(3) $\vec{E}_I = -\frac{2\sigma}{\epsilon_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} = \frac{2\sigma}{\epsilon 0}\hat{n}$

(4) $\vec{E}_I = -\frac{\sigma}{2\,\epsilon_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} = \frac{\sigma}{2\,\epsilon 0}\hat{n}$

Answer (2)

Sol. From the figure:

$\overrightarrow{E_1} = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$ (Leftward)

$\overrightarrow{E_2} = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0}$

$\overrightarrow{E_3} = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$ (Rightward)

20. An object moves with speed v_1, v_2 and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where AB=BC and AD = 3AB, then average speed of the object will be:

(1) $\frac{v_1v_2v_3}{3(v_1v_2 + v_2v_3 + v_3v_1)}$

(2) $\frac{(v_1 + v_2 + v_3)}{3}$

(3) $\frac{3v_1v_2v_3}{(v_1v_2 + v_2v_3 + v_3v_1)}$

(4) $\frac{(v_1 + v_2 + v_3)}{3v_1v_2v_3}$

Answer (3)

Sol. AB = BC = CD

$\Rightarrow$ Average speed $= \frac{\text{Distance}}{\text{Time}}$

$= \frac{AD}{\frac{AB}{V_1} + \frac{AB}{V_2} + \frac{AB}{V_3}}$

$= \frac{3V_1V_2V_3}{V_1V_2 + V_2V_3 + V_1V_3}$

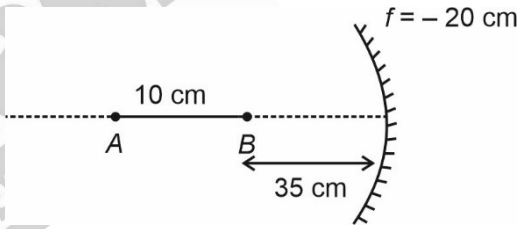
SECTION - B

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 thin cylindrical rod of length 10 cm is placed horizontally on the principle axis of a concave mirror of focal length 20 cm. The rod is placed in a such a way that mid point of the rod is at 40 cm from the pole of mirror. The length of the image formed by the mirror will be $\frac{x}{3}$ cm. The value of x is _____.

Answer (32)

Sol.



A : $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{v} + \frac{1}{-45} = \frac{1}{-20}$

$\Rightarrow \frac{1}{v} = \frac{1}{45} - \frac{1}{20} = \frac{4-9}{180} = -\frac{1}{36}$

$\Rightarrow v = -36$ cm

B: $\frac{1}{v} + \frac{1}{-35} = \frac{1}{-20}$

$\Rightarrow \frac{1}{v} = \frac{1}{35} - \frac{1}{20} = \frac{4-7}{140}$

$\Rightarrow v = -\frac{140}{3}$

$\Rightarrow$ length of image $= \frac{140}{3} - 36 = \frac{32}{3}$ cm

$\Rightarrow x = 32$

22. The amplitude of a particle executing SHM is 3 cm. The displacement at which its kinetic energy will be 25% more than the potential energy is: _____ cm.

Answer (2)

Sol. $A = 3$ cm

$K = 1.25U$

$\Rightarrow K + \frac{K}{1.25} = K_{max}$

$\Rightarrow \frac{9}{5}K = K_{max}$

$\Rightarrow \frac{9}{5}\frac{1}{2}mv^2 = \frac{1}{2}mv_{max}^2$

$\Rightarrow \frac{9}{5}\left[\omega\sqrt{A^2 - x^2}\right]^2 = \omega^2 A^2$

$\Rightarrow 9(A^2 - x^2) = 5A^2$

$\Rightarrow x^2 = \frac{4A^2}{9}$

$\Rightarrow x = \frac{2A}{3}$

$\Rightarrow x = 2$ cm

23. A certain pressure 'P' is applied to 1 litre of water and 2 litre of a liquid separately. Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03%. The bulk modulus of water to that of the liquid is $\frac{3}{x}$. The value of x is _____.

Answer (1)

Sol. $B = \frac{-dp}{\frac{dv}{v}}$

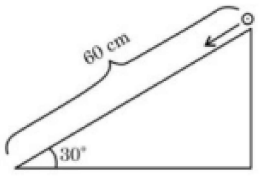
$\Rightarrow \frac{B_{water}}{B_{Liquid}} = \frac{\left(\frac{dv}{v}\right)_{liquid}}{\left(\frac{dv}{v}\right)_{water}}$

$= \frac{0.03}{0.01} = 3$

$\Rightarrow x = 1$

24. A solid cylinder is released from rest from the top of an inclined plane of inclination 30° and length 60 cm. If the cylinder rolls without slipping, its speed upon reaching the bottom of the inclined plane is_____ms^{-1}.

(Given g = 10 ms^{-2})



Answer (2)

Sol. Loss in potential energy = $mgh = mg[60 \sin 30° \text{ cm}]$

$\Rightarrow mg\left[\frac{30}{100}\right] = \frac{1}{2}mv^2 + \frac{1}{2}\frac{mv^2}{2}$

$\Rightarrow 0.3 \times 10 = \frac{3}{4}v^2$

$\Rightarrow v^2 = 4$

$\Rightarrow v = 2$ m/s

25. A light of energy 12.75 eV is incident on a hydrogen atom in its ground state. The atom absorbs the radiation and reaches to one of its excited states. The Angular momentum of the atom in the excited state is $\frac{x}{m} \times 10^{-17}$ eVs. The value of x is _____ (use $h = 4.14 \times 10^{-15}$ eVs, c = 3 × 10^8 ms^{-1}).

Answer (828)

Sol. Let the electron jumps to n^{th} orbit so

$12.75 = 13.6\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$

$\Rightarrow n = 4$

So $L = \frac{nh}{2\pi} = \frac{2h}{\pi}$

$= \frac{2 \times 4.14 \times 10^{-15}}{\pi}$

$= 8.28 \times 10^{-15}$

$= 828 \times 10^{-17}$ eVs

26. A small particle moves to position $5\hat{i} - 2\hat{j} + \hat{k}$ from its initial position $2\hat{i} + 3\hat{j} - 4\hat{k}$ under the action of force $5\hat{i} + 2\hat{j} + 7\hat{k}$ N. The value of work done will be _____ J.

Answer (40)

Sol. $W = \vec{F} \cdot (\vec{r}_2 - \vec{r}_1)$

$= (5\hat{i} + 2\hat{j} + 7\hat{k}) \cdot (3\hat{i} - 5\hat{j} + 5\hat{k})$

$= 15 - 10 + 35$

$= 40$ J

27. A series LCR circuit is connected to an ac source of 220 V, 50 Hz. The circuit contain a resistance R = 100 Ω and an inductor of inductive reactance X_L = 79.6 Ω. The capacitance of the capacitor needed to maximize the average rate at which energy is supplied will be _____ μF.

Answer (40)

Sol. Average rate of energy is maximum at resonance.

$\therefore X_L = X_C$

$$79.6 = \frac{1}{2\pi(50) \times C}$$

$$C = \frac{1}{79.6 \times 2\pi(50)}$$

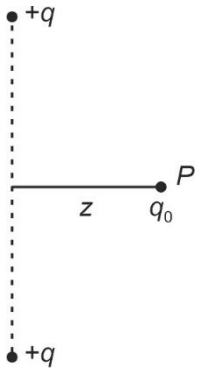
$\approx 40\,\mu F$

28. Two equal positive point charges are separated by a distance 2a. The distance of a point from the centre of the line joining two charges on the equatorial line (perpendicular bisector) at which force experienced by a test charge q_0 becomes maximum is $\frac{a}{\sqrt{x}}$. The value of x is _____.

Answer (2)

Sol. $$F_P = q_0 E_p = q_0 \frac{kqz}{\left(a^2 + z^2\right)^{3/2}}$$

or $$F_P = \frac{kqq_0 z}{\left(a^2 + z^2\right)^{3/2}}$$



To maximize $\frac{dF_P}{dz} = 0$

or $$kqq_0 \frac{\left(a^2 + z^2\right)^{3/2} - z\frac{3}{2} \times 2z\left(a^2 + z^2\right)^{\frac{1}{2}}}{\left(a^2 + z^2\right)^3} = 0$$

$$\Rightarrow z = \frac{a}{\sqrt{2}}$$

29. A charge particle of 2 μC accelerated by a potential difference of 100 V enters a region of uniform magnetic field of magnitude 4 mT at right angle to the direction of field. The charge particle completes semicircle of radius 3 cm inside magnetic field. The mass of the charge particle is _____ × 10^{-18} kg.

Answer (144)

Sol. $$R = \frac{\sqrt{2mqV}}{qB}$$

$$R = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

or $$m = \frac{R^2B^2q}{2V}$$

$$= \frac{\left(3 \times 10^{-2}\right)^2 \times \left(4 \times 10^{-3}\right)^2 \times 2 \times 10^{-6}}{2 \times 100}$$

$= 144 \times 10^{-18}$ kg

30. In an experiment to find emf of a cell using potentiometer, the length of null point for a cell of emf 1.5 V is found to be 60 cm. If this cell is replaced by another cell of emf E, the length of null point increases by 40 cm. The value of E is $\frac{x}{10}$ V. The value of *x* is _____.

Answer (25)

Sol. $E \propto l$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\frac{1.5}{E} = \frac{60}{100}$$

$$E = \frac{150}{60} = \frac{5}{2} = \frac{25}{10}$$

so $x = 25$