1. From the statements given below:

(A) The angular momentum of an electron in n orbit is an integral multiple of \( \hbar \).
(B) Nuclear forces do not obey inverse square law.
(C) Nuclear forces are spin dependent.
(D) Nuclear forces are central and charge independent.
(E) Stability of nucleus is inversely proportional to the value of packing fraction.

Choose the correct answer from the options given below:

1. (B), (C), (D), (E) only
2. (A), (C), (D), (E) only
3. (A), (B), (C), (E) only
4. (A), (B), (C), (D) only

Ans. (3)

2. A body of mass 4 kg experiences two forces \( \vec{F}_1 = 5\hat{i} + 8\hat{j} + 7\hat{k} \) and \( \vec{F}_2 = 3\hat{i} - 4\hat{j} - 3\hat{k} \). The acceleration acting on the body is:

1. \( 2\hat{i} + \hat{j} + \hat{k} \)
2. \( 4\hat{i} + 2\hat{j} + 2\hat{k} \)
3. \( -2\hat{i} - \hat{j} - \hat{k} \)
4. \( 2\hat{i} + 3\hat{j} + 3\hat{k} \)

Ans. (1)

Sol. \( \vec{a} = \frac{\vec{F}_1 + \vec{F}_2}{m} \)

\[ \vec{F}_1 + \vec{F}_2 = 8\hat{i} + 4\hat{j} + 4\hat{k} \]

\[ \vec{a} = \frac{8\hat{i} + 4\hat{j} + 4\hat{k}}{4} = 2\hat{i} + \hat{j} + \hat{k} \]

3. Monochromatic light of frequency \( 6 \times 10^{14} \) Hz is produced by a laser. The power emitted is \( 2 \times 10^{-3} \) W. How many photons per second on an average, are emitted by the source? (Given \( h = 6.63 \times 10^{-34} \) Js)

1. \( 1.5 \times 10^{15} \)
2. \( 7 \times 10^{16} \)
3. \( 6 \times 10^{15} \)
4. \( 9 \times 10^{18} \)

Ans. (1)

Sol. \( P = 2 \times 10^{-3} \) W

\[ P = \left( \frac{\Delta n}{\Delta T} \right) \times E_p \]

\[ \Rightarrow \frac{\Delta n}{\Delta T} = \frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}} = \frac{5.0276 \times 10^{15}}{5 \times 10^{15}}/\text{sec} \]
4. C₁ and C₂ are two hollow concentric cubes enclosing charges 2Q and 3Q respectively as shown in figure.

The ratio of electric flux passing through C₁ and C₂ is:

(1) 3 : 2  (2) 5 : 2  (3) 2 : 5  (4) 2 : 3

Ans. (3)

Sol. \[ \frac{\phi_{\text{out}}}{\phi_{\text{in}}} = \frac{q_{\text{in}}}{q_{\text{out}}} = \frac{2}{2+3} = \frac{2}{5} \]

5. A galvanometer (G) of 2 Ω resistance is connected in the given circuit. The ratio of charge stored in C₁ and C₂ is:

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

Ans. (4)

Sol. For DC source capacitor will act as an open circuit.

\[ i = \frac{6}{12} = 0.5 \text{ A} \]

\[ \Rightarrow V_{\text{AC}} = iR = 0.5 \times 6 = 3 \text{V} \]

\[ V_{\text{BD}} = iR = 0.5 \times 8 = 4 \text{V} \]

\[ Q = CV \]

\[ Q_{\text{AC}} = 4 \times 3 = 12 \mu\text{C} \]

\[ Q_{\text{BD}} = \frac{1}{2} \times 4 = 2 \mu\text{C} \]

\[ Q_{\text{AC}} : Q_{\text{BD}} = 12:2 = 6:1 \]
6. Match List I with List - II.

<table>
<thead>
<tr>
<th>List – I</th>
<th>List - II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 1001</td>
<td>(I) 3</td>
</tr>
<tr>
<td>(B) 010.1</td>
<td>(II) 4</td>
</tr>
<tr>
<td>(C) 100.100</td>
<td>(III) 5</td>
</tr>
<tr>
<td>(D) 0.0010010</td>
<td>(IV) 6</td>
</tr>
</tbody>
</table>

Choose the correct answer from the options given below:

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

Ans. (1)

7. A big drop is formed by coalescing 1000 small droplets of water. The surface energy will become:

(1) \( \frac{1}{100} \) th
(2) \( \frac{1}{10} \) th
(3) 100 times
(4) 10 times

Ans. (2)

Sol. Based on volume conservation

\[ R = n^{\frac{1}{3}} r \]

\[ R = (1000)^{\frac{1}{3}} r \]

\[ R = 10r \]

The surface energy \( U = TA \)

\[ \frac{U_I}{U_R} = 1000 \frac{A_I}{A_R} \]

\[ \frac{U_I}{U_R} = \frac{1000 \times r^2}{100r^2} \]

\[ U_R = \frac{U_I}{10} \]

8. A cricket player catches a ball of mass 120 g moving with 25 m/s speed. If the catching process is completed in 0.1 s then the magnitude of force exerted by the ball on the hand of player will be (in SI unit):

(1) 30
(2) 24
(3) 12
(4) 25

Ans. (1)
9. In a metre-bridge when a resistance in the left gap is $2\Omega$ and unknown resistance in the right gap, the balance length is found to be 40 cm. On shunting the unknown resistance with $2\Omega$, the balance length changes by:

(1) 62.5  
(2) 22.5  
(3) 20 cm  
(4) 65 cm

Ans. (2)

Sol. 

\[
\frac{2}{R} = \frac{40}{60} \Rightarrow R = 3\Omega
\]

10. A diatomic gas ($\gamma = 1.4$) does 300 J of work when it is gas in the process is: is expanded isobarically. The heat given to the gas in the process is:

(1) 800 J  
(2) 600 J  
(3) 700 J  
(4) 850 J

Ans. (3)
11. Train A is moving along two parallel rail tracks towards north with speed 72 km/h and train B is moving towards south with speed 108 km/h. Velocity of train B with respect to A and velocity of ground with respect to B are (in ms\(^{-1}\)):

(1) \(-50 \text{ and } -30\)  
(2) \(-50 \text{ and } 30\)  
(3) \(-30 \text{ and } 50\)  
(4) \(50 \text{ and } -30\)

Ans. (2)

Sol. \[ V_A = 72 \text{ km/h} = 20 \text{ m/s}, \]
\[ V_B = -108 \text{ km/h} = -30 \text{ m/s} \]
\[ \Rightarrow V_{BA} = V_B - V_A = -30 - (20) = -50 \text{ m/s} \]
\[ \Rightarrow V_{GB} = V_G - V_B = 0 - (-30) = 30 \text{ m/s} \]

12. A light planet is revolving around a massive star in a circular orbit of radius \(R\) with a period of revolution \(T\). If the force of attraction between planet and star is proportional to \(R\) then choose the correct option:

(1) \(T^2 \propto R^{3/2}\)  
(2) \(T^2 \propto R^3\)  
(3) \(T^2 \propto R^{5/2}\)  
(4) \(T^2 \propto R^{3/2}\)

Ans. (3)

Sol. \[ F \propto R \omega^2 \]
\[ \text{given } F \propto R^{-3/2} \]
\[ R^{-3/2} \propto R \omega^2 \]
\[ \omega^2 \propto R^{-5/2} \]
\[ \frac{1}{T^2} \propto R^{5/2} \]
\[ T^2 \propto R^{5/2} \]

13. A microwave of wavelength 2.0 cm falls normally on a slit of width 4.0 cm. The angular spread of the central maxima of the diffraction pattern obtained on a screen 1.5 m away from the slit, will be:

(1) 60°  
(2) 45°  
(3) 15°  
(4) 30°

Ans. (1)

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Sol. \[ \sin \theta = n \lambda. \]
\[ \sin \theta = \frac{\lambda}{a} = \frac{2 \times 10^{-2}}{4 \times 10^{-2}} = \frac{1}{2} \]
\[ \theta = 30^\circ \]
Angular spread = \[ \Theta = 60^\circ \]

14. If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 km/s, the root mean square velocity of oxygen at the same condition in km/s is:

(1) 1.0   (2) 1.5   (3) 2.0   (4) 0.5

Ans. (4)

Sol. \[ \frac{V_{O_2}}{V_{H_2}} = \frac{M_{O_2}}{M_{H_2}} \]
\[ \frac{V_{O_2}}{2 \text{ km/s}} = \sqrt{\frac{2}{32}} \]
\[ V_{O_2} = \frac{1}{2} \text{ km/s} \]

15. If frequency of electromagnetic wave is 60 MHz and it travels in air along z direction then the corresponding electric and magnetic field vectors will be mutually perpendicular to each other and the wavelength of the wave (in m) is:

(1) 2.5   (2) 5   (3) 10   (4) 2

Ans. (2)

Sol. \[ \lambda f = c \]
\[ 3 \times 10^8 = \lambda \times 60 \times 10^6 \]
\[ \lambda = \frac{3 \times 10^8}{60 \times 10^6} = \frac{300}{60} \]
\[ \lambda = 5 \text{ m} \]
16. To measure the temperature coefficient of resistivity $\alpha$ of a semiconductor, an electrical arrangement shown in the figure is prepared. The arm BC is made up of the semiconductor. The experiment is being conducted at 25°C and resistance of the semiconductor arm is 3 mΩ. Arm BC is cooled at a constant rate of 2°C/s. If the galvanometer G shows no deflection after 10 s. then $\alpha$ is:

\begin{align*}
(1) & \quad -1 \times 10^{-2} \text{°C}^{-1} \\
(2) & \quad -2 \times 10^{-2} \text{°C}^{-1} \\
(3) & \quad -2.5 \times 10^{-2} \text{°C}^{-1} \\
(4) & \quad -1.5 \times 10^{-2} \text{°C}^{-1}
\end{align*}

Ans. (1)

Sol. $T_{\text{initial}} = 25\text{°C}$

$T_{\text{final}} = 25\text{°C} - (2 \times 10\text{°C})$

$= 5\text{°C}$

$\Delta T = 5\text{°C} - 25\text{°C}$

$= -20\text{°C}$

When deflection of galvanometer is 0, this is balanced Wheatstone bridge.

\[ \frac{0.8}{3} = \frac{(R_{AB})_T}{R_{AB}} \]

$\Rightarrow (R_{AB})_T = R_{AB} [1 + \alpha(T - 25\text{°C})]$ 

$\Rightarrow 2.4 = 3 (1 + \alpha \Delta T)$ 

$\Rightarrow -0.2 = \alpha \Delta T$ 

$\Rightarrow \alpha = \frac{-0.2}{-20\text{°C}} = 1 \times 10^{-2}$

The semiconductor has a negative temperature coefficient.

So $\alpha = -1 \times 10^{-2}$

17. Conductivity of a photodiode starts changing only if the wavelength of incident light is less than 660 nm. The band gap of photodiode is found to be $\frac{x}{8}$ eV. The value of $x$ is:

(Given, $h = 6.6 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$ C)

\begin{align*}
(1) & \quad 11 \\
(2) & \quad 13 \\
(3) & \quad 15 \\
(4) & \quad 21
\end{align*}

Ans. (3)
Sol. Energy of band gap = energy of photons

\[
E_G = \frac{hc}{\lambda} = \left( \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{660 \times 10^{-9} \times 1.6 \times 10^{-19}} \right) \text{eV} = \frac{15}{8} \text{eV}
\]

So \( x = 15 \)

18. A transformer has an efficiency of 80% and works at 10 V and 4 kW. If the secondary voltage is 240 V, then the current in the secondary coil is:

\[ V_i = 10 \text{V}, \quad P_i = 4 \text{kW} \]

efficiency is 80%

\[
\therefore P_i \times \frac{80}{100} = (V_{output}) I_{output}
\]

\[
(4 \times 10^3) \times \frac{80}{100} = 240 \times I_{output}
\]

\[
I_{output} = \frac{40}{3} = 13.33 \text{A}
\]

19. In an ammeter, 5% of the main current passes through the galvanometer. If resistance of the galvanometer is \( G \), the resistance of ammeter will be:

\[ I_s = I_s \rightarrow S \rightarrow G \rightarrow R_a \rightarrow O \rightarrow B \]

\[
I_s = I_s \times R_a = I_s \cdot S
\]

\[
5 \times G = \frac{95}{100} = S
\]

\[
G = \frac{19}{19}
\]

\[
R_a = \frac{G \times S}{G + S} = \frac{G \times \frac{19}{20}}{G + \frac{19}{19}} = \frac{G}{20}
\]
20. A disc of radius R and mass M is rolling horizontally without slipping with speed v. It then moves up an inclined smooth surface as shown in figure. The maximum height that the disc can go up the incline is:

\[ h = \frac{3v^2}{4g} \]

Ans. (1)

Sol. \( \frac{1}{2} \pi R^2 + \frac{1}{2} \text{mv}^2 = \text{mgh} \)

\[ \frac{1}{2} \left( \frac{\text{mR}^2}{2} \right) \left( \frac{v^2}{R^2} \right) + \frac{1}{2} \text{mv}^2 = \text{mgh} \]

\[ 3v^2 = gh \]

\[ h = \frac{3v^2}{4g} \]

21. A mass m is suspended from a spring of negligible mass and the system oscillates with a frequency \( f_1 \).

The frequency of oscillations if a mass 9m is suspended from the same spring is \( f_2 \). The value of \( \frac{f_1}{f_2} \) is:

Ans. 03.00

Sol. \[ \frac{1}{f_1} = 2\pi \sqrt{\frac{m}{k}} \]

\[ \frac{1}{f_2} = 2\pi \sqrt{\frac{9m}{k}} \]

\[ \frac{f_1}{f_2} = 3 \]

22. In an electrical circuit drawn below the amount of charge stored in the capacitor is ____ \( \mu \text{C} \).

Ans. 60.00

Sol.

\[ \text{P.D. across capacitor} \]

\[ V = IR = 1 \times 6 = 6 \text{V} \]

\[ Q = CV = 10 \times 6 = 60 \ \mu \text{C} \]
23. A particle initially at rest starts moving from reference point $x = 0$ along $x$-axis, with velocity $v$ that varies as $v = 4\sqrt{x}$ m/s. The acceleration of the particle is ______ m/s$^2$.

Ans. 08.00

Sol.

$$v = 4\sqrt{x}$$

$$\frac{dv}{dt} = \frac{d}{dx}(4\sqrt{x}) \frac{dx}{dt}$$

$$\Rightarrow a = \frac{4}{2\sqrt{x}} \frac{dx}{dt}$$

$$\Rightarrow a = \frac{4}{2\sqrt{x}} (4\sqrt{x}) \Rightarrow a = 8 \text{ m/s}^2$$

24. Suppose a uniformly charged wall provides a uniform electric field of $2 \times 10^4$ N/C normally. A charged particle of mass 2 g being suspended through a silk thread of length 20 cm and remain stayed at a distance of 10 cm from the wall. Then the charge on the particle will be $\frac{1}{\sqrt{x}} \mu\text{C}$ where $x = ____$

[use $g = 10$ m/s$^2$]

Ans. 03.00

Sol.

\[ \begin{align*}
\tan 30^\circ &= \frac{qE}{mg} \\
q &= \frac{\tan 30^\circ \times mg}{E} \\
q &= \frac{1}{\sqrt{3}} \times \frac{2 \times 10^{-3} \times 10}{2 \times 10^4} \\
q &= \frac{1}{\sqrt{3}} \times 10^{-6} \\
\frac{1}{\sqrt{x}} &= \frac{1}{\sqrt{3}} \times 10^{-6} \\
x &= 3
\end{align*} \]
25. A moving coil galvanometer has 100 turns and each turn has an area of 2.0 cm². The magnetic field produced by the magnet is 0.01 T and the deflection in the coil is 0.05 radian when a current of 10 mA is passed through it. The torsional constant of the suspension wire is \( x \times 10^{-5} \) N·m/rad. The value of \( x \) is

**Ans.** 0.04

**Sol.**

Torque due to magnetic field = Torque due to torsional wire

\[
\text{NiAB} = C \theta
\]

\[
C = \frac{\text{NiAB}}{\theta} = \frac{100 \times 10 \times 10^{-3} \times 2 \times 10^{-4} \times 0.01}{0.05} = 4 \times 10^{-5} \text{ N·m/rad}
\]

26. One end of a metal wire is fixed to a ceiling and a load of 2 kg hangs from the other end. A similar wire is attached to the bottom of the load and another load of 1 kg hangs from this lower wire. Then the ratio of longitudinal strain of upper wire to that of the lower wire will be [Area of cross section of wire = 0.005 cm², \( Y = 2 \times 10^{11} \) Nm⁻² and \( g = 10 \text{ m/s}^2 \)]

**Ans.** 0.03

**Sol.**

\[
\text{Strain}_1 : \text{Strain}_2 = \left( \frac{\Delta l_1}{l_1} \right) : \left( \frac{\Delta l_2}{l_2} \right) = \frac{F_1/A_1 Y_1}{F_2/A_2 Y_2} = \frac{30}{10} = 3 : 1
\]

27. In Young's double slit experiment, monochromatic light of wavelength 5000 Å is used. The slits are 1.0 mm apart and screen is placed at 1.0 m away from slits. The distance from the centre of the screen where intensity becomes half of the maximum intensity for the first time is ______ ×10⁻⁶ m.

**Ans.** 125

**Sol.**

\[
\begin{align*}
\frac{l_{\text{max}}}{2} & = l_1 + l_2 + 2l_1 l_2 \cos \theta \\
& = 2l + 2l \cos \theta \\
& \Rightarrow \cos \theta = 0
\end{align*}
\]

\[
\frac{2\pi}{\lambda} \Delta x = \frac{\pi}{2} \Rightarrow \Delta x = \frac{\lambda}{4}
\]

\[
\frac{\Delta y}{4d} = \frac{\lambda}{4} \Rightarrow y = \frac{\lambda D}{4d}
\]

\[
y = \frac{5000 \times 10^{-10} \times 1}{4 \times 10^{-3}} = 125 \times 10^{-6} \text{ m}
\]
28. A coil of 200 turns and area 0.20 m² is rotated at half a revolution per second and is placed in uniform magnetic field of 0.01 T perpendicular to axis of rotation of the coil. The maximum voltage generated in the coil is \( \frac{2\pi}{\beta} \) volt. The value of \( \beta \) is ____

Ans. 05.00

Sol. \( \phi = B A \cos(\omega t) \)

\[
e = \left| \frac{d\phi}{dt} \right| = B A \omega \sin \omega t
\]

\[
e_{\text{max}} = B A \omega = 200 \times 0.01 \times 0.20 \times \pi = \frac{2\pi}{5}
\]

\( \beta = 5 \)

29. A uniform rod AB of mass 2 kg and length 30 cm at rest on a smooth horizontal surface. An impulse of force 0.2 Ns is applied to end B. The time taken by the rod to turn through at right angles will be \( \frac{\pi}{x} \) s, where \( x = ____ \)

Ans. 04.00

Sol. Angular Impulse = change in angular momentum

\[
P = \frac{mL^2}{12} \cdot \omega
\]

about centre of mass

\( \omega = \frac{6P}{mL} \)

For \( \theta = \frac{\pi}{2} \Rightarrow \frac{\pi}{2} = \omega t \)

\[
t = \frac{\pi}{2\omega} = t = \frac{\pi}{2\omega}
\]

\[
t = \frac{\pi}{2} \times 0.3 = \frac{\pi}{4} \text{ sec.}
\]

\[
\frac{\pi}{4} = \frac{\pi}{x}
\]

So \( x = 4 \)
30. A particular hydrogen-like ion emits the radiation of frequency \(3 \times 10^{15}\) Hz when it makes transition from \(n = 2\) to \(n = 1\). The frequency of radiation emitted in transition from \(n = 3\) to \(n = 1\) is \(\frac{x}{9} \times 10^{15}\) Hz, when \(x = \) 

**Ans. 32.00**

**Sol.**

\[
h_f = 13.6 \left[ 1 - \frac{1}{4} \right]
\]

\[
h'_f = 13.6 \left[ 1 - \frac{1}{9} \right]
\]

\[
h_f = 13.6 \times \frac{3}{4} \quad \text{..........(i)}
\]

\[
h'_f = 13.6 \times \frac{8}{9} \quad \text{..........(ii)}
\]

Equation (2) by (1),

\[
\frac{f'_o}{f_o} = \frac{8}{9} \times \frac{4}{3}
\]

\[
f'_o = \frac{32}{27} \times 3 \times 10^{15} = \frac{32}{9} \times 10^{15}
\]

\[
x = 32
\]
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