Physics

1. Three blocks A, B and C, of masses 4 kg, 2 kg and 1 kg respectively, are in contact on a frictionless surface, as shown. If a force of 14 N is applied on the 4 kg block, then the contact force between A and B is:

- (1) 8 N
- (2) 18 N
- (3) 2 N
- (4) 6 N

Solution: (4)

\[ F = Ma = (M_a + M_b + M_c)a \]
\[ 14 = (4 + 2 + 1)a = 7a \]
\[ a = 2 \]

Let \( F' \) be the contact force between A & B,

\[ F - F' = 4a \]
\[ 14 - F' = 4a = 4 \times 2 \]
\[ F' = 6N \]

2. If radius of the \( ^{27}_{13}\text{Al} \) nucleus is taken to be \( R_{\text{Al}} \) then the radius of \( ^{125}_{53}\text{Te} \) nucleus is nearly:

- (1) \( \frac{3}{5} R_{\text{Al}} \)
- (2) \( \left( \frac{13}{53} \right)^\frac{1}{3} R_{\text{Al}} \)
- (3) \( \left( \frac{53}{13} \right)^\frac{1}{3} R_{\text{Al}} \)
- (4) \( \frac{3}{5} R_{\text{Al}} \)

Solution: (4)

We know,

Radius of the nucleus is \( R = R_0 \text{ (mass Number)}^\frac{1}{3} \)
\[ R = R_0 A^3 \]

\[ \frac{R_{Al}}{R_{Te}} = \left( \frac{27}{725} \right)^{\frac{1}{3}} = \frac{3}{5} \]

\[ R_{Te} = \frac{5}{3} R_{Al} \]

3. Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?

Solution: (4)

\[ \lambda = \frac{h}{p} \]
\[ p\lambda = h \]
\[ \lambda p = h \text{ Same as } (xy = c) \]
\[ P \propto \frac{1}{\lambda} \text{ (Rectangles hyperbola)} \]

4. The two ends of a metal rod are maintained at temperatures 100°C and 110°C. The rate of heat flow in the rod is found to be 4.0 J/s. If the ends are maintained at temperatures 200°C and 210°C, the rate of heat flow will be:

(1) 8.0 J/s  
(2) 4.0 J/s  
(3) 44.0 J/s  
(4) 16.8 J/s  

Solution: (2)

In case I, temperature difference between the ends of rod is \(110 - 100 = 10^\circ \text{C}\)
In case II, temperature difference between the ends of rod is \(210 - 200 = 10^\circ \text{C}\)
Hence, in both the case temperature difference are same i.e. \(10^\circ \text{C}\)
∴ Rate of heat flow is also 4 J/s in both the cases.

5. For a parallel beam of monochromatic light of wavelength '\(\lambda\)', diffraction is produced by a single slit whose width 'a' is of the order of the wavelength of the light. If 'D' is the distance of the screen from the slit, the width of the central maxima will be:

(1) \(\frac{D\lambda}{a}\)  
(2) \(\frac{2D\lambda}{a}\)  
(3) \(\frac{2D\lambda}{a}\)  
(4) \(\frac{2\lambda}{a}\)  

Solution: (3)

Linear width of central maximum.
\[ D(2\theta) = 2D\theta = \frac{2D\lambda}{a} \]
6. Which logic gate is represented by the following combination of logic gates?

![Logic gates diagram]

(1) AND
(2) NOR
(3) OR
(4) NAND

Solution: (1)

\[ y_1 = \bar{A}, y_2 = \bar{B} \]

\[ y = y_1 + y_2 = \bar{A} + \bar{B} \]

Using De-Morgan's theorem

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>( y_1 )</th>
<th>( y_2 )</th>
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7. A particle is executing SHM along a straight line. Its velocities at distances \( x_1 \) and \( x_2 \) from the mean position are \( V_1 \) and \( V_2 \) respectively. Its time period is:
Solution: (4)

For particle undergoing SHM,

\[ V = \omega \sqrt{A^2 - x^2} \Rightarrow V^2 = \omega^2 (A^2 - x^2) \]

\[ V_1 = \omega \sqrt{A^2 - x_1^2} \Rightarrow V_1^2 = \omega^2 (A^2 - x_1^2) \quad \text{(i)} \]

\[ V_2 = \omega \sqrt{A^2 - x_2^2} \Rightarrow V_2^2 = \omega^2 (A^2 - x_2^2) \quad \text{(ii)} \]

\[ V_1^2 - V_2^2 = \omega^2 (x_2^2 - x_1^2) \]

\[ \omega = \sqrt{\frac{V_1^2 - V_2^2}{x_2^2 - x_1^2}} \]

\[ T = 2\pi \sqrt{\frac{x_2^2 - x_1^2}{V_1^2 - V_2^2}} \]

8. Two identical thin Plano-convex glass lenses (refractive index 1.5) each having radius of curvature of 20 cm are placed with their convex surfaces in contact at the center. The intervening space is filled with oil of refractive index 1.7. The focal length of the combination is :-

(1) −50 cm
(2) 50 cm
(3) −20 cm
(4) −25 cm

Solution: (1)
Len’s maker’s formula
\[
\frac{1}{f} = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)
\]
\[
\frac{1}{f_1} = (\mu - 1) \frac{1}{20} \Rightarrow (1.5 - 1) \frac{1}{20} = \frac{1}{40}
\]
\[
\frac{1}{f_1} = \frac{1}{40}
\]

For lens \( \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{40} + \frac{1}{40} = \frac{1}{20} \)

For concave \( \frac{1}{f_3} = (1.7 - 1) \left( -\frac{1}{R} - \frac{1}{R} \right) \)
\[
= -0.7 \times 2 \frac{1}{R}
\]
\[
\frac{1}{f_{eq}} = \frac{1}{20} + \left( \frac{-0.7 \times 2}{R} \right)
\]
\[
= \frac{1}{20} - \frac{1.4}{20}
\]
\[
f_{eq} = -\frac{20}{0.4} = -50 \text{ cm}
\]

9. An electron moving in a circular orbit of radius \( r \) makes \( n \) rotations per second. The magnetic field produced at the center has magnitude:

(1) \( \frac{\mu_0 n^2 e}{r} \)
(2) \( \frac{\mu_0 n e}{2\pi} \)
(3) \( \frac{\mu_0 n e}{2\pi r} \)
(A) Zero

Solution: (2)

An electron moving in a circular orbit makes \( n \) rotations. The magnetic field produced at the center has magnitude:

\[
B = \frac{\mu_0 i}{2R} = \frac{\mu_0 n e}{2R}
\]

where \( i = n e \) and \( \omega = 2\pi n \).
10. A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to \( v(x) = \beta x^{-2n} \), where \( \beta \) and \( n \) are constants and \( x \) is the position of the particle. The acceleration of the particle as a function \( x \), is given by:

\[
\begin{align*}
(1) & \quad -2\beta^2 x^{-2n+1} \\
(2) & \quad -2n\beta^2 e^{-4n+1} \\
(3) & \quad -2\beta^2 x^{-2n-1} \\
(4) & \quad -2n\beta^2 x^{-4n-1}
\end{align*}
\]

Solution: (4)
\[
a = \frac{dv}{dx} = \frac{d}{dx} \beta x^{-2n} = -2n\beta x^{-2n-1} \times \beta x^{-2n} = -2n\beta^2 x^{-4n-1}
\]

11. The electric field in a certain region is acting radially outward and is given by \( E = A r \). A charge contained in a sphere of radius ‘a’ centred at the origin of the field, will be given by:

\[
\begin{align*}
(1) & \quad 4\pi \epsilon_0 A a^3 \\
(2) & \quad \epsilon_0 A a^3 \\
(3) & \quad 4\pi \epsilon_0 A a^2 \\
(4) & \quad A \epsilon_0 a^2
\end{align*}
\]

Solution: (1)

\[
\begin{align*}
\text{We know} & \quad E_{\text{Sphere}} = \frac{1}{4\pi \epsilon_0} \frac{q}{r^2} \\
\frac{1}{4\pi \epsilon_0} \frac{q}{a^2} & = A a. \\
q & = 4\pi \epsilon_0 A a^3
\end{align*}
\]

12. A radiation of energy ‘E’ falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (\( C = \) Velocity of light) :-
Solution: (4)

\[ E = \frac{hc}{\lambda}, \quad P = \frac{h}{\lambda} \quad \Rightarrow \quad P = \frac{E}{c} \]

Initial momentum of light when falls on a perfectly reflecting surface.

\[ P_i = \frac{E}{c} \]

When it is reflected momentum is in opposite direction

\[ P_f = -\frac{E}{c} \]

Net momentum \( = P_f - P_i \)

\[ = -\frac{E}{c} - \frac{E}{c} = \frac{-2E}{c} \]

\[ \Delta P = \frac{2E}{c} \]

13. A, B and C are voltmeters of resistance R, 1.5 R and 3R respectively as shown in the figure. When some potential difference is applied between X and Y, the voltmeter readings are \( V_A \), \( V_B \) and \( V_C \) respectively. Then:

(1) \( V_A = V_B \neq V_C \)
(2) \( V_A \neq V_B \neq V_C \)
(3) \( V_A = V_B = V_C \)
(4) \( V_A \neq V_B = V_C \)

Solution: (3)
Voltage in parallel is constant
\[ i_p = i_B + i_C \quad V_B = V_C \]
\[ \frac{V_p}{R_i} = \frac{V_B}{R_B} + \frac{V_C}{R_C} \]
\[ \frac{1}{R_p} = \frac{1}{R_B} + \frac{1}{R_C} \quad \Rightarrow \quad \frac{1}{R'} = \frac{2}{3R} + \frac{1}{3R} \]
\[ \Rightarrow \quad R' = R \]
\[ V_{XP} = V_A = iR \]
\[ V_{PQ} = V_B = V_C = iR \]
\[ \Rightarrow \quad V_A = V_B = V_C \]

14. A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. the normal reaction on A is:

(1) \[ \frac{W(d-x)}{x} \]
(2) \[ \frac{W(d-x)}{d} \]
(3) \[ \frac{Wx}{d} \]
(4) \[ \frac{Wd}{x} \]

Solution: (2)

Equation for force balance
\[ N_A + N_B = W \quad \text{(i)} \]
\[ N_B = W - N_A \]
Equation for torque balance about centre of mass of rod.
\[ N_A x = N_B (d - x) \]
\[ N_A x = (W - N_A)(d - x) \]
\[ N_A x = Wd - Wx - N_A d + N_A x \]
\[ N_A d = W(d - x) \]
\[ N_A = \frac{W(d - x)}{d} \]

15. A wire carrying current I has the shape as shown in adjoining figure. Linear parts of the wire are very long and parallel to X-axis while semicircular portion of radius R is lying in Y-Z plane. Magnetic field at point O is:

\[ \vec{B} = -\frac{\mu_0 I}{4\pi R} (\pi \hat{i} + 2\hat{k}) \]

\[ \vec{B} = \frac{\mu_0 I}{4\pi R} (\pi \hat{i} - 2\hat{k}) \]

\[ \vec{B} = \frac{\mu_0 I}{4\pi R} (\pi \hat{i} + 2\hat{k}) \]

\[ \vec{B} = -\frac{\mu_0 I}{4\pi R} (\pi \hat{i} - 2\hat{k}) \]

Solution: (1)
16. A wind with speed 40 m/s blows parallel to the roof of a house. The area of the roof is 250 m². Assuming that the pressure inside the house is atmospheric pressure, the force exerted by the wind on the roof and the direction of the force will be:

(1) $2.4 \times 10^5$ N, upwards
(2) $2.4 \times 10^5$ N, downwards
(3) $4.8 \times 10^5$ N, downwards
(4) $4.8 \times 10^5$ N, upwards

Solution: (1)

By Bernoulli’s equation,

$$P + \frac{1}{2}PV^2 = P_0 + 0$$

$$P_0 - P = \frac{1}{2}PV^2$$

$$F = \frac{1}{2}PV^2A$$

$$= \frac{1}{2} \times 1.2 \times (40)^2 \times 250$$

$$= \frac{1}{2} \times 1.2 \times 1600 \times 250$$

$$= 2.4 \times 10^5$$ N, upwards

17. In a double slit experiment, the two slits are 1 mm apart and the screen is placed 1 m away. A monochromatic light of wavelength 500 nm is used. What will be the width of each slit for obtaining ten maxima of double slit within the central maxima of single slit pattern?

(1) 0.5 mm
(2) 0.02 mm
(3) 0.2 mm
(4) 0.1 mm
Solution: (3)

\[ d = 1 \text{ mm} = 1 \times 10^{-3} \text{ m} \]
\[ D = 1 \text{ m} \quad , \quad \lambda = 500 \times 10^{-9} \text{ m} \]

Width of central maximum = width of maxima

\[ \frac{\beta}{D} = \frac{\lambda D}{d} = \frac{\lambda}{d} \]

Angular width of central maxima in single slit experiment = \( \frac{2\lambda}{d'} \)

As per the question

\[ \frac{10\lambda}{d} = \frac{2\lambda}{d'} \]
\[ d' = 0.2d = 0.2\text{ mm} \]

18. A mass \( m \) moves in a circle on a smooth horizontal plane with velocity \( v_0 \) at a radius \( R_0 \). The mass is attached to a string which passes through a smooth hole in plane as shown.

18. The tension in the string is increased gradually and finally \( m \) moves in a circle of radius \( \frac{R_0}{2} \). The final value of the kinetic energy is:

(1) \( 2mv_0^2 \)
(2) \( \frac{1}{2}mv_0^2 \)
(3) \( mv_0^2 \)
(4) \( \frac{1}{4}mv_0^2 \)

Solution: (1)

From conservation of angular momentum.

\[ mv_0R_0 = mv' \left( \frac{R_0}{2} \right) \]
Hence, final KE = \( \frac{1}{2}mv'^2 = \frac{1}{2}m(2v_0)^2 \)

\[ = 2mv_0^2 \]

19. Kepler’s third law states that square of period of revolution (T) of a planet around the sun, is proportional to third power of average distance r between sun and planet i.e., \( T^2 = Kr^3 \)

here K is constant. If the masses of sun and planet are M and m respectively then as per Newton’s law of gravitation force of attraction between them is

\[ F = \frac{GMm}{r^2} \]

here G is gravitational constant

The relation between G and K is described as:

(1) \( K = G \)

(2) \( K = \frac{1}{G} \)

(3) \( GK = 4\pi^2 \)

(4) \( GMK = 4\pi^2 \)

Solution: (4)

Here gravitational force is equal to centripetal force required for motion of planet.

Hence,

\[ \frac{GMm}{r^2} = \frac{mv^2}{r} \]

\[ v^2 = \frac{GM}{r} \]

Time period is given by,

\[ T = \frac{2\pi r}{v} \]

\[ T^2 = \frac{4\pi^2r^2}{v^2} \]

\[ T^2 = \frac{4\pi^2r^3}{GM} = \frac{4\pi^2r^3}{Gm} \]

We have given,

\[ T^2 = kr^3 \]

On comparing,

\[ k = \frac{4\pi^2}{GM} \Rightarrow GMk = 4\pi^2 \]
20. Three identical spherical shells, each of mass m and radius r are placed as shown in figure. Consider an axis \(XX'\) which is touching to tow shells and passing through diameter of third shell. Moment of inertia of the system consisting of these three spherical shell about \(XX''\) axis is:

\[
(1) \frac{16}{5} mr^2 \\
(2) 4 mr^2 \\
(3) \frac{11}{5} mr^2 \\
(4) 3mr^2
\]

Solution: (2)

Total MI of the system,
\[
I = I_1 + I_2 + I_3
\]
\[
I_2 = I_3 = \frac{2}{3} mr^2 + mr^2 = \frac{5mr^2}{3}
\]
\[
I_1 = \frac{2}{3} mr^2
\]
\[
\therefore I = 2 \times \frac{5mr^2}{3} + \frac{2}{3} mr^2
\]
\[
= \frac{12mr^2}{3} = 4mr^2
\]

21. A ship A is moving Westwards with a speed of 10 km\(h^{-1}\) and a ship B 100 km south of A, is moving Northwards with a speed of 10 km\(h^{-1}\). The time after which the distance between them becomes shortest, is:

\[
(1) 5\sqrt{2} \text{ h} \\
(2) 10\sqrt{2} \text{ h} \\
(3) 0 \text{ h} \\
(4) 5 \text{ h}
\]

Solution: (4)
Relative velocity of ship B is,

\[ |\vec{V}_{BA}| = \sqrt{10^2 + 10^2} = 10\sqrt{2} \text{ kmph} \]

Let shortest distance between ship A & B is AO,

Distance OB = 100 \cos 45^\circ = 50\sqrt{2} \text{ km}

Hence time taken to reach the shortest distance,

\[ t = \frac{50\sqrt{2}}{10\sqrt{2}} = 5 \text{ hrs} \]

22. The ratio of the specific heats \( \frac{C_p}{C_v} = \gamma \) in terms of degrees of freedom (n) is given by:

(1) \( \left( 1 + \frac{2}{n} \right) \)

(2) \( \left( 1 + \frac{n}{2} \right) \)

(3) \( \left( 1 + \frac{1}{n} \right) \)

(4) \( \left( 1 + \frac{n}{3} \right) \)

Solution: (1)

\[ C_v = \frac{n}{2} R \]

\[ C_p = C_v + R = \frac{n}{2} R + R = \left( \frac{n}{2} + 1 \right) R \]

\[ r = \frac{C_p}{C_v} = \frac{\left( \frac{n}{2} + 1 \right) R}{\frac{n}{2} R} \]

\[ = \left( \frac{n}{2} + 1 \right) \frac{2}{n} \]

\[ r = 1 + \frac{2}{n} \]

23. If in a p-n junction, a square input signal of 10 V is applied as shown,
then the output across $R_L$ will be:

(1)

(2)

(3)

(4)

Solution: (2)

In the given circuit the P-N junction is acting as a half wave rectifier (as it is forward-bias) output will be +Ve

5V
24. A certain metallic surface is illuminated with monochromatic light of wavelength, \( \lambda \). The stopping potential for photo-electric current for this light is \( 3V_0 \). If the same surface is illuminated with light of wavelength \( 2\lambda \), the stopping potential is \( V_0 \). The threshold wavelength for this surface for photoelectric effect is:

(1) \( \frac{\lambda}{4} \)
(2) \( \frac{\lambda}{6} \)
(3) \( 6\lambda \)
(4) \( 4\lambda \)

Solution: (4)

\[
e V_s = E - \phi \Rightarrow V_s
\]

\[
V_s = \frac{hc}{\lambda e} - \frac{hc}{\lambda_0 e}
\]

\[
3V_0 = \frac{hc}{\lambda e} - \frac{hc}{\lambda_0 e} \quad \cdots \text{(i)}
\]

\[
V_0 = \frac{hc}{2\lambda e} - \frac{hc}{\lambda_0 e} \quad \cdots \text{(ii)}
\]

by solving (i) and (ii)

\[
0 = \frac{hc}{2\lambda e} + \frac{2hv}{\lambda_0 e}
\]

\[
\lambda_0 = 4\lambda
\]

25. A parallel plate air capacitor of capacitance \( C \) is connected to a cell of emf \( V \) and then disconnected from it. A dielectric slab of dielectric constant \( K \), which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect?

(1) The change in energy stored is \( \frac{1}{2} CV^2 \left( \frac{1}{K} - 1 \right) \)
(2) The charge on the capacitor is not conserved
(3) The potential difference between the plates decreases \( K \) times
(4) The energy stored in the capacitor decreases \( K \) times

Solution: (2)

\[
C_{i} = CK
\]

\[
\Rightarrow \quad C_{j} \quad \text{when disconnected}
\]

For air \( k = 1 \)

\[
C_{i} = C
\]

\[
q = C_{j}V \quad \cdots (i)
\]
Charge remains constant

\[ U_1 = \frac{q^2}{2c} \]

\[ U_2 = \frac{q^2}{2ck} \]

Change in Energy stored in Capacitor

\[ U = U_2 - U_1 = \frac{q^2}{2c} \left( \frac{1}{k} - 1 \right) \Rightarrow \frac{1}{2} CV^2 \left( \frac{1}{k} - 1 \right) \]

\[ V' = \frac{q}{ck} \Rightarrow V' = \frac{V}{k} \]

Here

1- Potential difference between the plates decreases by k times

2- The change in energy stored \( U \frac{1}{2} CV^2 \left( \frac{1}{k} - 1 \right) \)

3- Charge is conserved

4- The energy stored in capacitor decrease by \( K U_2 = \frac{1}{2} \frac{q^2}{2ck} \).

26. A particle of mass \( m \) is driven by a machine that delivers a constant power \( k \) watts. If the particle starts from rest the force on the particle at time \( t \) is:

(1) \( \sqrt{2mk} t^{-\frac{1}{2}} \)

(2) \( \frac{1}{2} \sqrt{mk} t^{-\frac{1}{2}} \)

(3) \( \frac{mk}{\sqrt{2}} t^{-\frac{1}{2}} \)

(4) \( \sqrt{mk} t^{-\frac{1}{2}} \)

Solution: (3)

\[ FV = \text{constant} = k \]

\[ \frac{mdv}{dt} V = k \]

\[ \int Vdv = \int \frac{k}{m} dt \]

\[ \frac{V^2}{2} = \frac{k}{m} t \]

\[ V = \sqrt{\frac{2k}{m} t} \]
\[ F = \frac{mdv}{dt} \]
\[ = m \sqrt{\frac{2k}{m} t^{-\frac{1}{2}}} \]
\[ = \sqrt{\frac{mk}{2}} t^{-\frac{1}{2}} \]

27. A Carnot engine, having an efficiency of \( \eta = \frac{1}{10} \) as heat engine, is used as refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is:

(1) 90 J  
(2) 1 J  
(3) 100 J  
(4) 99 J

Solution: (1)

For engine and refrigeration operating between two same temperature,

\[ \eta = \frac{1}{1 + \beta} \]

\[ \frac{1}{10} = \frac{1}{1 + \beta} \Rightarrow \beta = 9 \]

From the principle of refrigerator,

\[ \frac{Q_2}{W} = \beta \]

\[ \frac{Q_2}{10} = 9 \]

\[ Q_2 = 90 \text{ Joule.} \]

28. One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in the figure.

The change in internal energy of the gas during the transition is:
20 J
– 12 kJ
20 kJ
– 20 kJ

Solution: (4)

$$\Delta U = nC_v\Delta T$$

$$T = \frac{PV}{nR}$$

$$\Delta T = \frac{P_2V_2 - P_1V_1}{nR}$$

$$\Delta U = \frac{nR}{\gamma - 1} \left( \frac{P_2V_2 - P_1V_1}{nR} \right)$$

$$\Delta U = \frac{P_2V_2 - P_1V_1}{\gamma - 1}$$

$$= - \frac{8 \times 10^3}{2} = -20\text{ kJ}$$

29. A block of mass 10 kg, moving in x direction with a constant speed of 10 ms$^{-1}$, is subjected to a retarding force $F = 0.1 x$ J/m during its travel from $x = 20$ m to 30m. Its final KE will be:

(1) 275 J
(2) 250 J
(3) 475 J
(4) 450 J

Solution: (3)

$m = 10\text{ kg}, v = 10\text{ ms}^{-1}$

Final KE will be given by

$$KE_f = KE_i + \Delta W \cdot D$$

$$= \frac{1}{2}mv^2 + \int_{20}^{30} -0.1 xdx$$

$$= \frac{1}{2} \times 10 \times 100 + \left( -0.1 \right) \frac{x^2}{2} \bigg|_{20}^{30}$$

$$= 500 + \left( -0.1 \right) \frac{(900 - 400)}{2}$$
KE_f = 500 + \( \frac{(-0.1)500}{2} \)

= 475 J

30. Consider 3rd orbit of He⁺ (helium), using non-relativistic approach, the speed of electron in this orbit will be

[given \( K = 9 \times 10^9 \) constant, \( Z = 2 \) and \( h \) (Planck’s Constant) = \( 6.6 \times 10^{-34} \) Js]

(1) 0.73 \times 10^6 \text{ m/s}  
(2) 3.0 \times 10^6 \text{ m/s}  
(3) 2.92 \times 10^6 \text{ m/s}  
(4) 1.46 \times 10^6 \text{ m/s}  

Solution: (4)

Energy of electron \( \text{He}^+ \)

\[ E_3 = -13.6 \left( \frac{2}{3} \right)^2 \times 1.6 \times 10^{-19} \text{J} \]

In Bohr’s model energy \( E = -KE \)

\[ E_3 = -KE_3 \]

\[ 9.7 \times 10^{-19} = \frac{1}{2} \text{meV}^2 \]

\[ v = \sqrt{\frac{2 \times 9.7 \times 10^{-19}}{9.1 \times 10^{-31}}} \]

Velocity of electron in 3rd orbit of He⁺ is \( 1.46 \times 10^6 \text{ m/s} \)

31. A resistance ‘R’ draws power ‘P’ when connected to an AC source. If an inductance is now placed in series with the resistance, such that the impedance of the circuit becomes ‘Z’, the power drawn will be:

(1) \( P \left( \frac{R}{Z} \right) \)  
(2) \( P \)  
(3) \( P \left( \frac{R}{Z} \right)^2 \)  
(4) \( P \sqrt{\frac{R}{Z}} \)  

Solution: (3)
We know
\[ P = \frac{V^2}{R}; \quad P' = \frac{V V}{z} \cos \Phi \]
\[ V^2 = PR \cos \Phi = \frac{R}{z} \]
\[ P' = \frac{V^2 R}{z} \]
\[ \Rightarrow \frac{P' R}{z^2} R = P' \left( \frac{R^2}{z^2} \right) \]
\[ = P' \left( \frac{R^2}{z} \right) \]

32. A block A of mass \( m_1 \) rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of the table and from its other end another block B of mass \( m_2 \) is suspended. The coefficient of kinetic friction between the block and the table is \( \mu_k \). When the block A is sliding on the table, the tension in string is:

(1) \( \frac{m_1 m_2 (1+\mu_k)g}{(m_1+m_2)} \)
(2) \( \frac{m_1 m_2 (1-\mu_k)g}{(m_1+m_2)} \)
(3) \( \frac{(m_2+\mu_k m_1)g}{(m_1+m_2)} \)
(4) \( \frac{(m_2-\mu_k m_1)g}{(m_1+m_2)} \)

Solution: (1)
From the figure,

\[ m_2 g - T - m_2 a \ldots (i) \]
\[ T - \mu_k m_1 g = m_1 a \ldots (ii) \]

(i) \times m_1 \text{ and } (ii) \times m_2

\[ m_1 m_2 g - T m_1 = m_1 m_2 a \]
\[ T m_2 - \mu_k m_1 m_2 g = m_1 m_2 a \]
\[ m_1 m_2 g - T m_1 = T m_2 - \mu_k m_1 m_2 g \]
\[ m_1 m_2 g (1 + \mu_k) = T (m_1 + m_2) \]

\[ \therefore T = \frac{m_1 m_2 g (1 + \mu_k)}{m_1 + m_2} \]

33. The refracting angle of a prism is \( A \), and refractive index of the material of the prism is \( \cot \left( \frac{A}{2} \right) \). The angle of minimum deviation is :-

(1) \( 90^\circ - A \)
(2) \( 180^\circ + 2A \)
(3) \( 180^\circ - 3A \)
(4) \( 180^\circ - 2A \)

Solution: (4)

\[ \mu = \frac{\sin \left( \frac{\delta m + A}{2} \right)}{\sin \left( \frac{A}{2} \right)} \]

\[ \therefore \mu = \cot \left( \frac{A}{2} \right) \]

\[ \therefore \cot \left( \frac{A}{2} \right) = \frac{\sin \left( \frac{\delta m + A}{2} \right)}{\sin \left( \frac{A}{2} \right)} \]
\[
\cos \frac{A}{2} = \sin \left( \frac{\delta m + A}{2} \right)
\]
\[
\frac{\pi - A}{2} = \frac{\delta m + A}{2}
\]
\[
\delta m = \pi - 2A
\]

34. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. If \( T_P, T_Q \) and \( T_R \) are the respective absolute temperatures of P, Q and R, then it can be concluded from the above observations that:

(1) \( T_P < T_R < T_Q \)
(2) \( T_P < T_Q < T_R \)
(3) \( T_P > T_Q > T_R \)
(4) \( T_P > T_R > T_Q \)

Solution: (4)

From Wein’s Displacement law,

\[
\lambda \text{m}T = \text{constant} \Rightarrow \lambda \text{m} \propto \frac{1}{T}
\]

From the light spectrum,

\[
(\lambda \text{m})_P < (\lambda \text{m})_R < (\lambda \text{m})_Q
\]

Hence,

\( T_P > T_R > T_Q \)

35. A conducting square frame of side ‘a’ and a long straight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity ‘V’. The e.m.f induced in the frame will be proportional to:

![Diagram of a conducting square frame with a long straight wire](image-url)
(1) \( \frac{1}{(2x+a)^2} \)
(2) \( \frac{1}{(2x-a)(2x+a)} \)
(3) \( \frac{1}{x^2} \)
(4) \( \frac{1}{(2x-a)^2} \)

Solution: (2)

Potential difference across AB is
\[ V_A - V_B = B_1 a.V. \]
\[ \Rightarrow \frac{\mu_i}{2\pi \left( x - \frac{a}{2} \right)} aV \]

Potential difference across CD is
\[ V_C - V_D = B_2 a.V \]
\[ B_2 = \frac{\mu_0 l}{2\pi (x + \frac{a}{2})} \]
\[ V_C - V_D = \frac{\mu_0 l}{2\pi \left( x + \frac{a}{2} \right)} aV \]

Net P.d = \( \frac{\mu_i a V}{2\pi} \left( \frac{1}{x - \frac{a}{2}} - \frac{1}{x + \frac{a}{2}} \right) \)

\[ (V_A - V_B) - (V_C - V_D) = \frac{\mu_i a}{2\pi} \left( \frac{2a}{x^2 - \frac{a^2}{4}} \right) \]
\[ \propto \frac{1}{4x^2 - a^2} \propto \frac{1}{(2x + a)(2x - a)} \]

36. Two spherical bodies of mass M and 5 M and radii R and 2R released in free space with initial separation between their centres equal to 12 R. If they attract each other due to gravitational force only, then the distance covered by the smaller body before collision is:

(1) 7.5 R
(2) 1.5 R
(3) 2.5 R
(4) 4.5 R

Solution: (1)
Initial position,

\[
\begin{array}{c}
\text{M} \\
\text{R} \\
12R \\
5M \\
\text{R} \\
9R \\
2R \\
\end{array}
\]

For collision, both bodies have to travel distance \(= 12R - 3R = 9R\)
Since the bodies move under the mutual forces, centre of mass will remain stationary,

\[
m_1x_1 = m_2x_2
\]
\[
Mx = 5M(9R - x)
\]
\[
x = 45R - 5x
\]
\[
6x = 45R
\]
\[
x = \frac{45}{6}R = 7.5R
\]

37. Two similar springs P and Q have spring constants \(K_P\) and \(K_Q\), such that \(K_P > K_Q\). They are stretched, first by the same amount (case a), then by the same force (case b). The work done by the springs \(W_P\) and \(W_Q\) are related as, in case (a) and case (b), respectively:

(1) \(W_P > W_Q; W_Q > W_P\)
(2) \(W_P < W_Q; W_Q < W_P\)
(3) \(W_P = W_Q; W_P > W_Q\)
(4) \(W_P = W_Q; W_P = W_Q\)

Solution: (1)

\(K_P > K_Q\)

Case (a): Stretched by same amount

\[
W_P = \frac{1}{2}K Px^2
\]
\[
W_Q = \frac{1}{2}K Qx^2 \quad (\because x_P = x_Q = x)
\]
\[
\therefore W_P > W_Q
\]

Case (b): Stretched by same force,

\[
F = KPx_p = KQx_Q
\]
38. Two particles of masses \(m_1, m_2\) move with initial velocities \(u_1\) and \(u_2\). On collision, one of the particles get excited to higher level, after absorbing energy \(\varepsilon\). If final velocities of particles be \(v_1\) and \(v_2\) then we must have:

\[
\begin{align*}
(1) & \quad \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 \\
(2) & \quad \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 + \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 \\
(3) & \quad m_1u_1 + m_2u_2 - \varepsilon = m_1v_1 + m_2v_2 \\
(4) & \quad \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \varepsilon
\end{align*}
\]

Solution: (1)

From conservation of energy initial total energy

\[
\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2
\]

After collision total final energy

\[
\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon
\]

\[
\therefore \quad \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon
\]

39. The approximate depth of an ocean is 2700 m. The compressibility of water is \(45.4 \times 10^{-11}\) Pa\(^{-1}\) and density of water is \(10^3\) kg m\(^{-3}\). What fractional compression of water will be obtained at the bottom of the ocean?

\[
\begin{align*}
(1) & \quad 1.2 \times 10^{-2} \\
(2) & \quad 1.4 \times 10^{-2} \\
(3) & \quad 0.8 \times 10^{-2} \\
(4) & \quad 1.0 \times 10^{-2}
\end{align*}
\]

Solution: (1)
Pressure at the bottom of ocean

\[ P = \rho gd \]
\[ = 10^3 \times 10 \times 2700 \]
\[ = 27 \times 10^6 \text{Pa} \]

\[ \therefore \text{Fractional compression} = \text{compressibility} \times \text{pressure} \]
\[ = 45.4 \times 10^{-11} \text{Pa}^{-1} \times 27 \times 10^6 \text{Pa} \]
\[ = 1.2 \times 10^{-2} \]

40. Figure below shows two paths that may be taken by a gas to go from a state A to a state C.

![Diagram of two paths from A to C](image)

In process AB, 400 J of heat is added to the system and in process BC, 100 J of heat is added to the system. The heat absorbed by the system in the process AC will be:

(1) 460 J
(2) 300 J
(3) 380 J
(4) 500 J

Solution: (1)

In cyclic process ABCA,
\[ \Delta U_{\text{cyclic}} = 0 \]
\[ Q_{\text{cyclic}} = \text{Weight} \]
\[ Q_{AB} + Q_{BC} + Q_{CA} = \text{Closed loop area} \]
\[ 400 + 100 + Q_{CA} = \frac{1}{2} \times 2 \times 10^{-3} \times 4 \times 10^4 \]
\[ 500 - Q_{AC} = 40 \]
\[ Q_{AC} = 460 \text{ J} \]
41. The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe at both the ends is:

(1) 120 cm
(2) 140 cm
(3) 80 cm
(4) 100 cm

Solution: (1)

For closed organ pipe,
\[ n_c = \frac{V}{4\ell} \]

For open organ pipe,
\[ n_0 = \frac{V}{2\ell'} \]

For the second overtone of open organ pipe,
\[ n' = 3n_0 = \frac{3V}{2\ell'} \]

\[ n_c = n' \]

\[ \frac{V}{4\ell} = \frac{3V}{2\ell'} \]

\[ \ell' = 6\ell = 6 \times 20 \]

\[ \ell' = 120 \text{ cm} \]

42. When two displacements represented by \( y_1 = a \sin(\omega t) \) and \( y_2 = b \cos(\omega t) \) are superimposed the motion is:

(1) Simple harmonic with amplitude \( \sqrt{a^2 + b^2} \)
(2) Simple harmonic with amplitude \( \frac{(a+b)}{2} \)
(3) Not a simple harmonic
(4) Simple harmonic with amplitude \( \frac{a}{b} \)

Solution: (1)

\[ y_1 = a \sin \omega t \]

\[ y_2 = b \cos \omega t = b \sin \left( \omega t + \frac{\pi}{2} \right) \]

Amplitude \( A = \sqrt{a^2 + b^2 + 2ab \cos \frac{\pi}{2}} \)
\[ A = \sqrt{a^2 + b^2} \]

Since the frequency for both motions are same, then the resultant motion will be SHM.

43. If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be:

(1) \([E^{-2} V^{-2} T^{-2}]\)
(2) \([E^{-2} V^{-1} T^{-3}]\)
(3) \([E V^{-2} T^{-1}]\)
(4) \([E V^{-1} T^{-2}]\)

Solution: (1)

\[ ST = M^1 L^0 T^{-2} \]
\[ E = M^1 L^2 T^{-2} \]
\[ V = m^0 L^1 T^{-1} \]

By applying dimensional analysis,

\[ S = E^a V^b T^c \]
\[ M^1 L^0 T^{-2} = [M^1 L^2 T^{-2}]^a [M^0 L^1 T^{-1}]^b [T]^c \]
\[ M^1 L^0 T^{-2} = M^a L^{2a+b} T^{-2a-b+c} \]

On comparing,
\[ a = 1 \]
\[ 2a + b = 0 \Rightarrow b = -2 \]
\[-2a - b + c = -2 \Rightarrow c = -2 \]
\[ \therefore S = E^1 V^{-2} T^{-2} \]

44. Across a metallic conductor of non-uniform cross section a constant potential difference is applied. The quantity which remains constant along the conductor is:

(1) Drift velocity
(2) Electric field
(3) Current density
(4) Current

Solution: (4)
Correct flow across the metallic conductor remains constant because the area of cross section of conductor is non-uniform so. Current density will be different but the number of flow of electrons will be same.

45. A potentiometer wire has length 4 m and resistance 8Ω. The resistance that must be connected in series with the wire and an accumulator of e.m.f. 2V, so as to get a potential gradient 1 mV per cm on the wire is:

(1) 44 Ω
(2) 48 Ω
(3) 32 Ω
(4) 40 Ω

Solution: (3)

\[
\frac{dV}{dt} = \frac{1 mV}{cm}
\]

For a potentiometer

1 cm of wire has 1 mV of voltage

400 cm has 0.4V.

Given R must be connected in series

\[
\Delta V = 0.4 = \frac{2}{8 + R} \times 8
\]

\[
8 + R = \frac{16}{0.4} = \frac{160}{4} = 40
\]

\[
\Rightarrow R = 32 \Omega
\]
46. \[ \text{♀} \quad \text{♂} \quad \text{♀} \quad \text{♂} \quad \text{♀} \quad \text{♂} \quad \text{♀} \quad \text{♂} \quad \text{♀} \] is the floral formula of:

(1) Petunia
(2) Brassica
(3) Allium
(4) Sesbania

Solution: (1)

Given floral formula is of Solanaceae family. Petunia is a plant of Solanaceae family.

47. In Bt cotton, the Bt toxin present in plant tissue as pro-toxin is converted into active toxin due to:

(1) Action of gut micro-organisms
(2) Presence of conversion factors in insect gut
(3) Alkaline pH of the insect gut
(4) Acidic pH of the insect gut

Solution: (3) Bacillus thurigensis which contain cry protein in inactive form known as pro-toxin. When this is ingested by insect it get activated by alkaline ph of gut, which solubilize the protein crystal. This activated toxin bind to the epithelial midgut cell result into lysis of epithelial cell and eventually lead to the death of insect.

48. Match each disease with its correct type of vaccine:

<table>
<thead>
<tr>
<th>(a)</th>
<th>Tuberculosis</th>
<th>(i)</th>
<th>Harmless virus</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Whooping cough</td>
<td>(ii)</td>
<td>Inactivated toxin</td>
</tr>
<tr>
<td>(c)</td>
<td>Diphtheria</td>
<td>(iii)</td>
<td>Killed bacteria</td>
</tr>
<tr>
<td>(d)</td>
<td>Polio</td>
<td>(iv)</td>
<td>Harmless bacteria</td>
</tr>
</tbody>
</table>

(1)
Solution: (1)

Tuberculosis – Harmless bacteria – *Mycobacterium tuberculosis*

Whooping cough – Killed Bacteria - *Bordetella pertussis* bacterium

Diptheria – Inactivated Toxin – *Corynebacterium diphtheriae*

Polio – harmless virus – *Poliovirus*

49. Which of the following endoparasites of humans does show viviparity?

(1) *Trichinella spiralis*
(2) *Ascaris lumbricoides*
(3) *Ancylostoma duodenale*
(4) *Enterobius vermicularis*

Solution: (1) Viviparity means development of an embryo inside the body of mother rather than laying eggs. E.g.: *Trichinella spiralis* is an endoparasite of human body that shows viviparity whereas the remaining endoparasites lay eggs (oviparity).

50. Which body of the Government of India regulates GM research and safety of introducing GM organisms for public services?

(1) Genetic Engineering Approval Committee
(2) Research Committee on Genetic Manipulation
(3) Bio-safety committee  
(4) Indian Council of Agricultural Research

Solution: (1) Genetic Engineering Approval Committee regulates GM research and safety of introducing GM organisms for public services.

51. Which one of the following statements is wrong?  
(1) Chlorella and Spirulina and used a space food  
(2) Mannitol is stored food in Rhodophyceae  
(3) Algin and carrageen are products of algae  
(4) Agar-agar is obtained from Gelidium and Gracilaria

Solution: (2) Mannitol is the stored food in Phaeophyceae (brown algae) In RHODOPHYCEAE stored food is Floridean starch.

52. True nucleus is absent in:  
(1) Vaucheria  
(2) Volvox  
(3) Anabaena  
(4) Mucor

Solution: (3) Anabaena cells do not have any organelles so they do not have a nucleus. This is because they can perform photosynthesis in their own cell membrane.

53. The mass of living material at a trophic level at a particular time is called:  
(1) Net primary productivity  
(2) Standing crop  
(3) Gross primary productivity  
(4) Standing state

Solution: (2) Biomass is the mass of the living material present at a given time at a particular trophic level, also called as standing crop.

54. A major characteristic of the monocot root is the presence of:  
(1) Vascular without cambium  
(2) Cambium sandwiched between phloem and xylem along the radius  
(3) Open vascular bundles  
(4) Scattered vascular bundles

Solution: (1) Vascular cambia are found in dicots and gymnosperms but not in monocots because radial vascular bundle is present in monocot root in which cambium is not present.
55. A gymnast is able to balance his body upside down even in the total darkness because of:
(1) Tectorial membrane
(2) Organ of corti
(3) Cochlea
(4) Vestibular apparatus

Solution: (4) The vestibular system is the sensory system that provides the sense of balance and spatial orientation for the purpose of coordinating movement with balance.

56. In ginger vegetative propagation occurs through:
(1) Bulbils
(2) Runners
(3) Rhizome
(4) Offsets

Solution: (3) In Ginger vegetative propagation occurs through rhizome. Rhizome which is a modified subterranean stem of the plant that is usually found underground. The rhizome retains the ability to allow new shoots to grow upwards. The plant uses rhizome to store starch & protein. If Rhizome is separated into pieces each piece may be able to give rise to a new plant. This is called as vegetative propagation.

57. In a ring girdled plant:
(1) The shoot and root die together
(2) Neither root nor shoot will die
(3) The shoot dies first
(4) The root dies first

Solution: (4) In a ring girdled plant the root dies first. Like all vascular plants, trees use two vascular tissues for transportation of water and nutrients: the xylem (also known as the wood), and the phloem (the innermost layer of the bark). Girdling results in the removal of the phloem, and death occurs from the inability of the leaves to transport sugars (primarily sucrose) to the roots.

58. Vertical distribution of different species occupying different levels in a biotic community is known as:
(1) Zonation
(2) Pyramid
(3) Divergence
(4) Stratification

Solution: (4) By the definition of stratification, it is the distribution of a community in different levels by various socioeconomic means.

59. Secondary Succession takes place on/in:
60. Which of the following cells during gametogenesis is normally diploid?
(1) Spermatogonia
(2) Secondary polar body
(3) Primary polar body
(4) Spermatid

Solution: (1) Spermatogonia or the sperm mother cell is diploid while all other cells are formed in later steps of spermatogenesis during mitotic cell division.

61. An abnormal human baby with ‘XXX’ sex chromosomes was born due to:
(1) Fusion of two ova and one sperm
(2) Fusion of two sperms and ovum
(3) Formation of abnormal sperms in the father
(4) Formation of abnormal ova in the mother

Solution: (4) Formation of abnormal ova i.e., 22 + XX in the mother will lead to birth of baby with ‘XXX’ genotype, due to chromosomal non disjunction in ova. Nondisjunction is the failure of the chromosomes to disjoin and move to opposite poles.

62. Which of the following are the important floral rewards to the animal pollinators?
(1) Floral fragrance and calcium crystals
(2) Protein pellicle and stigmatic exudates
(3) Colour and large size of flower
(4) Nectar and pollen grains

Solution: (4) The important floral rewards to the animal pollinators are nectar & pollen grain. Plants attract pollinators to their flowers by advertising their floral rewards i.e. nectar & pollen grain. They take the advantage of the fact that the animals can see, smell & taste by evolving different flower sizes, shapes, colors and scents to selectively attract pollinators.

63. Gastric juice of infants contains:
(1) Pepsinogen, lipase, rennin
(2) Amylase, rennin, pepsinogen
(3) Maltase, pepsinogen, rennin
(4) Nuclease, pepsinogen, lipase
Solution: (1) Gastric acid is a digestive fluid, formed in the stomach. In infants, it primarily has the ability to digest milk protein by enzyme rennin, along with small amounts of pepsinogen & lipase.

64. The active form of *Entamoeba histolytica* feeds upon:
(1) Food in intestine
(2) Blood only
(3) Erythrocytes mucosa and submucosa of colon
(4) Mucosa and submucosa of colon only

Solution: (3)
The active form of Entamoeba Histolytica feeds upon erythrocytes, mucosa and submucosa of colon as it causes damage by lysis of epithelial cells, neutrophils and also red blood cells.

65. DNA is not present in:
(1) Nucleus
(2) Mitochondria
(3) Chloroplast
(4) Ribosomes

Solution: (4) The ribosome is a cellular machine which is highly complex and is made up of dozens of distinct protein as well as a few specialized RNA molecules known as ribosomal RNA (rRNA) and does not contain DNA.

66. Most animals are tree dwellers in a:
(1) Temperate deciduous forest
(2) Tropical rain forest
(3) Coniferous forest
(4) Thorn woodland

Solution: (2) Most animals are tree dwellers in tropical rain forests because rainforests have a canopy which is the layer of branches and leaves formed by closely spaced rainforest trees and most of the tree dwellers live in the canopy.

67. Minerals known to be required in large amounts for plant growth include:
(1) Potassium, phosphorus, selenium, boron
(2) Magnesium, Sulphur, iron, zinc
(3) Phosphorus, potassium, Sulphur, calcium
(4) Calcium, magnesium, manganese, copper

Solution: (3) Major/macronutrients/macronutrients/meganutrients are required in large amounts which include: C, H, O, N, P, K, Ca, S, Mg and Fe.

68. Erythropoiesis starts in:
(1) Spleen
(2) Red bone marrow
(3) Kidney
(4) Liver
Solution: (2) Erythropoiesis starts in liver and spleen in a foetus whereas in adults it starts in the red bone marrow. As we cannot opt for two options (spleen and liver) simultaneously which are for foetus, therefore the answer is red bone marrow.

69. Which one of the following statements is incorrect?
(1) The competitive inhibitor does not affect the rate of breakdown of the enzyme-substrate complex.
(2) The presence of the competitive inhibitor decreases the Km of the enzyme for the substrate.
(3) A competitive inhibitor reacts reversibly with the enzyme to form an enzyme-inhibitor complex.
(4) In competitive inhibition, the inhibitor molecule is not chemically changed by the enzyme.

Solution: (4)
Competitive inhibition is a form of enzyme inhibition where binding of the inhibitor to the active site on the enzyme prevents binding of the substrate and vice versa. Presence of competitive inhibitor, increase the Km constant of enzyme (and not decrease) while does not affects the Vmax as the competitive inhibitor binds at active site, so decrease the affinity of enzyme for its substrate, so Km constant increase. If substrate concentration is increased, inhibition over comes and attains normal Vmax.

70. Capacitation refers to changes in the:
(1) Ovum after fertilization
(2) Sperm after fertilization
(3) Sperm before fertilization
(4) Ovum before fertilization

Solution: (3) Sperm capacitation refers to the physiological changes spermatozoa must undergo in order to have the ability to penetrate and fertilize an egg. The changes take place via the sperm cell membrane in which it may be that receptors are made available through the removal of a glycoprotein layer. The area of the acrosomal cap is also so altered thereby that the acrosome reaction becomes possible.

71. The guts of cow and buffalo possess:
(1) Methanogens
Solution: (1) The Bovine rumen is a niche that has a narrow pH range and is kept fairly stabilized, so that the bacteria in the rumen as well as the intake sacs for food and water are not too disturbed. The organisms responsible for producing methane through bovine rumen are termed methanogens and do so in order to reduce the amount of carbon in the rumen system for fermentation. There are two major divisions within the methanogens found in the bovine rumen. The Methanobrevibacter ruminantium and the Methanosphaera stadtmanae.

72. Perigynous flowers are found in:
   (1) China rose
   (2) Rose
   (3) Guava
   (4) Cucumber

Solution: (2) Perigynous flower means thalamus is either disc/cup/flasked shaped. Thalamus of rose is cup shaped, ovary lies in the centre of thalamus, all the whorls arise from periphery and remain at the same level. Flowers of guava and cucumber are epigynous (i.e. gynoecium is completely inserted within thalamus).

73. Gene regulation governing lactose operon of *E.coli* that involves the lac I gene product is:
   (1) Negative and repressible because repressor protein prevents transcription
   (2) Feedback inhibition because excess of β-galactosidase can switch off transcription
   (3) Positive and inducible because it can be induced by lactose
   (4) Negative and inducible because repressor protein prevents transcription

Solution: (4)
In negative regulation, a repressor molecule binds to the operator of an operon and terminates transcription. The lac operon is a negatively controlled inducible operon, where the inducer molecule is allolactose.

74. Which of the following represents the correct combination without any exception?
   (1) Characteristics
      Sucking and circular mouth; jaws absent, integument without scales; paired appendages
      Class
      Cyclostomata

   (2) Characteristics
      Body covered with feathers; skin moist and glandular; fore – limbs form wings; lungs with air sacs
      Class
      Aves
### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammary gland; hair on body; pinnae; two pairs of limbs</td>
<td>Mammalia</td>
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</tbody>
</table>

### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth ventral; gills without operculum; skin with placoid scales; persistent notochord</td>
<td>Chondrichthyes</td>
</tr>
</tbody>
</table>

**Solution:**

(4) Mammalia: pinnae absent in whales.

Cyclostomata: paired appendages absent in Agnatha.

Aves: Almost all the aves show presence of nonglandular skin.

75. Alleles are:

1. Different molecular forms of a gene
2. Heterozygotes
3. Different phenotype
4. True breeding homozygotes

**Solution:**

(1) An allele or an allelomorph is one of a number of alternative forms of the same gene or same genetic locus.

76. Cytochromes are found in:

1. Cristae of mitochondria
2. Lysosomes
3. Matrix of mitochondria
4. Outer wall of mitochondria

**Solution:**

(1) Cytochromes are the Iron containing electron acceptors, which are present on inner mitochondrial membrane, called cristae, helpful in ETS.

77. Which one of the following matches is correct?

1. Mucor – Reproduction by Conjugation – Ascomycetes
2. Agaricus – Parasitic fungus – Basidiomycetes
3. Phytophthora - Aseptate mycelium – Basidiomycetes
4. Alternaria – Sexual reproduction absent – Deuteromycetes

**Solution:**

(4) As Alternaria belongs to Class Deuteromycetes and have asexual reproduction by conidia, thus sexual reproduction absent.
78. The following graph depicts changes in two populations (A and B) of herbivores in a grassy field. A possible reason for these changes is that.

- Population A produced more offspring than population B
- Population A consumed the members of population B
- Both plant populations in this habitat decreased
- Population B composed more successfully for food than population A

Solution: (4) Population B competed more successfully for food than population A and hence due to this success was able to increase the number of its offsprings.

79. The UN Conference of Parties on climate change in the year 2011 was held in:

- Peru
- Qatar
- Poland
- South Africa

Solution: (4) UN conference of parties on climate change (2011) was held at Durban South Africa.

80. When you hold your breath, which of the following gas changes in blood would first lead to the urge to breathe?

- Falling CO₂ concentration
- Rising CO₂ and falling O₂ concentration
- Falling O₂ concentration
- Rising CO₂ concentration

Solution: (4)

Rise in CO₂ concentration stimulates chemoreceptors present in aorta and carotid artery which stimulates respiratory centre. Respiratory centre is not directly sensitive to oxygen concentration & hence desire to breath is induced by rise in CO₂ concentration of blood.

81. Which of the following statements is not correct?

- Oxyntic cells are present in the mucosa of stomach and secrete HCL
- Acini are present in the pancreas and secrete carboxypeptidase
- Brunner’s glands are present in the submucosa of stomach and secrete pepsinogen
- Goblet cells are present in the mucosa of intestine and secrete mucus

Solution: (3)
Brunner's glands (or duodenal glands) are compound tubular submucosal glands found in that portion of the duodenum which is above the hepatopancreatic sphincter (Sphincter of Oddi). The main function of these glands is to produce a mucus-rich alkaline secretion (containing bicarbonate), which is the non-enzymatic part of intestinal juice.

82. A chemical signal that has both endocrine and neural roles is:
(1) Epinephrine
(2) Cortisol
(3) Melatonin
(4) Calcitonin

Solution: (1) Epinephrine (also known as adrenaline) is a hormone and a neurotransmitter.

83. Which one of the following is correct?
(1) Lymph = Plasma + RBC + WBC
(2) Blood = Plasma + RBC + WBC + Platelets
(3) Plasma = Blood – Lymphocytes
(4) Serum = Blood + Fibrinogen

Solution: (2) Blood is a liquid connective tissue which contains plasma, RBCs, WBCs & Platelet. In animals it delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells.

84. Sliding filament theory can be best explained as:
(1) Actin and Myosin filaments do not shorten but rather slide pass each other
(2) When myofilaments slide pass each other, Myosin filaments shorten while Actin filaments do not shorten
(3) When myofilaments slide pass each other Actin filaments shorten while Myosin filament do not shorten
(4) Actin and Myosin filaments shorten and slide pass each other

Solution: (1) In the sliding filament model, the thick and thin filaments past each other, shortening the sarcomere, i.e., actin & myosin filaments do not shorten, rather actin filaments slide over myosin filaments.

85. In which of the following both pairs have correct combination?

(1) In situ conservation: Seed Bank
   Ex situ conservation: National Park
(2) In situ conservation: Tissue culture
   Ex situ conservation: Sacred groves
(3) In situ conservation: National Park
   Ex situ conservation: Botanical Garden
(4) In situ conservation: Cryopreservation
**Ex situ conservation: Wildlife Sanctuary**

Solution: (3) In situ conservation is the conservation of resources in its natural populations. Ex situ conservation is the conservation of resources outside its habitat maybe wild area or within human care. Best example is of botanical gardens.

86. Transpiration and root pressure cause water to rise in plants by:
   (1) Pushing it upward
   (2) Pushing and pulling it, respectively
   (3) Pulling it upward
   (4) Pulling and pushing it, respectively

Solution: (4)
In transpiration water rises in plant due to strong cohesive force of transpiration pull in which water is pulled (absorbed) from soil to roots, roots to stem, stem to xylem of leaf and lastly xylem to vein of leaf which is then evaporated.

Whereas, root pressure causes passive absorption of water resulting in rise of water in plants i.e. it creates tension in xylem elements which is transmitted downwards up to the root hair, as a result roots are subjected to tension and suction is set up in xylem; hence water is pulled inside the roots.

87. Which of the following animals is not viviparous?
   (1) Platypus
   (2) Whale
   (3) Flying Fox (Bat)
   (4) Elephant

Solution: (1) Platypus is an oviparous mammal i.e. it lays eggs whereas the remaining are viviparous.

88. A technique of micropropagation is
   (1) Protoplast fusion
   (2) Embryo rescue
   (3) Somatic hybridization
   (4) Somatic Embryogenesis

Solution: (4) Micropropagation or PTC (Plant tissue culture) is a technique of producing thousands of plantlets from explant in aseptic environment, it can be performed by callus culture or somatic embryogenesis.

89. Nuclear envelope is a derivative of:
   (1) Microtubules
   (2) Rough endoplasmic reticulum
   (3) Smooth endoplasmic reticulum
   (4) Membrane of Golgi complex

Solution: (2) Rough endoplasmic reticulum form the nuclear envelop during karyokinesis. The nuclear membrane (outer) is contiguous with the endoplasmic reticulum.
90. Blood pressure in the mammalian aorta is maximum during:
(1) Systole of the left ventricle
(2) Diastole of the right atrium
(3) Systole of the left atrium
(4) Diastole of the right ventricle

Solution: (1) Left ventricular systole drives blood through the aortic valve (AoV) to the body and organs excluding the lungs. Hence B.P. in Aorta will be maximum when left ventricle pumps the stroke volume into its lumen during its systole.

91. Hysterectomy is surgical removal of
(1) Vas-deference
(2) Mammary glands
(3) Uterus
(4) Prostate gland

Solution: (3) Hystero is the term used for uterus. Hysterectomy is the surgical removal of the uterus. It may also involve removal of the cervix, ovaries, fallopian tubes and other surrounding structures.

92. Which of these is not an important component of initiation of parturition in humans?
(1) Release of oxytocin
(2) Release of prolactin
(3) Increase in estrogen and progesterone ratio
(4) Synthesis of prostaglandins

Solution: (2) Prolactin has no role in parturition, it helps in lactation process, (lactogenic hormone), development of mammary glands (mammotropin) & maintenance of corpus luteum (leutotropin).

93. A population will not exist in Hardy-Weinberg equilibrium if:
(1) There is no migration
(2) The population is large
(3) Individuals mate selectively
(4) There are no mutation

Solution: (3) A population will not exist in Hardy-Weinberg equilibrium if the individuals mate selectively as the mating has to be random and influences like mutation, natural selection and genetic drift affect the equilibrium.

94. Glenoid cavity articulates:
(1) Clavicle with scapula
(2) Humerus with scapula
(3) Clavicle with acromion
(4) Scapula with acromion
Solution: (2) The glenoid cavity (or glenoid fossa of scapula) is a part of the shoulder, located on the lateral angle of the scapula. It is directed laterally and forward and articulates with the head of the humerus.

95. The movement of a gene from one linkage group to another is called:
(1) Translocation
(2) Crossing over
(3) Inversion
(4) Duplication

Solution: (1) A set of genes at different loci on the same chromosome tend to act as a single pair of genes in meiosis instead of undergoing independent assortment. Chromosome translocation is a chromosome abnormality caused by rearrangement of parts between non-homologous chromosomes. Hence in translocation there is movement of gene from one linkage group to another and lead to change the position of gene.

96. The structures that are formed by stacking of organized flattened membranous sacs in the chloroplasts are:
(1) Stroma lamellae
(2) Stroma
(3) Cristae
(4) Grana

Solution: (4) Cristae found in mitochondria.

Stroma lamellae, they are thylakoids that cross the stroma of a chloroplast, interconnecting the grana.

Stroma is the matrix of a chloroplast.

97. Which one of the following may require pollinators, but is genetically similar to autogamy?
(1) Apogamy
(2) Cleistogamy
(3) Geitonogamy
(4) Xenogamy

Solution: (3) Geitonogamy is functionally cross-pollination involving a pollinating agent, genetically it is similar to autogamy since the pollen grains come from the same plant.

98. Which of the following is not a sexually transmitted disease?
(1) Trichomobiasis
(2) Encephalitis
(3) Syphilis
(4) Acquired Immuno Deficiency Syndrome (AIDS)

Solution: (2) Encephalitis is an acute inflammation (swelling up) of the brain resulting either from a viral infection or when the body's own immune system mistakenly attacks brain tissue. The most common cause is a viral infection.
99. Typical growth curve in plants is:
(1) Stair-steps shaped
(2) Parabolic
(3) Sigmoid
(4) Linear

Solution: (3) Growth pattern of cell, organisms is uniform under favorable conditions & a typical growth curve in plants is sigmoidal. Thus following phases of growth are recognized.

(i) **Lag phase:** In lag period the growth is slow. It represents formative or cell division phase.

(ii) **Log phase:** Also called as exponential phase. During this phase growth is maximum & most rapid. It represents cell elongation phase.

(iii) **Steady or stationary phase:** It represents cell maturation phase.

Time taken in growth phases (mainly log phase) is called as grand period of growth.

100. What causes a green plant exposed to the light on only one side, to bend toward the source of light as it grows?
(1) Light stimulates plant cells on the lighted side to grow faster.
(2) Auxin accumulates on the shaded side, stimulating greater cell elongation there.
(3) Green plants need light to perform photosynthesis.
(4) Green plants seek light because they are phototropic.

Solution: (2) Auxins accumulates on the shaded side, stimulating grater cell elongation there. Since auxins move from morphological apex to morphological base therefore gets accumulated on the shaded side. Thus plants exposed to the light on only one side bends towards the source of light. It is also due to the tropic movement of auxins which causes phototropism and geotropism in plants.
101. Which of the following enhances or induces fusion of protoplasts?
(1) IAA and kinetin
(2) IAA and Gibberellins
(3) Sodium chloride and potassium chloride
(4) Polyethylene glycol and sodium nitrate

Solution: (4) The high molecular weight polymer (1000-6000) of PEG acts as a molecular bridges connecting the protoplasts. Calcium ions linked the negatively charged PEG and membrane surface. When PEG elute, the surface potential are disturbed, leading to intramembrane contact and subsequent fusion due to the strong affinity of PEG for water which may cause local dehydration of the membrane and increase fluidity, thus inducing fusion.

102. Select the correct matching in the following pairs:
(1) Rough ER – Synthesis of glycogen
(2) Rough ER – Oxidation of fatty acids
(3) Smooth ER - Oxidation of phospholipids
(4) Smooth ER - Synthesis of lipids

Solution: (4) Synthesis of lipids is the main function of smooth ER, besides this smooth ER also engaged in synthesis of glycogen and steroids. Rough ER is responsible for protein synthesis. Oxidation of fatty acids takes place in microbodies (Glyoxysomes).

103. Which is the most common mechanism of genetic variation in the population of sexually-reproducing organism?
(1) Genetic Drift
(2) Recombination
(3) Transduction
(4) Chromosomal aberrations

Solution: (2) The most common mechanism of genetic variation is recombination. In sexually reproducing organism during gametogenesis, the homologus chromosomes exchanges genetic material by process of crossing over. This produces new combination. It is responsible for variation.

104. In which of the following gametophyte is not independent free living?
(1) Pteris
(2) Pinus
(3) Funaria
(4) Marchantia

Solution: (2) In plants (gymnosperms and angiosperms), gametophytes is dependent and develop into multicellular organisms while still enclosed within the sporangium while in bryophytes (mosses, liverworts, and hornworts), the gametophyte free living (photosynthetic) e.g. Funaria, Marchantia In ferns, gametophytes are photosynthetic free living organism called a prothallus (Pteris).

105. Which one of the following statements is not true?
(1) The flowers pollinated by files and bats secrete foul odour to attract them
(2) Honey is made by bees by digesting pollen collected from flowers
(3) Pollen grains are rich in nutrients, and they are used in the form of tablets and syrups
(4) Pollen grains of some plants cause severe allergies and bronchial afflictions in some people

Solution: (2) Honey is made by bees by digesting the nectar collected from flowers.

106. The chromosomes in which centromere is situated close to one end are:
(1) Telocentric
(2) Sub-metacentric
(3) Metacentric
(4) Acrocentric

Solution: (4) Metacentric chromosomes has centromere in the middle position.

Telocentric chromosomes has centromere at the terminal position.

Submetacentric chromosomes has centromere near the centre but not in the middle.

107. Read the following five statements (A to E) and select the option with all correct statements:
(A) Mosses and Lichens are the first organisms to colonize a bare rock.
(B) Selaginella is a homosporous pteridophyte.
(C) Coraloid roots in Cycas have VAM.
(D) Main plant body in bryophytes is gametophytic, whereas in pteridophytes it is sporophytic.

In gymnosperms, male and female gametophytes are present with in sporangia located on sporophytes.

(1) (A), (D) and (E)
(2) (B), (C) and (E)
Solution: (1) Mosses are found in moist, shady places, moist rocks, and damp walls or on tree trunks as well as lichens grow on rock surfaces & named by Theophrastus are the first organisms to colonize bare rock.

Main plant body in bryophytes is gametophyte because gametophyte is dominant over sporophyte as gametophyte is branched, haploid, long lived and independent whereas sporophyte is diploid short lived and dependent upon gametophyte. Main plant body in pteridophyte is sporophyte.

108. Which one of the following is not an inclusion body found in prokaryotes?

1. Glycogen Granule
2. Polysome
3. Phosphate Granule
4. Cyanophycean Granule

Solution: (2) Polysomes are the cell organelle found in cytoplasm in a free floating form.

109. Which one gives the most valid and recent explanation for stomatal movements?

1. Starch hydrolysis
2. Guard cell photosynthesis
3. Transpiration
4. Potassium influx and efflux

Solution: (4) The most recent & valid explanation of stomatal movements is given by potassium influx & efflux/potassium ion pump theory which is also as the modern theory. The theory was given by Levitt in 1974. This theory states that the accumulation K+ ions leads to opening of stomata during the day while the reverse situation prevails during dark when the stomata is closed.

110. The terga, sterna and pleura of cockroach body are joined by:

1. Arthrodial membrane
2. Cartilage
3. Cementing glue
4. Muscular tissue

Solution: (1) Tough flexible cuticle between the sclerotized parts (skeletal elements) that allows relative movement is called as arthrodial membrane. The terga, sterna and pleura are chitinous plates which covers cockroach body. These three are linked together by thin arthrodial membrane.

111. Which of the following had the smallest brain capacity?

1. Homo neanderthalensis
2. Homo habilis
3. Homo erectus
4. Homo sapiens
Solution: (2) *Homo habilis* (Handy man) is considered to be the first human which evolved from Australopithecus its cranial capacity was smallest (650 – 800cc) among humans.

112. Vascular bundles in monocotyledons are considered closed because:
   (1) There are no vessels with perforations
   (2) Xylem is surrounded all around by phloem
   (3) A bundle sheath surrounds each bundle
   (4) Cambium is absent

Solution: (4) The vascular bundles of monocotyledonous plants do not contain a layer of meristematic tissue (cambium) as the dicots do. Thus no new cells can be formed inside the vascular bundles of monocots and their vascular bundles are termed closed whereas those of dicot plants are open.

113. A somatic cell that has just completed the S phase of its cell cycle, as compared to gamete of the same species, has:
   (1) Twice the number of chromosomes and four times the amount of DNA
   (2) Four times the number of chromosomes and twice the amount of DNA
   (3) Twice the number of chromosomes and twice the amount of DNA
   (4) Same number of chromosomes but twice the amount of DNA

Solution: (1) S-phase (synthesis phase) is the part of the cell cycle in which DNA is replicated, but number of chromosome does not change.
If a cell is diploid then after S phase DNA content in cell will be 4 C and Chromosome in cell will be 2 N.
While in gamete,
DNA content in gamete = C
Chromosome in gamete = N
Hence, Number of chromosome in somatic cell will be twice than gamete while DNA content will be four times.

114. Cryopreservation of gametes of threatened species in viable and fertile condition can be referred to as:
   (1) in situ conservation by sacred groves
   (2) in situ cryo-conservation of biodiversity
   (3) in situ conservation of biodiversity
   (4) Advanced ex-situ conservation of biodiversity

Solution: (4) Cryopreservation of gametes of threatened species in viable and fertile condition can be referred to as advanced ex-situ conservation of biodiversity because these gametes are stored in liquid nitrogen at a temperature of about -196°C.

115. The hilum is a scar on the:
   (1) Fruit, where style was present
   (2) Seed, where micropyle was present
(3) Seed, where funicle was attached
(4) Fruit, where it was attached to pedicel

Solution: (3) Hilum is a scar on the surface of a seed marking its point of attachment to the seed stalk (funicle)

116. In sea urchin DNA, which is double stranded, 17% of the bases were shown to be cytosine. The percentages of the other three bases expected to be present in this DNA are
(1) G 17%, A 33%, T 33%
(2) G 8.5%, A 50%, T 24.5%
(3) G 34%, A 24.5%, T 24.5%
(4) G 17%, A 16.5%, T 32.5%

Solution: (1) According to Chargaff’s rule,
A = T, G = C
C = 17% So G = 17%

A+G / T+C =1

A + G + C + T = 100
A + 17 + 17 + T = 100
A + T = 100 – 34
So A = 33%, T = 33% = 66

117. Multiple alleles are present:
(1) At the same locus of the chromosomes
(2) On non-sister chromatids
(3) On different chromosomes
(4) At different loci on the same chromosome

Solution: (1) Multiple alleles is a type of non-Mendelian inheritance pattern that involves more than just the typical two alleles that usually code for a certain characteristic in a species.

118. A man with blood group ‘A’ marries a woman with blood group ‘B’. What are all the possible blood groups of their offsprings :
(1) A, B, AB and O
(2) O only
(3) A and B only
(4) A, B, and AB only

Solution: (1)
119. HIV that causes AIDS, first starts destroying:
   (1) Helper T-Lymphocytes
   (2) Thrombocytes
   (3) B-Lymphocytes
   (4) Leucocytes

Solution: (1) HIV that causes AIDS, first starts destroying helper T-lymphocytes which are also called CD4 positive lymphocytes because HIV uses the protein CD4, present on the surface of the cell, to attach itself and pry its way into the cell.

120. Transmission tissue is characteristic feature of:
   (1) Dry stigma
   (2) Wet stigma
   (3) Hollow style
   (4) Solid style

Solution: (4) Transmission tissue is characteristic feature of solid style. They are located in centre of style and cytoplasm of these cells are rich in organelles. It is essential for pollen tube growth, because of the nutrients and guidance. It also regulates GSI (Gametophytic self – Incompatibility) in style.

121. In an ecosystem the rate of production of organic matter during photosynthesis is termed as:
   (1) Secondary productivity
   (2) Net productivity
   (3) Net primary productivity
   (4) Gross primary productivity

Solution: (4) Gross primary productivity is amount of organic matter produced at given length of time during photosynthesis.

122. Which of the following viruses is not transferred through semen of an infected male?
   (1) Chikungunya virus
   (2) Ebola virus
   (3) Hepatitis B virus
   (4) Human immunodeficiency virus
123. Which of the following characteristics is mainly responsible for diversification of insects on land?
(1) Exoskeleton
(2) Eyes
(3) Segmentation
(4) Bilateral symmetry

Solution: (1) Exoskeleton plays a role in defence from the prey and is also an important characteristic in diversification of many species. E.g.: Insects having chitin as the form of exoskeleton.

124. Keel is the characteristic feature of flower of:
(1) Aloe
(2) Tomato
(3) Tulip
(4) Indigofera

Solution: (4) As Indigofera belongs to Family Fabaceae. This family was earlier called Papilionoideae, a sub-family of family Leguminosae. Keel is a characteristic of Family Fabaceae (enclosing stamens and pistil)

125. How many pairs of contrasting characters in pea plants were studied by Mendel in his experiments?
(1) Eight
(2) Seven
(3) Five
(4) Six

Solution: (2) Mendel had studied 7 pairs of contrasting characters in pea plants in his experiments which are stem height, seed colour, seed shape, pod colour, pod shape, flower position & flower colour.

126. Which of the following does not favour the formation of large quantities of dilute urine?
(1) Renin
(2) Atrial – natriuretic factor
(3) Alcohol
(4) Caffeine

Solution: (1) Renin does not favor for the formation of large quantities of dilute urine as it activates RAAS (Renin angiotensin activating system) so it causes reabsorption of sodium which leads to formation of concentrated urine.

127. Which of the following regions of the brain is incorrectly paired with its function?
(1) Cerebrum – calculation and contemplation
(2) Cerebrum – calculation and contemplation
(3) Medulla oblongata – homeostatic control
(4) Cerebellum – language comprehension

Solution: (4) The cerebellum is involved in the coordination of voluntary motor movement, balance and equilibrium and not language comprehension. It is located just above the brain stem and toward the back of the brain.

128. Which of the following is not one of the prime health risks associated with greater UV radiation through the atmosphere due to depletion of stratospheric ozone?
   (1) Damage to eyes
   (2) Increased liver cancer
   (3) Increased skin cancer
   (4) Reduced Immune System

Solution: (2)

Due to the depletion of stratospheric ozone there are a few prime health risks associated with the greater UV radiation through the atmosphere and they are increased risks of skin cancer, reduced immune system and damage to eyes.

129. The crops engineered for glyphosate are resistant/tolerant to:
   (1) Insects
   (2) Herbicides
   (3) Fungi
   (4) Bacteria

Solution: (2) Glyphosate (N-(phosphonomethyl) glycine) is a broad-spectrum systemic herbicide used to kill weeds. Herbicide tolerant crops are designed to tolerate specific broad-spectrum herbicides, which kill the surrounding weeds, but leave the cultivated crop intact.

130. Removal of proximal convoluted tubule from the nephron will result in:
   (1) No change in quality and quantity of urine
   (2) No urine formation
   (3) More diluted urine
   (4) More concentrated urine

Solution: (3) The question is wrongly framed in concept. Hence no appropriate answer which is absolutely correct, can be found.
Still the least incorrect answer can be (1) because maximum reabsorption of filtrate (70%) occurs from P.C.T.
Hence removal of PCT will increase the urine volume.

131. High value of BOD (Biochemical Oxygen Demand) indicates that:
   (1) Water is less polluted
   (2) Consumption of organic matter in the water is higher by the microbes
(3) Water is pure
(4) Water is highly polluted

Solution: (4) High value of BOD (Biological Oxygen Demand) indicates that water is highly polluted because there is a high concentration of organic matter which is consequently also increase the number of organisms.

132. Select the correct option:

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<tbody>
<tr>
<td>(a)</td>
<td>Synapsis aligns homologous chromosomes</td>
<td>(i) Anaphase – II</td>
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<tr>
<td>(b)</td>
<td>Synthesis of RNA and protein</td>
<td>(ii) Zygotene</td>
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<td>(c)</td>
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<td>(iii) $G_2$ – phase</td>
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<tr>
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<td></td>
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<td>(v) Pachytene</td>
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</tbody>
</table>

Solution: (4) Synapsis of homologous chromosome – Zygotene
Synthesis of RNA & protein – $G_2$ phase
Action of enzyme recombinase – Pachytene
Centromeres do not separate but chromatids move towards opposite pole – Anaphase-I
133. Leaves become modified into spines in:
(1) Onion
(2) Silk Cotton
(3) Opuntia
(4) Pea

Solution: (3) *Opuntia* leaves get modified into spikes to protect them from grazing animals, also reduce area of transpiration.

Pea leaves are modified into tendrils.

Onion leaves become fleshy since food is stored in it.

Silk cotton get modified from unifoliate leaves to multifoliate leaves.

134. Rachel Carson's famous book "Silent Spring" is related to:
(1) Population explosion
(2) Ecosystem management
(3) Pesticide pollution
(4) Noise pollution

Solution: (3) Rachel Carson's book "Silent Spring" is related to pesticide pollution which documented the detrimental effects on the environment particularly on birds by the indiscriminate use of pesticides. Carson accused the chemical industry of spreading disinformation and public officials of accepting industry claims unquestioningly.

135. Male gametes are flagellated in:
(1) *Ectocarpus*
(2) *Spirogyra*
(3) *Polysiphonia*
(4) *Anabaena*

Solution: (1) Ectocarpus gametes and spores are characterized by two flagella. Male and female gametes are morphologically identical in Ectocarpus but differ with respect to their physiology and their behavior. Female gametes settle sooner and produce a pheromone whilst male gametes swim for longer and are attracted to the pheromone produced by the female.
Chemistry

136. Which of the following pairs of ion are isoelectronic and isostructural?
(1) SO$_{3}^{2-}$, NO$_{3}^{-}$
(2) ClO$_{3}^{-}$, SO$_{3}^{2-}$
(3) CO$_{3}^{2-}$, SO$_{3}^{2-}$
(4) ClO$_{3}^{-}$, CO$_{3}^{2-}$

Solution: (2) Isoelectronic (same no of electrons)
ClO$_{3}^{-}$ & SO$_{3}^{2-}$ ⇒ 17 + 24 + 1 = 42
and 16 + 24 + 2 = 42
Isostructural (same type of hybridization)
ClO$_{3}^{-}$ ⇒ H = $\frac{1}{2}(7 + 1) = 4$ (sp$^{3}$)
SO$_{3}^{2-}$ ⇒ H = $\frac{1}{2}(6 + 2) = 4$ (sp$^{3}$)

137. The reaction

\[
\text{CH}_3\text{C-ONa} + \text{CH}_3\text{CH}_2\text{Cl} \rightarrow \text{CH}_3\text{C-O-CH}_2\text{CH}_3 + \text{NaCl}
\]

is called:
(1) Etard reaction
(2) Gatterman-Koch reaction
(3) Williamson synthesis
(4) Williamson continuous etherification process

Solution: (3) It is called Williamson’s synthesis for ether formation.

138. The boiling point of 0.2 mol kg$^{-1}$ solution of X in water is greater than equimolal solution of Y in water. Which one of the following statements is true in this case?
(1) Molecular mass of X is less than the molecular mass of Y.
(2) Y is undergoing dissociation in water while X undergoes no change
(3) X is undergoing dissociation in water
(4) Molecular mass of X is greater than the molecular mass of Y.

Solution: (3) \[ \Delta T_b = \ln K_b \cdot m \]

\[ K_b \text{ and } m \text{ are constant for solutions of X and Y. } \Delta T_b \text{ is greater for solution of X implies i(van’t Hoff factor for X } > 1) \text{ i.e X undergoes dissociation.} \]

139. The activation energy of a reaction can be determined from the slope of which of the following graphs?
   (1) \( \ln K \text{ vs. } \frac{1}{T} \)
   (2) \( \frac{T}{\ln K} \text{ vs. } \frac{1}{T} \)
   (3) \( \ln K \text{ vs. } T \)
   (4) \( \frac{\ln K}{T} \text{ vs. } T \)

Solution: (1) As per Arrhenius equation
\[
k = A e^{-\frac{E_a}{RT}}
\]
\[
\ln k = \ln A - \frac{E_a}{RT}
\]
Plot of \( \ln k \text{ v/s } \frac{1}{T} \) will give
\[
\text{Slope } = -\frac{E_a}{R}
\]
\[
\therefore E_a = -R(\text{slope})
\]

140. Biodegradable polymer which can be produced from glycine and aminocaproic acid is:
   (1) Buna-N
   (2) Nylon-6,6
   (3) Nylon-2-nylon-6
   (4) PHBV

Solution: (3)
\[
nH_2N - CH_2 - COOH + nH_2N - (CH_2)_5 - COOH \rightarrow [\text{NH} - CH_2 - CO - NH - (CH_2)_5 - CO - ]_n
\]

(\text{Glycine}) \quad Amino \text{ caproic acid} \quad (\text{Nylon } - 2 - \text{ nylon } - 6)

141. A single compound of the structure
is obtainable from ozonolysis of which of the following cyclic compounds?

(1) 

(2) 

(3) 

(4) 

Solution: (3)
142. The $K_{sp}$ of $Ag_2CrO_4$, $AgCl$, $AgBr$ and $AgI$ are respectively, $1.1 \times 10^{-12}$, $1.8 \times 10^{-10}$, $5.0 \times 10^{-13}$, and $8.3 \times 10^{-17}$. Which one of the following salts will precipitate last if $AgNO_3$ solution is added to the solution containing equal moles of $NaCl$, $NaI$, $NaBr$ and $Na_2CrO_4$?

(1) $AgBr$
(2) $Ag_2CrO_4$
(3) $AgI$
(4) $AgCl$

Solution: (2) Let the concentration of each $[Cl^-] = [Br^-] = [I^-] = [CrO_4^{2-}] = (x)M$

Then for precipitation concentration of $[Ag^+]$ in case of $Ag_2CrO_4$ will be

$$[Ag^+] = \frac{K_{sp}(Ag_2CrO_4)}{x} = \frac{1.1 \times 10^{-12}}{x}$$

i.e. maximum and therefore $Ag_2CrO_4$ salt will precipitate out last.

143. The correct bond order in the following species is:

(1) $O_2^+ < O_2^- < O_2^{2+}$
(2) $O_2^- < O_2^+ < O_2^{2+}$
(3) $O_2^{2+} < O_2^+ < O_2^-$
(4) $O_2^{2+} < O_2^- < O_2^+$

Solution: (2) Bond order = $\frac{N_b-N_a}{2}$ as per M.O.T

$$O_2 \Rightarrow B.O = \frac{10-7}{2} = 1.5$$

$$O_2^+ \Rightarrow B.O = \frac{10-5}{2} = 2.5$$

$$O_2^{2+} \Rightarrow B.O = \frac{10-4}{2} = 3.0$$

$$O_2^- < O_2^+ < O_2^{2+}$$

144. Magnetic moment 2.84 B.M. is given by:

(At. Nos, Ni = 28, Ti = 22, Cr = 24, Co = 27)

(1) $Cr^{2+}$
(2) $Co^{2+}$
(3) $Ni^{2+}$
(4) $Ti^{3+}$

Solution: (3) $\mu = \sqrt{N(N+2)}$ B.M.
\[ 28\text{Ni}^{2+} \Rightarrow 18[\text{Ar}] \simplex{\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\text{N} = 2} \]

\[ \mu = \sqrt{8} = 2.84 \text{ B.M.} \]

145. The number of d-electrons in \( \text{Fe}^{2+} (Z = 26) \) is not equal to the number of electrons in which one of the following?
(1) d-electrons in Fe \((Z = 26)\)
(2) p-electrons in Ne \((Z = 10)\)
(3) s-electrons in Mg \((Z = 12)\)
(4) p-electrons in Cl \((Z = 17)\)

Solution: (4) \[ 26\text{Fe}^{2+} \Rightarrow 18[\text{Ar}] 3d^6 \text{ (d electrons = 6)} \]
\[ 17\text{Cl} \Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^5 \text{ (p – electrons = 11)} \]

146. Which of the following options represents the correct bond order?
(1) \( O_2^- > O_2 < O_2^+ \)
(2) \( O_2^- < O_2 > O_2^+ \)
(3) \( O_2^- > O_2 > O_2^+ \)
(4) \( O_2^- < O_2 < O_2^+ \)

Solution: (4) \[ \text{B.O} = \frac{N_b - N_a}{2} \]

B.O for \( O_2^- = 1.5 \Rightarrow \frac{10 - 7}{2} = 1.5 \]
B.O for \( O_2 = 2.0 \Rightarrow \frac{10 - 6}{2} = 2 \]
B.O for \( O_2^+ = 2.5 \Rightarrow \frac{10 - 5}{2} = 2.5 \]

As per M.O.T electronic configurations
\[ O_2^- \Rightarrow \sigma 1s^2, \sigma 1s^2, 1s2s^2, 1s2s^2, 2s^2, 2s^2, 2p^2, 2p^2, 2p^2, 2p^2 \]
\[ O_2 \Rightarrow \sigma 1s^2, \sigma 1s^2, 1s2s^2, 1s2s^2, 2s^2, 2s^2, 2p^2, 2p^2, 2p^2, 2p^2 \]
\[ O_2^+ \Rightarrow \sigma 1s^2, \sigma 1s^2, 1s2s^2, 1s2s^2, 2s^2, 2s^2, 2p^2, 2p^2, 2p^2, 2p^2 \]

\[ \therefore O_2^- < O_2 < O_2^+ \]

147. Which one of the following electrolytes has the same value of van’s Hoff’s factor (i) as that of \( Al_2(SO_4)_3 \) (If all are 100% ionized)?
(1) \( Al(NO_3)_3 \)
(2) \( K_4[Fe(CN)_6] \)
(3) \( K_2SO_4 \)
(4) \( K_3[Fe(CN)_6] \)
Solution: (2)  \[ \text{Al}_2(\text{SO}_4)_3 \rightarrow 2\text{Al}^{3+} + 3\text{SO}_4^{2-} \quad (i = 5) \]

\[ \text{K}_2\text{SO}_4 \rightarrow 2\text{K}^+ + \text{SO}_4^{2-} \quad (i = 3) \]

\[ \text{K}_3[\text{Fe(CN)}_6] \rightarrow 3\text{K}^+ + [\text{Fe(CN)}_6]^{3-} \quad (i = 4) \]

\[ \text{Al(NO}_3)_3 \rightarrow \text{Al}^{3+} + 3\text{NO}_3^- \quad (i = 4) \]

\[ \text{K}_4[\text{Fe(CN)}_6] \rightarrow 4\text{K}^+ + [\text{Fe(CN)}_6]^{4-} \quad (i = 5) \]

148. “Metals are usually not found as nitrates in their ores”.

Out of the following two (a and b) reasons which is or are true for the above observation?

(a) Metal nitrates are highly unstable.
(b) Metal nitrates are highly soluble in water.

(1) a is false but b is true
(2) a is true but b is false
(3) a and b are true
(4) a and b are false

Solution: (1) Metal nitrates are not unstable metal nitrates are highly soluble.

149. Treatment of cyclopentanone \[ \text{C}_{6} \text{H}_{10} \text{O} \] with methyl lithium gives which of the following species?

(1) Cyclopentanonyl radical
(2) Cyclopentanonyl biradical
(3) Cyclopentanonyl anion
(4) Cyclopentanonyl cation

Solution: (3)

150. The function of “Sodium pump” is a biological process operating in each and every cell of all animals. Which of the following biologically important ions is also a constituent of this pump?

(1) \( K^+ \)
(2) $Fe^{2+}$
(3) $Ca^{2+}$
(4) $Mg^{2+}$

Solution: (1) Memory based
$K^+$ ions is constituent of this pump.

151. The total number of $\pi$-bond electrons in the following structure is:

![Chemical Structure]

(1) 12
(2) 16
(3) 4
(4) 8

Solution: (4) $\pi$ bond electrons =
No. of $\pi$ bonds $\times 2 = 4 \times 2 = 8$

152. When initial concentration of a reactant is doubled in a reaction, its half-life period is not affected. The order of the reaction is:
(1) Second
(2) More than zero but less than first
(3) Zero
(4) First

Solution: (4) $t_{1/2} \propto \frac{1}{(a_0)^{n-1}}$

$t_{1/2}$ is independent of initial concentration i.e.
$t_{1/2} \propto \frac{1}{(a_0)^{1-1}}$ (is constant)
i.e $n = 1$ (order of reaction)

153. A given metal crystallizes out with a cubic structure having edge length of 361 pm. If there are four metal atoms in one unit cell, what is the radius of one atom?
(1) 80 pm
(2) 108 pm
Solution: (4) 4 atoms/unit cell is FCC

\[ i.e. \, 4r = \sqrt{2} \cdot a \]

\[ r = \frac{\sqrt{2} \cdot a}{4} = 1.414 \times \frac{361}{4} \]

\[ = 127 \, \text{pm} \]

154. Which of the following statements is correct for a reversible process in a state of equilibrium?

(1) \( \Delta G^o = -2.30 \, \text{RT} \log K \)

(2) \( \Delta G^o = 2.30 \, \text{RT} \log K \)

(3) \( \Delta G = -2.30 \, \text{RT} \log K \)

(4) \( \Delta G = 2.30 \, \text{RT} \log K \)

Solution: (1) For a reversible process at equilibrium

\[ \Delta G = 0 = \Delta G^o + \text{RT} \ln K \quad (Q = K) \]

\[ i.e. \, \Delta G^o = -2.303 \, \text{RT} \log K \]

155. A mixture of gases contains \( \text{H}_2 \) and \( \text{O}_2 \) gases in the ratio of 1 : 4 (w/w). What is the molar ratio of the two gases in the mixture?

(1) 16 : 1

(2) 2 : 1

(3) 1 : 4

(4) 4 : 1

Solution: (4)

\[ \frac{\text{H}_2}{\text{O}_2} = \frac{1}{4} \]

\[ \text{W/W} \Rightarrow 1 : 4 \]

\[ \text{Moles} \Rightarrow \frac{1}{2} : \frac{4}{32} \]

\[ \Rightarrow 1 : \frac{1}{4} \]

\[ i.e \, \frac{4}{1} \]

156. Cobalt (III) chloride forms several octahedral complexes with ammonia. Which of the following will not give test for chloride ions with silver nitrate at 25°C?

(1) \( \text{CoCl}_3 \cdot 5\text{NH}_3 \)

(2) \( \text{CoCl}_3 \cdot 6\text{NH}_3 \)

(3) \( \text{CoCl}_3 \cdot 3\text{NH}_3 \)

(4) \( \text{CoCl}_3 \cdot 4\text{NH}_3 \)
Solution: (3) In CoCl₃ · 3NH₃ the complex can be written as [CoCl₃(NH₃)₃]

With Co³⁺ oxidation state 3, Cl⁻ ions & 3, NH₃ molecules be with in the co-ordination sphere
Co - Cl bonds in co-ordination sphere not ionisable.

157. If the value of an equilibrium constant for a particular reaction is $1.6 \times 10^{12}$, then at equilibrium the system will contain:
(1) Mostly products
(2) Similar amounts of reactants and products
(3) All reactants
(4) Mostly reactants

Solution: (1) For any reaction of equilibrium

$$ K = \frac{[\text{Product}]^x}{[\text{Reactant}]^y} $$

If $K$ is $1.6 \times 10^{12}$ (very high) then equilibrium mixture shall mostly contain products.

158. Which of the following species contains equal number of σ – and π – bonds?
(1) (CN)₂
(2) CH₂(CN)₂
(3) HCO₃⁻
(4) XeO₄

Solution: (4) XeO₄ ⇒ hybridization of central atom

$$ H = \frac{1}{2}(8) = 4 \ (\text{sp}^3) $$

There are 4σ bonds & 4π bonds as central Xe atom joined to O atoms at corners of regular tetrahedron by double bonds.

159. Which of these statements about [Co(CN)₆]³⁻ is true?
(1) [Co(CN)₆]³⁻ has four unpaired electrons and will be in a high-spin configuration.
(2) [Co(CN)₆]³⁻ has no unpaired electrons and will be in a high-spin configuration.
(3) [Co(CN)₆]³⁻ has no unpaired electrons and will be in a low-spin configuration.
(4) [Co(CN)₆]³⁻ has four unpaired electrons and will be in a low-spin configuration.

Solution: (3)

$$ _{27}^{3+} \text{Co} \rightarrow _{18}^{3+} \text{Ar} \quad \begin{array}{cccc} \uparrow & \uparrow & \uparrow & \uparrow \\ 3d^6 \end{array} $$

Due to strong Ligand field of CN⁻ ions pairing of electrons takes place in inner 3d orbital it is a low spin complex with no unpaired electrons.
160. An organic compound ‘X’ having molecular formula C₅H₁₀O yields phenyl hydrazone and gives negative response to the iodoform test and Tollen’s test. It produces n-pentane on reduction. ‘X’ could be:

(1) 3-pentanone
(2) N-amyl alcohol
(3) Pentanal
(4) 2-pentanone

Solution: (4)

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{C} & \text{CH}_2\text{CH}_3 \\
\text{Reduction} & \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 & \text{(n-pentane)}
\end{align*}
\]

161. Given,

\[
\begin{align*}
\text{CH}_3 & \\
\text{CH}_3 & \\
\text{O} & \\
\text{I} & \\
\text{CH}_3 & \\
\text{CH}_3 & \\
\text{O} & \\
\text{II} & \\
\text{CH}_3 & \\
\text{CH}_3 & \\
\text{O} & \\
\text{III} & \\
\text{CH}_3 & \\
\end{align*}
\]

Which of the given compounds can exhibit tautomerism?

(1) II and III
(2) I, II and III
(3) I and II
(4) I and III

Solution: (2) All compounds show tautomerism.

\[
\begin{align*}
\text{CH}_3 & \\
\text{O} & \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 & \\
\text{OH} & \\
\end{align*}
\]
162. Bithional is generally added to the soaps as an additive to function as a/an:

(1) Buffering agent
(2) Antiseptic
(3) Softener
(4) Dryer

Solution: (2) Bithional is added as antiseptic to soaps.

163. Given,

The enthalpy of hydrogenation of these compounds will be in the order as:

(1) II > III > I
(2) II > I > III
(3) I > II > III
(4) III > II > I

Solution: (4) Enthalpy of hydrogenation is inversely proportional to stability of alkene.

164. Which of the following is the most correct electron displacement for a nucleophile reaction to take place?

(1) D
Problem 165. Solubility of the alkaline earth’s metal sulphates in water decreases in the sequence:

1. Sr > Ca > Mg > Ba
2. Ba > Mg > Sr > Ca
3. Mg > Ca > Sr > Ba
4. Ca > Sr > Ba > Mg

Solution: (3)

Lattice energies of alkaline earth sulphates are almost constant but hydration energy $\propto \frac{1}{\text{Size of cation}}$ from Mg$^{2+} \rightarrow$ Ca$^{2+} \rightarrow$ Sr$^{2+} \rightarrow$ Ba$^{2+}$, cationic size increases, hydration energy decreases i.e.

$\text{MgSO}_4$ is soluble & $\text{BaSO}_4$ is a precipitate.

$\text{MgSO}_4 > \text{CaSO}_4 > \text{SrSO}_4 > \text{BaSO}_4$

Problem 166. Maximum bond angle at nitrogen is present in which of the following?
(1) $\text{NO}_2^+$
(2) $\text{NO}_3^-$
(3) $\text{NO}_2$
(4) $\text{NO}_2^-$

Solution: (1) $\text{NO}_2^+$ ion

$$H = \frac{1}{2} (5 - 1) = 2 \text{ (sp hybridisation)}$$

![Image](image.png)

Linear geometry
Bond angle $180^\circ$

167. In Duma’s method for estimation of nitrogen, 0.25 g of an organic compound gave 40 mL of nitrogen collected at 300 K temperature and 725 mm pressure. If the aqueous tension at 300 K is 25 mm, the percentage of nitrogen in the compound is:

(1) 16.76
(2) 15.76
(3) 17.36
(4) 18.20

Solution: (1) $n_{\text{N}_2} = \frac{PV}{RT}$

$$= \frac{(725 - 25)40 \times 10^{-3}}{760 \times 0.082 \times 300}$$

$$= \frac{28}{760 \times 24.6}$$

$$= \frac{28 \times 28}{760 \times 24.6} \text{ g of } \text{N}_2$$

$$% \text{N}_2 = \frac{28 \times 28}{760 \times 24.6} \times \frac{1}{0.25} \times 100$$

$$= 16.77\%$$

168. Nitrogen dioxide and sulphur dioxide have some properties in common. Which property is shown by one of these compounds, but not by the other?

(1) Is soluble in water
(2) Is used as a food-preservative
(3) Forms ‘acid-rain’
(4) Is a reducing agent

Solution: (2) $\text{SO}_2$ is used as food preservative.

$\text{NO}_2$ is not used as food preservative.
169. The reaction of \( \text{C}_6\text{H}_5\text{CH} = \text{CHCH}_3 \) with HBr produces:

(A) \( \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} \)

(B)

CH=CHCH₃

Br

(C)

\( \text{C}_6\text{H}_5\text{CHCH}_2\text{CH}_3 \)

Br

(D)

\( \text{C}_6\text{H}_5\text{CH}_2\text{CHCH}_3 \)

Br

Solution: (3)

170. Which of the following processes does not involve oxidation of iron?

(1) Formation of Fe(CO)\(_5\) from Fe
(2) Liberation of \( \text{H}_2 \) from steam by iron at high temperature
(3) Rusting of iron sheets
(4) Decolourization of blue \( \text{CuSO}_4 \) solution by iron

Solution: (1) Rusting of iron \( \text{Fe} \rightarrow \text{Fe}^{3+} \) (oxidation)
\[ \text{Cu}^{2+} + \text{Fe} \rightarrow \text{Fe}^{2+} + \text{Cu} \text{ (oxidation)} \]

\[ \text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2 \uparrow \text{ (g) (oxidation)} \]

\[ \text{Fe(CO)}_5 \Rightarrow \text{oxidation state of Fe is zero} \]

171. Which one is not equal to zero for an ideal solution?

(1) \( \Delta V_{\text{mixture}} \)
(2) \( \Delta P = P_{\text{Observed}} - P_{\text{Raoult}} \)
(3) \( \Delta H_{\text{mixture}} \)
(4) \( \Delta S_{\text{mixture}} \)

Solution: (4) \( \Delta S_{\text{mix}} \) (per mole) = \( -\Sigma x_i \log x_2 \)

\( x_i \) is mole fraction of \( i^{\text{th}} \) component in solution \( \Delta S_{\text{mix/mole}} \) is +ve and not zero for an ideal solution.

172. Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii? (Number in the parenthesis are atomic numbers).

(1) Zr (40) and Hf (72)
(2) Zr (40) and Ta (73)
(3) Ti (22) and Zr (40)
(4) Zr (40) and Nb (41)

Solution: (1) \( ^{40}\text{Zr} \) is \( ^{36}\text{Kr} \) \( 5s^2 \) \( 4d^2 \)

\( ^{72}\text{Hf} \) is \( ^{54}\text{Xe} \) \( 6s^2 \) \( 4f^{14} \) \( 5d^2 \)

Both lie in period IV(B)

Lanthanide contraction & additional shell introduction cancel size effects & both metals have same radii.

173. Which property of colloidal solution is independent of charge on the colloidal particles?

(1) Electro-osmosis
(2) Tyndall effect
(3) Coagulation
(4) Electrophoresis

Solution: (2) Tyndall effect is related to scattering of light by colloidal particles and not dependent on charge.

174. The electrolytic reduction of nitrobenzene in strongly acidic medium produces:

(1) Azobenzene
(2) Aniline
(3) \( p \)-aminophenol
(4) Azoxybenzene
Consider the following compounds

Hyperconjugation occurs in:

1. III only
2. I and III
3. I only
4. II only

Solution: (1) Hyper conjugation possible in only due to presence of $\alpha - H$.

The enolic form of ethyl acetoacetate as below has:

(1) 9 sigma bonds and 2 pi-bonds
(2) 9 sigma bonds and 1 pi-bonds
(3) 18 sigma bonds and 2 pi-bonds
(4) 16 sigma bonds and 1 pi-bonds

Solution: (3) 18 $\sigma$ and 2$\pi$ bonds in both keto and enol form of ethyl acetoacetate.
177. The species Ar, K⁺ and Ca²⁺ contain the same number of electrons. In which order do their radii increase?
(1) Ca²⁺ < K⁺ < Ar
(2) K⁺ < Ar < Ca²⁺
(3) Ar < K⁺ < Ca²⁺
(4) Ca²⁺ < Ar < K⁺

Solution: (1) For isoelectronic species as \( \frac{z}{e} \) ratio increases ionic size decreases. e (Total no of electrons) = 18

For Ar \( \left( \frac{z}{e} \right) = \frac{18}{18} \)
K⁺ \( \left( \frac{z}{e} \right) = \frac{19}{18} \)
Ca²⁺ \( \left( \frac{z}{e} \right) = \frac{20}{18} \)
i.e. Ca²⁺ < K⁺ < Ar

178. The angular momentum of electron 'd' orbital is equal to:
(1) \( 2\sqrt{3} \, \hbar \)
(2) 0 \( \hbar \)
(3) \( \sqrt{6} \, \hbar \)
(4) \( \sqrt{2} \, \hbar \)

Solution: (3) For d-electrons \( l = 2 \)

Angular orbital momentum = \( \sqrt{l(l + 1)} \frac{\hbar}{2\pi} \)

= \( \sqrt{6} \frac{\hbar}{2\pi} = \sqrt{6} \, \hbar \)

179. A device that converts energy of combustion of fuels like hydrogen and methane, directly into electrical energy is known as:
(1) Dynamo
(2) Ni-Cd cell
(3) Fuel cell
(4) Electrolytic cell

Solution: (3) Fuel cell Burns fuels like \( H_2(g) \) & \( CH_4(g) \) & converts chemical energy into electrical energy.
180. In which of the following compounds, the $C - Cl$ bond ionization shall give most stable carbonium ion?

(1) ![Structure](image1.png)

(2) ![Structure](image2.png)

(3) ![Structure](image3.png)

(4) ![Structure](image4.png)

Solution: (1)

![Structure](image5.png)

Carbocation is most stable as $3^\circ$ carbocation.