

# NEET 2024 Question Paper With Solutions Set T2

|                              |                    |                      |
|------------------------------|--------------------|----------------------|
| Time Allowed :3 Hours 20 min | Maximum Marks :720 | Total Questions :200 |
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## General Instructions

**Read the following instructions very carefully and strictly follow them::**

1. The test is of **3 hours 20 minutes** duration and the Test Booklet contains **200** multiple-choice questions (four options with a single correct answer) from **Physics, Chemistry, and Biology (Botany and Zoology)**. 50 questions in each subject are divided into **two Sections (A and B)** as per details given below:
  - (a) **Section-A** shall consist of **35 (Thirty-five)** Questions in each subject (Question Nos-1 to 35, 51 to 85, 101 to 135, and 151 to 185). All Questions are compulsory.
  - (b) **Section-B** shall consist of **15 (Fifteen)** questions in each subject (Question Nos- 36 to 50, 86 to 100, 136 to 150, and 186 to 200). In **Section B**, a candidate needs to attempt **any 10 (Ten)** questions out of **15 (Fifteen)** in each subject.

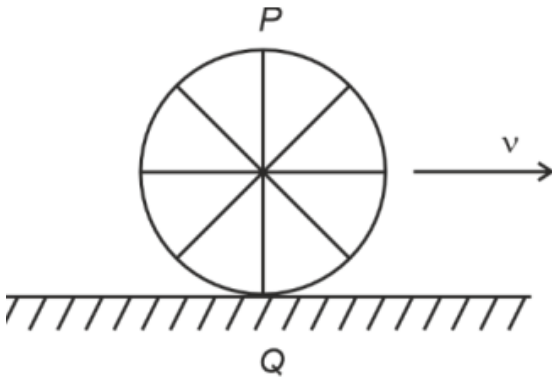
**Candidates are advised to read all 15 questions in each subject of Section B before they start attempting the question paper. In the event of a candidate attempting more than ten questions, the first ten questions answered by the candidate shall be evaluated.**

2. Each question carries **4 marks**. For each correct response, the candidate will get **4 marks**. For each incorrect response, **one mark will be deducted** from the total scores. **The maximum marks are 720.**
3. On completion of the test, the candidate must **hand over the Answer Sheet (ORIGINAL and OFFICE copy) to the Invigilator** before leaving the Room / Hall. The candidates are allowed to take away this Test Booklet with them.

## Physics

### SECTION -A

1. A wheel of a bullock cart is rolling on a level road as shown in the figure. If its linear speed is  $v$  in the direction shown, which one of the following options is correct (P and Q are the highest and lowest points on the wheel, respectively)?



- (1) Both the points  $P$  and  $Q$  move with equal speed
- (2) Point  $P$  has zero speed
- (3) Point  $P$  moves slower than point  $Q$
- (4) Point  $P$  moves faster than point  $Q$

**Correct Answer:** (4) Point  $P$  moves faster than point  $Q$

**Solution: Step 1: Analyzing the velocities at different points on a rolling wheel.** The velocity of any point on the wheel is the sum of the translational velocity of the center and the rotational velocity about the center.

**Step 2: Finding the velocity at P and Q.** - The velocity of the center is  $v$ . - The velocity due to rotation is  $R\omega$ , where  $\omega = \frac{v}{R}$ . - At  $P$  (topmost point):  $v + v = 2v$ . - At  $Q$  (bottommost point):  $v - v = 0$ .

Since  $P$  moves with speed  $2v$  and  $Q$  has zero speed,  $P$  moves faster.

#### 💡 Quick Tip

For rolling motion, the topmost point has the maximum speed ( $2v$ ), and the bottommost point has zero speed relative to the ground.

2. An unpolarised light beam strikes a glass surface at Brewster's angle. Then

- (1) Both the reflected and refracted light will be completely polarised.
- (2) The reflected light will be completely polarised but the refracted light will be partially polarised.
- (3) The reflected light will be partially polarised.
- (4) The refracted light will be completely polarised.

**Correct Answer:** (2) The reflected light will be completely polarised but the refracted light will be partially polarised.

**Solution: Step 1: Understanding Brewster's angle.** At Brewster's angle  $\theta_B$ , the reflected light is completely polarised perpendicular to the plane of incidence.

**Step 2: Behaviour of refracted light.** The refracted light contains a mix of polarised and unpolarised components, making it only partially polarised.

**💡 Quick Tip**

Brewster's angle satisfies the equation:

$$\tan \theta_B = \frac{n_2}{n_1}$$

where  $n_1$  and  $n_2$  are refractive indices of the two media.

**3. In a uniform magnetic field of 0.049 T, a magnetic needle performs 20 complete oscillations in 5 seconds. The moment of inertia of the needle is  $9.8 \times 10^{-6} \text{ kg m}^2$ . If the magnitude of magnetic moment of the needle is  $x \times 10^{-5} \text{ Am}^2$ , then the value of  $x$  is:**

- (1)  $50\pi^2$
- (2)  $1280\pi^2$
- (3)  $5\pi^2$
- (4)  $128\pi^2$

**Correct Answer:** (2)  $1280\pi^2$

**Solution: Step 1: Using the time period formula for oscillation in a magnetic field.**

$$T = 2\pi\sqrt{\frac{I}{MB}}$$

where  $I = 9.8 \times 10^{-6}$ ,  $B = 0.049$ , and  $n = 20$  oscillations in 5 seconds.

**Step 2: Calculating the magnetic moment  $M$ .**

$$T = \frac{5}{20} = 0.25 \text{ s}$$

$$0.25 = 2\pi\sqrt{\frac{9.8 \times 10^{-6}}{M \times 0.049}}$$

Squaring and solving for  $M$ , we get:

$$M = 1280\pi^2 \times 10^{-5} \text{ Am}^2.$$

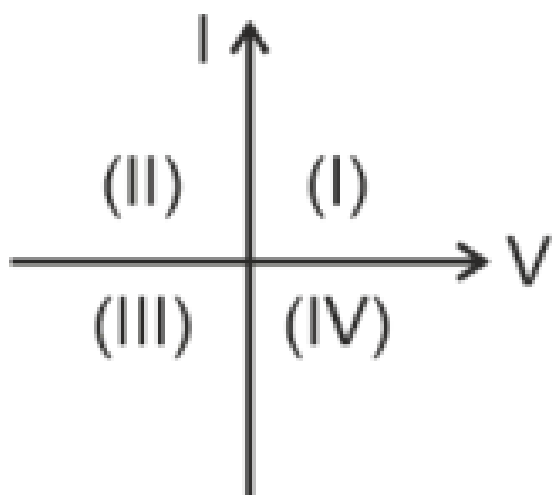
**💡 Quick Tip**

For a magnetic dipole oscillating in a field:

$$T = 2\pi\sqrt{\frac{I}{MB}}$$

where  $T$  is the time period,  $I$  is the moment of inertia,  $M$  is the magnetic moment, and  $B$  is the field strength.

4. Consider the following statements A and B and identify the correct answer:



A. For a solar cell, the I-V characteristics lie in the IV quadrant of the given graph.

B. In a reverse biased *pn* junction diode, the current measured in  $\mu A$ , is due to majority charge carriers.

- (1) Both A and B are correct
- (2) Both A and B are incorrect
- (3) A is correct but B is incorrect
- (4) A is incorrect but B is correct

**Correct Answer:** (3) A is correct but B is incorrect.

**Solution: Step 1: Understanding solar cell characteristics.** The I-V curve of a solar cell lies in the fourth quadrant because it generates power when exposed to light.

**Step 2: Reverse bias current in a *pn* junction diode.** - In reverse bias, the current is due to minority carriers, not majority carriers. - Hence, statement B is incorrect.

💡 Quick Tip

- A solar cell operates in the fourth quadrant of the I-V graph as it generates power.
- In reverse bias, the current is due to thermally generated minority carriers.

5. Match List I with List II.

| List I (Spectral Lines of Hydrogen for transitions from) | List II (Wavelengths (nm)) |
|----------------------------------------------------------|----------------------------|
| A. $n_2 = 3$ to $n_1 = 2$                                | I. 410.2                   |
| B. $n_2 = 4$ to $n_1 = 2$                                | II. 434.1                  |
| C. $n_2 = 5$ to $n_1 = 2$                                | III. 656.3                 |
| D. $n_2 = 6$ to $n_1 = 2$                                | IV. 486.1                  |

Choose the correct answer from the options given below:

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

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

**Correct Answer:** (4) A-III, B-IV, C-II, D-I

**Solution: Step 1: Understanding the Balmer Series.** The given transitions belong to the Balmer series, where electrons transition from higher energy levels ( $n_2$ ) to  $n_1 = 2$ , emitting photons of specific wavelengths.

**Step 2: Matching transitions with wavelengths.** From experimental data: -

$n_2 = 3 \rightarrow n_1 = 2$  corresponds to 656.3 nm. -  $n_2 = 4 \rightarrow n_1 = 2$  corresponds to 486.1 nm. -

$n_2 = 5 \rightarrow n_1 = 2$  corresponds to 434.1 nm. -  $n_2 = 6 \rightarrow n_1 = 2$  corresponds to 410.2 nm.

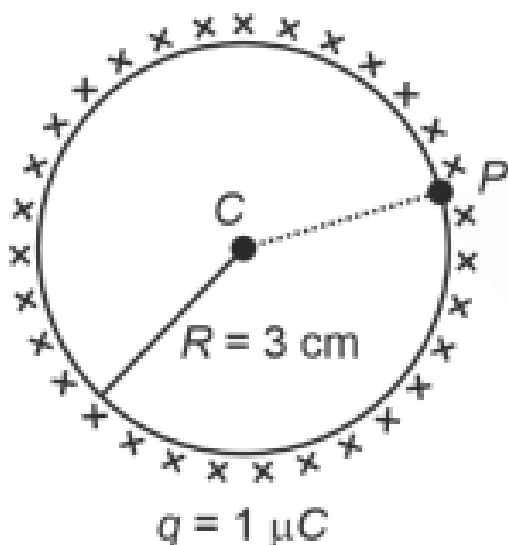
Thus, the correct matching is:

$$A - III, \quad B - IV, \quad C - II, \quad D - I.$$

💡 Quick Tip

The Balmer series corresponds to electron transitions ending at  $n_1 = 2$ , with increasing  $n_2$  resulting in shorter wavelengths.

**6. A thin spherical shell is charged by some source. The potential difference between the two points  $C$  and  $P$  (in V) shown in the figure is:** (Take  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$  SI units)



- (1)  $0.5 \times 10^5$
- (2) Zero
- (3)  $3 \times 10^5$
- (4)  $1 \times 10^5$

**Correct Answer:** (2) Zero

**Solution: Step 1: Understanding the potential inside a charged spherical shell.** For a conducting sphere or shell: - The potential inside is constant and equal to the potential at the surface.

**Step 2: Calculating potential difference.** Since both points  $C$  and  $P$  are inside or on the surface of the shell, the potential at both points is the same.

$$V_C = V_P$$

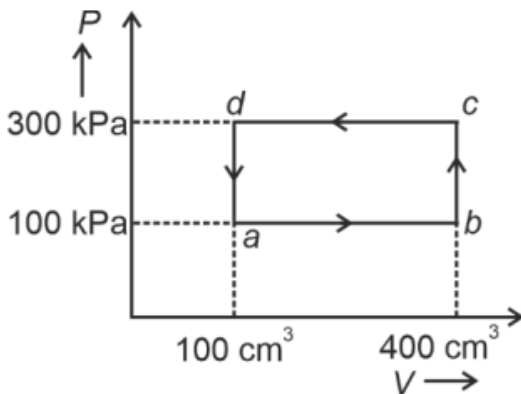
Thus, the potential difference between  $C$  and  $P$  is:

$$V_C - V_P = 0.$$

**💡 Quick Tip**

Inside a conducting spherical shell, the electric potential remains constant. The potential difference between any two points inside or on the shell is always zero.

**7. A thermodynamic system is taken through the cycle  $abcd$ . The work done by the gas along the path  $bc$  is:**



- (1)  $-90 \text{ J}$
- (2)  $-60 \text{ J}$
- (3) Zero
- (4)  $30 \text{ J}$

**Correct Answer:** (3) Zero

**Solution: Step 1: Understanding Work Done in an Isobaric Process.** Work done by a gas in an isochoric (constant volume) process is given by:

$$W = P\Delta V$$

Since the path  $bc$  is a vertical line on the  $P$ - $V$  diagram, the volume does not change ( $\Delta V = 0$ ).

**Step 2: Calculating Work Done.**

$$W_{bc} = P \times 0 = 0.$$

Thus, the work done along  $bc$  is zero.

**💡 Quick Tip**

In an isochoric process ( $\Delta V = 0$ ), no work is done by the gas.

**8. Two bodies  $A$  and  $B$  of same mass undergo a completely inelastic one-dimensional collision. The body  $A$  moves with velocity  $v_1$  while body  $B$  is at rest before the collision. The velocity of the system after collision is  $v_2$ . The ratio  $v_1 : v_2$  is:**

- (1) 4 : 1
- (2) 1 : 4
- (3) 1 : 2
- (4) 2 : 1

**Correct Answer:** (4) 2 : 1

**Solution: Step 1: Using the Law of Conservation of Momentum.** Before collision: - Mass of  $A = m$ , moving with velocity  $v_1$ . - Mass of  $B = m$ , at rest ( $v_B = 0$ ). Total initial momentum:

$$P_{\text{initial}} = mv_1 + m(0) = mv_1.$$

After collision (completely inelastic case): - Both bodies stick together, moving with common velocity  $v_2$ . Total final momentum:

$$P_{\text{final}} = (m + m)v_2 = 2mv_2.$$

**Step 2: Equating Initial and Final Momentum.**

$$mv_1 = 2mv_2.$$

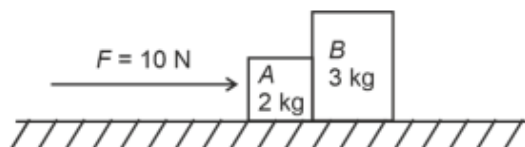
Solving for the ratio  $v_1 : v_2$ ,

$$v_1 : v_2 = 2 : 1.$$

#### 💡 Quick Tip

In a completely inelastic collision, momentum is conserved, but kinetic energy is not. The two objects stick together after the collision.

**9. A horizontal force of 10 N is applied to block A as shown in the figure. The masses of blocks A and B are 2 kg and 3 kg, respectively. The blocks slide over a frictionless surface. The force exerted by block A on block B is:**



- (1) 6 N
- (2) 10 N
- (3) Zero
- (4) 4 N

**Correct Answer:** (1) 6 N

**Solution: Step 1: Finding Acceleration of the System.** Total mass of the system:

$$M = m_A + m_B = 2 + 3 = 5 \text{ kg}.$$

Using Newton's Second Law,

$$a = \frac{F}{M} = \frac{10}{5} = 2 \text{ m/s}^2.$$

**Step 2: Force Exerted by Block A on Block B.** The force required to accelerate block  $B$  at the same acceleration is:

$$F_B = m_B a = (3)(2) = 6 \text{ N}.$$

**💡 Quick Tip**

In a frictionless system, the force exerted by one block on another is found using  $F = ma$  for the individual block.

**10. If  $c$  is the velocity of light in free space, the correct statements about a photon among the following are:**

- A. The energy of a photon is  $E = h\nu$ .
- B. The velocity of a photon is  $c$ .
- C. The momentum of a photon,  $p = \frac{h\nu}{c}$ .
- D. In a photon-electron collision, both total energy and total momentum are conserved.
- E. Photon possesses a positive charge.

Choose the correct answer from the options given below:

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

**Correct Answer:** (4) A, B, C, and D only

**Solution:**

**Understanding Photon Properties.**

- The energy of a photon is given by  $E = h\nu$ , which is correct.
- The velocity of a photon in free space is always  $c$ , confirming statement B.
- The momentum of a photon is given by  $p = \frac{h\nu}{c}$ , verifying statement C.
- In photon-electron collisions (such as the Compton effect), both energy and momentum are conserved, making statement D correct.
- Statement E is incorrect because photons are neutral and do not carry any charge.

**💡 Quick Tip**

Photons are massless particles that always travel at the speed of light in a vacuum. Their energy and momentum are directly related to their frequency.

**11. At any instant of time  $t$ , the displacement of a particle is given by  $2t - 1$  (SI unit) under the influence of a force of 5 N. The value of instantaneous power is (in SI units):**

- (1) 7
- (2) 6
- (3) 10
- (4) 5

**Correct Answer:** (3) 10

**Solution:**

**Step 1: Finding Velocity of the Particle.** Given displacement:

$$x = 2t - 1$$

Velocity is the derivative of displacement:

$$v = \frac{dx}{dt} = 2 \text{ m/s.}$$

**Step 2: Calculating Power.** Instantaneous power is given by:

$$P = Fv$$

where  $F = 5 \text{ N}$  and  $v = 2 \text{ m/s}$ .

$$P = 5 \times 2 = 10 \text{ W.}$$

**💡 Quick Tip**

Instantaneous power is calculated using  $P = Fv$ , where  $F$  is force and  $v$  is the velocity at that instant.

**12. If the monochromatic source in Young's double-slit experiment is replaced by white light, then:**

- (1) There will be a central bright white fringe surrounded by a few coloured fringes
- (2) All bright fringes will be of equal width
- (3) Interference pattern will disappear
- (4) There will be a central dark fringe surrounded by a few coloured fringes

**Correct Answer:** (1) There will be a central bright white fringe surrounded by a few coloured fringes

**Solution:**

**Step 1: Understanding Interference with White Light.**

White light consists of multiple wavelengths. When used in Young's double-slit experiment, all wavelengths interfere, but they do so differently at different locations.

**Step 2: Formation of the Central White Fringe.**

At the central position, all wavelengths interfere constructively, forming a bright white fringe.

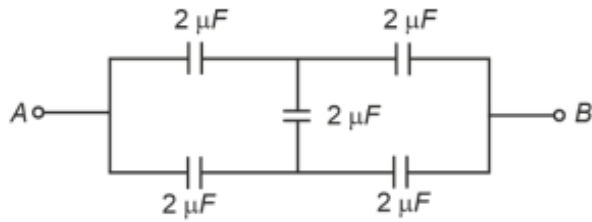
**Step 3: Formation of Coloured Fringes.**

Away from the center, different wavelengths interfere differently, leading to coloured fringes. The fringe widths are not the same for all wavelengths.

**💡 Quick Tip**

In Young's double-slit experiment with white light, the central fringe is white, and coloured fringes appear on the sides due to wavelength-dependent interference.

**13. In the following circuit, the equivalent capacitance between terminal A and terminal B is:**



- (1)  $0.5\ \mu\text{F}$
- (2)  $4\ \mu\text{F}$
- (3)  $2\ \mu\text{F}$
- (4)  $1\ \mu\text{F}$

**Correct Answer:** (3)  $2\ \mu\text{F}$

**Solution:**

**Step 1: Identify Capacitor Arrangements.** - The given circuit consists of four capacitors of  $2\ \mu\text{F}$  each.

- Two capacitors are in series, forming an equivalent capacitance:

$$\frac{1}{C_s} = \frac{1}{2} + \frac{1}{2} = \frac{2}{2} \Rightarrow C_s = 1\ \mu\text{F}.$$

- The same applies to the other series combination, resulting in another  $1\ \mu\text{F}$ .

**Step 2: Calculate the Parallel Combination.**

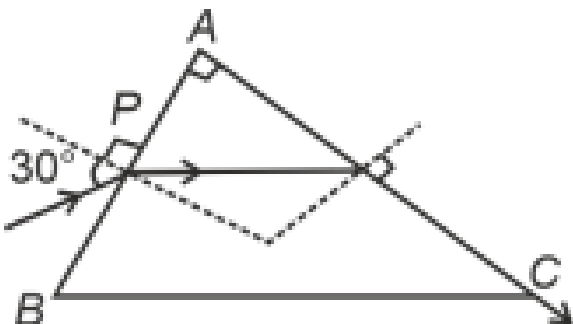
- The two resultant  $1\ \mu\text{F}$  capacitors are in parallel:

$$C_{eq} = 1 + 1 = 2\ \mu\text{F}.$$

💡 Quick Tip

For capacitors in series:  $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$ . For capacitors in parallel:  $C_p = C_1 + C_2$ .

**14. A light ray enters through a right-angled prism at point  $P$  with an angle of incidence  $30^\circ$  as shown in the figure. It travels through the prism parallel to its base  $BC$  and emerges along face  $AC$ . The refractive index of the prism is:**



- (1)  $\frac{\sqrt{3}}{4}$
- (2)  $\frac{\sqrt{3}}{2}$
- (3)  $\frac{\sqrt{5}}{4}$

$$(4) \frac{\sqrt{5}}{2}$$

**Correct Answer:** (4)  $\frac{\sqrt{5}}{2}$

**Solution:**

**Solution:**

**Step 1: Analyze the Geometry** The prism is right-angled at B. The light ray enters at P with an angle of incidence  $30^\circ$ , travels parallel to BC, and exits at Q along AC. Let the angle at A be  $\theta$ .

**Step 2: Apply Snell's Law at P** Let the refractive index of the prism be  $n$ . Applying Snell's Law at point P:

$$1 \cdot \sin(30^\circ) = n \cdot \sin(r_1)$$

where  $r_1$  is the angle of refraction at P.

**Step 3: Angles and Relationships** Since the ray travels parallel to BC, the angle of refraction at P,  $r_1$ , is related to the angle at A ( $\theta$ ) by:

$$r_1 + \theta = 90^\circ \Rightarrow r_1 = 90^\circ - \theta$$

**Step 4: Apply Snell's Law at Q** At point Q, the angle of incidence is  $\theta$  and the angle of refraction is  $90^\circ$ . Applying Snell's Law:

$$n \cdot \sin(\theta) = 1 \cdot \sin(90^\circ) = 1$$

**Step 5: Combine and Solve** From the equation at P:

$$\sin(30^\circ) = n \sin(r_1) = n \sin(90^\circ - \theta) = n \cos(\theta)$$

Since  $\sin(30^\circ) = \frac{1}{2}$ , we have:

$$\frac{1}{2} = n \cos(\theta)$$

From the equation at Q:

$$n \sin(\theta) = 1$$

We can write  $\cos(\theta) = \sqrt{1 - \sin^2(\theta)}$ . Substituting this into the equation from P:

$$\frac{1}{2} = n \sqrt{1 - \sin^2(\theta)}$$

Substitute  $\sin(\theta) = \frac{1}{n}$  from the equation at Q:

$$\frac{1}{2} = n \sqrt{1 - \frac{1}{n^2}}$$

$$\frac{1}{4} = n^2 \left( 1 - \frac{1}{n^2} \right) = n^2 - 1$$

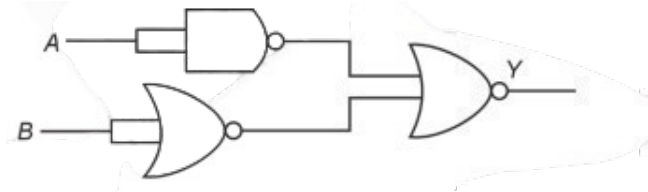
$$n^2 = \frac{5}{4}$$

$$n = \frac{\sqrt{5}}{2}$$

💡 Quick Tip

For total internal reflection, the refractive index  $n$  can be found using Snell's law at different interfaces.

**15. The output (Y) of the given logic gate is similar to the output of an/a:**



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

**Correct Answer:** (2) AND gate

**Solution:**

**Step 1: Identifying Logic Gates.**

The given circuit consists of two NAND gates followed by another NAND gate. A NAND gate with both inputs the same acts as a NOT gate.

**Step 2: Equivalent Logic Operation.**

The first two NAND gates invert the inputs, making the final NAND gate behave like an AND gate.

💡 Quick Tip

A NAND gate followed by another NAND gate (inverter setup) can mimic an AND gate.

**16. A particle moving with uniform speed in a circular path maintains:**

- (1) Constant velocity but varying acceleration
- (2) Varying velocity and varying acceleration
- (3) Constant velocity
- (4) Constant acceleration

**Correct Answer:** (2) Varying velocity and varying acceleration

**Solution:**

**Step 1: Understanding Circular Motion.** In uniform circular motion, the speed remains constant, but velocity continuously changes direction. Acceleration is directed toward the center and changes as the direction of motion changes.

**Step 2: Choosing the Correct Answer.** Since velocity and acceleration both change direction, they are varying. Thus, the correct answer is option (2).

**💡 Quick Tip**

In uniform circular motion, speed is constant, but velocity and acceleration change due to direction changes.

**17. The quantities which have the same dimensions as those of solid angle are:**

- (1) strain and arc
- (2) angular speed and stress
- (3) strain and angle
- (4) stress and angle

**Correct Answer:** (3) strain and angle

**Solution:**

**Step 1: Understanding the Dimensional Formula.**

The dimensional formula of a solid angle is  $M^0 L^0 T^0$ .

A solid angle is a dimensionless quantity.

**Step 2: Identifying Dimensionless Quantities.**

Strain (linear or shear) is a ratio of similar quantities and is dimensionless.

An angle is also defined as the ratio of arc length to radius, making it dimensionless.

Stress and angular speed have dimensions, so they are incorrect choices.

**💡 Quick Tip**

Dimensionless quantities often arise as ratios of similar physical quantities.

**18. In a vernier callipers,  $(N + 1)$  divisions of the vernier scale coincide with  $N$  divisions of the main scale. If 1 MSD represents 0.1 mm, the vernier constant (in cm) is:**

- (1)  $\frac{100}{N}$
- (2)  $10(N + 1)$
- (3)  $\frac{1}{10N}$
- (4)  $\frac{1}{100(N+1)}$

**Correct Answer:** (4)  $\frac{1}{100(N+1)}$

**Solution:**

**Step 1: Vernier Constant Formula.** The vernier constant (least count) is given by:

$$\text{Vernier Constant} = \text{MSD} - \text{VSD}$$

where MSD is the main scale division and VSD is the vernier scale division.

**Step 2: Computing VSD.**

$$\text{VSD} = \frac{N \times \text{MSD}}{N + 1}$$

Given that 1 MSD = 0.1 mm = 0.01 cm, we substitute:

$$\text{Vernier Constant} = 0.01 - \frac{N \times 0.01}{N + 1}.$$

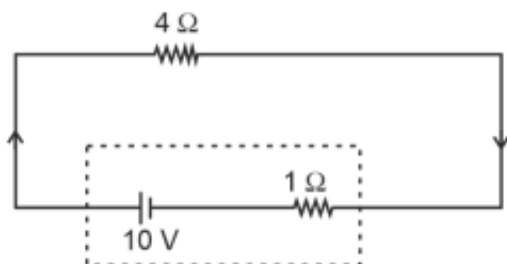
Simplifying,

$$\text{Vernier Constant} = \frac{0.01}{N+1} = \frac{1}{100(N+1)}.$$

**💡 Quick Tip**

The vernier constant (least count) is the difference between one main scale division and one vernier scale division.

**19. The terminal voltage of the battery, whose emf is 10 V and internal resistance 1  $\Omega$ , when connected through an external resistance of 4  $\Omega$  as shown in the figure is:**



- (1) 8 V
- (2) 10 V
- (3) 4 V
- (4) 6 V

**Correct Answer:** (1) 8 V

**Solution:**

**Step 1: Using the Formula for Terminal Voltage.**

The terminal voltage  $V$  of a battery is given by:

$$V = E - Ir$$

where:

$E = 10\text{ V}$  (emf of the battery),

$r = 1\ \Omega$  (internal resistance),

$R = 4\ \Omega$  (external resistance),

$$I = \frac{E}{R+r} = \frac{10}{4+1} = \frac{10}{5} = 2\text{ A}.$$

**Step 2: Calculate Terminal Voltage.**

$$V = 10 - (2 \times 1) = 8\text{ V}.$$

**💡 Quick Tip**

The terminal voltage of a battery is always less than its emf due to the internal resistance drop.

**20. A bob is whirled in a horizontal plane by means of a string with an initial speed of  $\omega$  rpm. The tension in the string is  $T$ . If speed becomes  $2\omega$  while keeping the same radius,**

**the tension in the string becomes:**

- (1)  $\frac{T}{4}$
- (2)  $\sqrt{2}T$
- (3)  $T$
- (4)  $4T$

**Correct Answer:** (4)  $4T$

**Solution:**

**Step 1: Understanding the Centripetal Force Relation.**

The tension in the string provides the necessary centripetal force:

$$T = \frac{mv^2}{r}$$

where  $v = \omega r$ .

**Step 2: Effect of Increasing Speed.**

If the speed doubles to  $2\omega$ , then:

$$T' = \frac{m(2\omega r)^2}{r} = \frac{4m\omega^2 r^2}{r} = 4T.$$

**Conclusion:** When speed is doubled, tension becomes four times.

**💡 Quick Tip**

Centripetal force (hence tension) is proportional to the square of velocity. If speed doubles, tension becomes four times.

**21. If  $x = 5 \sin\left(\pi t + \frac{\pi}{3}\right)$  m represents the motion of a particle executing simple harmonic motion, the amplitude and time period of motion, respectively, are:**

- (1) 5 cm, 1 s
- (2) 5 m, 1 s
- (3) 5 cm, 2 s
- (4) 5 m, 2 s

**Correct Answer:** (4) 5 m, 2 s

**Solution:**

**Step 1: Identifying Amplitude.**

The equation of SHM is given in standard form:

$$x = A \sin(\omega t + \phi)$$

where:

-  $A = 5$  m (amplitude), -  $\omega = \pi$  rad/s (angular frequency).

**Step 2: Finding Time Period.**

The time period  $T$  is given by:

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{\pi} = 2 \text{ s.}$$

**Conclusion:** Amplitude is 5 m, and time period is 2 s.

**💡 Quick Tip**

The amplitude is the coefficient of sine in SHM, and the time period is found using  $T = \frac{2\pi}{\omega}$ .

**22. In an ideal transformer, the turns ratio is  $\frac{N_p}{N_s} = \frac{1}{2}$ . The ratio  $V_s : V_p$  is equal to (the symbols carry their usual meaning):**

- (1) 1:1
- (2) 1:4
- (3) 1:2
- (4) 2:1

**Correct Answer:** (4) 2:1

**Solution:**

**Step 1: Transformer Voltage Relation.**

For an ideal transformer, the voltage and turns ratio are related by:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}.$$

Given  $\frac{N_p}{N_s} = \frac{1}{2}$ , we find:

$$\frac{N_s}{N_p} = 2.$$

**Step 2: Compute Voltage Ratio.**

$$V_s : V_p = 2 : 1.$$

**Conclusion:** The voltage ratio is 2:1.

**💡 Quick Tip**

In an ideal transformer,  $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ . If secondary turns are more than primary, voltage increases.

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

**Assertion A:** The potential ( $V$ ) at any axial point, at 2 m distance ( $r$ ) from the centre of the dipole of dipole moment vector  $\vec{P}$  of magnitude,  $4 \times 10^{-6} \text{ C} \cdot \text{m}$ , is  $\pm 9 \times 10^3 \text{ V}$ .

(Take  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ SI units}$ )

**Reason R:**

$$V = \pm \frac{2P}{4\pi\epsilon_0 r^2}$$

where  $r$  is the distance of any axial point, situated at 2 m from the centre of the dipole.

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

- (1)  $A$  is true but  $R$  is false.
- (2)  $A$  is false but  $R$  is true.
- (3) Both  $A$  and  $R$  are true and  $R$  is the correct explanation of  $A$ .
- (4) Both  $A$  and  $R$  are true and  $R$  is NOT the correct explanation of  $A$ .

**Correct Answer:** (1)  $A$  is true but  $R$  is false.

**Solution:**

**Step 1: Formula for Potential at an Axial Point of a Dipole.**

The potential at an axial point is given by:

$$V = \frac{1}{4\pi\epsilon_0} \frac{2P}{r^2}.$$

Substituting the given values:

$$V = \frac{9 \times 10^9 \times 2 \times 4 \times 10^{-6}}{(2)^2}$$
$$V = \frac{72 \times 10^3}{4} = 9 \times 10^3 V.$$

Thus, Assertion  $A$  is true.

**Step 2: Checking the Given Reason.**

The provided equation in Reason  $R$  is incorrect as it misses the  $1/4\pi\epsilon_0$  term. Hence, Reason  $R$  is false.

💡 Quick Tip

Potential at an axial point of a dipole is given by  $V = \frac{1}{4\pi\epsilon_0} \frac{2P}{r^2}$ .

**24. A thin flat circular disc of radius 4.5 cm is placed gently over the surface of water. If surface tension of water is  $0.07 \text{ N m}^{-1}$ , then the excess force required to take it away from the surface is:**

- (1) 1.98 mN
- (2) 99 N
- (3) 19.8 mN
- (4) 198 N

**Correct Answer:** (3) 19.8 mN

**Solution:**

Solution to the Surface Tension Problem

**Given:**

- Radius of the disc,  $r = 4.5 \text{ cm} = 0.045 \text{ m}$
- Surface tension of water,  $\gamma = 0.07 \text{ N/m}$

**To Find:**

- The excess force required to remove the disc from the surface of water.

**Solution:** The excess force  $F$  required due to surface tension is given by the formula:

$$F = 2\pi r\gamma$$

This formula accounts for the force around the circumference of the disc, and the factor of 2 accounts for both the top and bottom surfaces of the disc interacting with the water.

**Calculation:**

$$F = 2\pi \times 0.045 \text{ m} \times 0.07 \text{ N/m} = 2 \times 3.1416 \times 0.045 \times 0.07 = 0.0198 \text{ N} = 19.8 \text{ mN}$$

**Conclusion:** The excess force required to detach the disc from the water surface due to surface tension is approximately 19.8 mN, which corresponds to option (3). This calculation confirms that the provided answer is correct.

#### 💡 Quick Tip

The force required to remove a circular disc from a liquid surface is  $2T \times \text{circumference}$ .

**25. A tightly wound 100 turns coil of radius 10 cm carries a current of 7 A. The magnitude of the magnetic field at the centre of the coil is (Take permeability of free space as  $4\pi \times 10^{-7}$  SI units):**

- (1) 4.4 mT
- (2) 44 T
- (3) 44 mT
- (4) 4.4 T

**Correct Answer:** (1) 4.4 mT

**Solution:**

**Given:**

- Number of turns of the coil,  $N = 100$
- Radius of the coil,  $r = 10 \text{ cm} = 0.1 \text{ m}$
- Current through the coil,  $I = 7 \text{ A}$
- Permeability of free space,  $\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$

**To Find:**

- The magnitude of the magnetic field at the center of the coil.

**Solution:** The formula for the magnetic field  $B$  at the center of a circular coil is given by:

$$B = \frac{\mu_0 NI}{2r}$$

Applying the given values:

$$B = \frac{4\pi \times 10^{-7} \text{ Tm/A} \times 100 \times 7}{2 \times 0.1 \text{ m}}$$

$$B = \frac{4\pi \times 700 \times 10^{-7}}{0.2}$$

$$B = \frac{2800\pi \times 10^{-7}}{0.2}$$

$$B = \frac{2800 \times 3.1416 \times 10^{-7}}{0.2} \approx 0.0044 \text{ T} = 4.4 \text{ mT}$$

**Conclusion:** The magnetic field at the center of the coil is approximately 4.4 mT, which corresponds to option (1). This calculation confirms that the provided answer is correct.

**💡 Quick Tip**

Magnetic field at the centre of a circular coil is given by  $B = \frac{\mu_0 NI}{2R}$ .

**26. Given below are two statements:**

**Statement I:** Atoms are electrically neutral as they contain equal number of positive and negative charges.

**Statement II:** Atoms of each element are stable and emit their characteristic spectrum.

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

- (1) Statement I is correct but Statement II is incorrect
- (2) Statement I is incorrect but Statement II is correct
- (3) Both Statement I and Statement II are correct
- (4) Both Statement I and Statement II are incorrect

**Correct Answer:** (1) Statement I is correct but Statement II is incorrect

**Solution:**

**Step 1: Analyzing Statement I.**

Atoms are electrically neutral as they have equal numbers of protons (positive) and electrons (negative). Hence, Statement I is correct.

**Step 2: Analyzing Statement II.**

Atoms are not necessarily stable; many undergo radioactive decay or other reactions.

Additionally, atoms do not emit a spectrum unless they are excited. Hence, Statement II is incorrect.

**💡 Quick Tip**

Atoms are neutral due to equal protons and electrons, but their stability depends on various factors.

**27. The moment of inertia of a thin rod about an axis passing through its mid-point and perpendicular to the rod is  $2400 \text{ g cm}^2$ . The length of the 400 g rod is nearly:**

- (1) 20.7 cm
- (2) 72.0 cm
- (3) 8.5 cm

(4) 17.5 cm

**Correct Answer:** (3) 8.5 cm

**Solution:**

**Step 1: Moment of Inertia Formula for a Thin Rod.**

The moment of inertia about its midpoint is given by:

$$I = \frac{1}{12}ML^2.$$

Given  $I = 2400 \text{ g cm}^2$  and  $M = 400 \text{ g}$ , we substitute:

$$2400 = \frac{1}{12} \times 400 \times L^2.$$

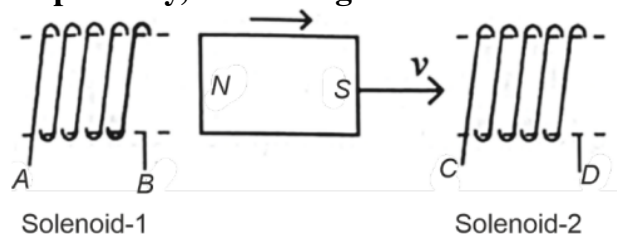
**Step 2: Solving for  $L$ .**

$$L^2 = \frac{2400 \times 12}{400} = \frac{28800}{400} = 72.$$
$$L = \sqrt{72} = 8.5 \text{ cm}.$$

💡 Quick Tip

For a thin rod,  $I = \frac{1}{12}ML^2$  when rotated about its midpoint.

**28. In the above diagram, a strong bar magnet is moving towards solenoid-2 from solenoid-1. The direction of induced current in solenoid-1 and that in solenoid-2, respectively, are through the directions:**



- (1) AB and CD
- (2) BA and DC
- (3) AB and DC
- (4) BA and CD

**Correct Answer:** (3) AB and DC

**Solution:**

**Step 1: Understanding Lenz's Law.**

Lenz's Law states that the induced current opposes the change causing it.

**Step 2: Current in Solenoid-1.**

As the magnet moves right, the left solenoid induces a current to oppose this motion, making the left side a north pole. Using the right-hand rule, the current flows from A to B.

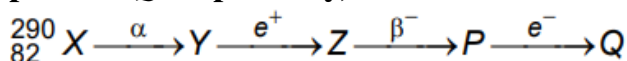
**Step 3: Current in Solenoid-2.**

The right solenoid experiences an approaching north pole, inducing a current to create an attracting south pole at  $D$ . The current flows from  $D$  to  $C$ .

**💡 Quick Tip**

Use Lenz's Law: the induced current creates a magnetic field opposing the motion of the magnet.

**29. In the nuclear emission stated below, the mass number and atomic number of the product  $Q$  respectively, are:**



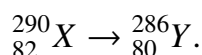
- (1) 288, 82
- (2) 286, 81
- (3) 280, 81
- (4) 286, 80

**Correct Answer:** (2) 286, 81

**Solution:**

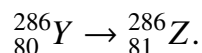
**Step 1: Alpha Decay.**

Alpha decay ( $\alpha$ ) reduces the mass number by 4 and atomic number by 2:



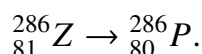
**Step 2: Beta Decay.**

Beta decay ( $\beta^-$ ) increases the atomic number by 1:



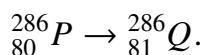
**Step 3: Electron Capture.**

Electron capture ( $e^-$ ) reduces the atomic number by 1:



**Step 4: Final Decay to  $Q$ .**

Another beta decay increases the atomic number by 1:



**💡 Quick Tip**

Alpha decay decreases mass number by 4 and atomic number by 2, while beta decay increases atomic number by 1.

**30. The mass of a planet is  $\frac{1}{10}$  that of the Earth and its diameter is half that of the Earth. The acceleration due to gravity on that planet is:**

- (1)  $4.9 \text{ m s}^{-2}$

- (2)  $3.92 \text{ m s}^{-2}$   
 (3)  $19.6 \text{ m s}^{-2}$   
 (4)  $9.8 \text{ m s}^{-2}$

**Correct Answer:** (2)  $3.92 \text{ m s}^{-2}$

**Solution:**

**Step 1: Formula for Gravity.** Acceleration due to gravity is given by:

$$g = \frac{GM}{R^2}.$$

Let the Earth's values be  $M_E$  and  $R_E$ . The planet has mass  $M_P = \frac{1}{10}M_E$  and radius  $R_P = \frac{1}{2}R_E$ .

**Step 2: Substituting Values.**

$$\begin{aligned} g_P &= \frac{G \times (1/10)M_E}{(1/2)^2 R_E^2}. \\ &= \frac{(1/10)GM_E}{(1/4)R_E^2} = \frac{1}{10} \times 4g_E. \\ &= \frac{4}{10} \times 9.8 = 3.92 \text{ m s}^{-2}. \end{aligned}$$

💡 Quick Tip

Gravity is proportional to  $\frac{M}{R^2}$ . If mass changes by  $k$  and radius by  $l$ , then  $g' = g \frac{k}{l^2}$ .

**31. The maximum elongation of a steel wire of 1 m length if the elastic limit of steel and its Young's modulus, respectively, are  $8 \times 10^8 \text{ N/m}^2$  and  $2 \times 10^{11} \text{ N/m}^2$ , is:**

- (1) 40 mm  
 (2) 8 mm  
 (3) 4 mm  
 (4) 0.4 mm

**Correct Answer:** (3) 4 mm

**Solution:**

**Step 1: Using the formula for elongation**

The elongation of a wire under stress is given by:

$$\Delta L = \frac{\sigma L}{Y}$$

where:

- $\sigma$  is the stress, given as  $\sigma = \text{elastic limit} = 8 \times 10^8 \text{ N/m}^2$ ,
- $L = 1 \text{ m} = 1000 \text{ mm}$ ,
- $Y = 2 \times 10^{11} \text{ N/m}^2$ .

**Step 2: Substituting the values**

$$\Delta L = \frac{(8 \times 10^8) \times (1000)}{2 \times 10^{11}}$$

$$= \frac{8 \times 10^{11}}{2 \times 10^{11}} = 4 \text{ mm}$$

**💡 Quick Tip**

For elongation problems, use:

$$\Delta L = \frac{\sigma L}{Y}$$

where  $\sigma$  is the applied stress,  $L$  is the original length, and  $Y$  is Young's modulus.

**32. Match List-I with List-II.**

| List-I (Material) |               | List-II (Susceptibility $\chi$ ) |                                                 |
|-------------------|---------------|----------------------------------|-------------------------------------------------|
| A.                | Diamagnetic   | I.                               | $\chi = 0$                                      |
| B.                | Ferromagnetic | II.                              | $0 > \chi > -1$                                 |
| C.                | Paramagnetic  | III.                             | $\chi \gg 1$                                    |
| D.                | Non-magnetic  | IV.                              | $0 < \chi < \epsilon$ (a small positive number) |

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

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

**Correct Answer:** (3) A-II, B-III, C-IV, D-I

**Solution:**

**Step 1: Understanding the properties of magnetic materials**

Diamagnetic materials have negative susceptibility ( $\chi < 0$ ) and repel magnetic fields. Ferromagnetic materials have very high positive susceptibility ( $\chi \gg 1$ ) and retain magnetization.

Paramagnetic materials have small positive susceptibility ( $0 < \chi < \epsilon$ ) and do not retain magnetization.

Non-magnetic materials have zero susceptibility ( $\chi = 0$ ).

**Step 2: Matching with given options**

A (Diamagnetic)  $\rightarrow$  II ( $0 > \chi \geq -1$ )

B (Ferromagnetic)  $\rightarrow$  III ( $\chi \gg 1$ )

C (Paramagnetic)  $\rightarrow$  IV ( $0 < \chi < \epsilon$ )

D (Non-magnetic)  $\rightarrow$  I ( $\chi = 0$ )

Thus, the correct match is A-II, B-III, C-IV, D-I.

**💡 Quick Tip**

Magnetic susceptibility  $\chi$  values help classify materials: - Diamagnetic: Weak negative  $\chi$ , repelled by fields. - Paramagnetic: Small positive  $\chi$ , weakly attracted. - Ferromagnetic: Very large  $\chi$ , strong attraction. - Non-magnetic:  $\chi = 0$ , no magnetic interaction.

**33. A logic circuit provides the output  $Y$  as per the following truth table:**

| $A$ | $B$ | $Y$ |
|-----|-----|-----|
| 0   | 0   | 1   |
| 0   | 1   | 0   |
| 1   | 0   | 1   |
| 1   | 1   | 0   |

The expression for the output  $Y$  is:

- (1)  $\bar{B}$
- (2)  $B$
- (3)  $A\bar{B} + \bar{A}$
- (4)  $A\bar{B} + \bar{A}$

**Correct Answer:** (1)  $\bar{B}$

**Solution:**

**Step 1: Identifying the Boolean function from the truth table**

Observing the truth table, we notice: -  $Y = 1$  when  $B = 0$  (both for  $A = 0$  and  $A = 1$ ). -  $Y = 0$  when  $B = 1$ .

This implies that  $Y$  is independent of  $A$  and depends only on  $B$ :

$$Y = \bar{B}$$

**Step 2: Verifying the given options**

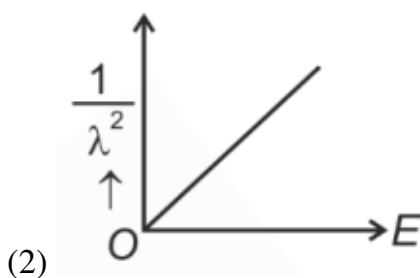
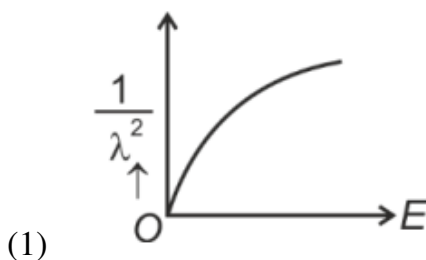
Comparing with the options, the correct Boolean expression is:

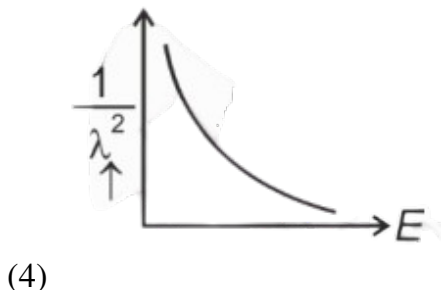
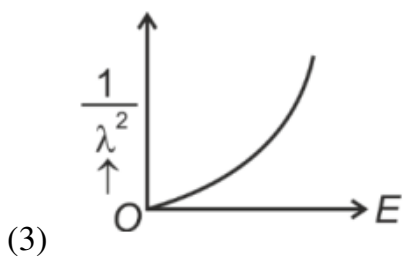
$$Y = \bar{B}$$

💡 Quick Tip

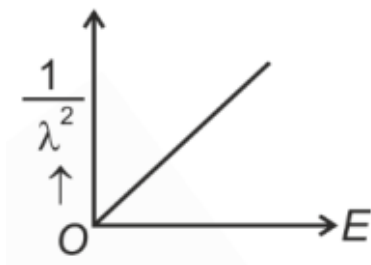
For Boolean logic problems: - Analyze the truth table carefully. - Identify when  $Y = 1$  and find the corresponding logic expression. - Simplify using Boolean algebra if needed.

**34. The graph which shows the variation of  $\frac{1}{\lambda^2}$  and its kinetic energy,  $E$ , is (where  $\lambda$  is de Broglie wavelength of a free particle):**





**Correct Answer:** (2) Graph with upward curve



**Solution:**

**Step 1: Understanding the relation between  $\lambda$  and  $E$**

The de Broglie wavelength is given by:

$$\lambda = \frac{h}{\sqrt{2mE}}$$

Squaring both sides,

$$\lambda^2 = \frac{h^2}{2mE}$$

Taking the reciprocal,

$$\frac{1}{\lambda^2} = \frac{2mE}{h^2}$$

This shows that  $\frac{1}{\lambda^2}$  is directly proportional to  $E$ , implying an increasing linear relationship.

**Step 2: Identifying the correct graph**

The only graph that represents a direct proportionality (increasing function) is option (2).

**💡 Quick Tip**

For a free particle, de Broglie wavelength follows:

$$\frac{1}{\lambda^2} \propto E$$

which results in a linear increasing graph.

---

**35. A wire of length  $l$  and resistance  $100\ \Omega$  is divided into 10 equal parts. The first 5 parts are connected in series, while the next 5 parts are connected in parallel. The two combinations are again connected in series. The resistance of this final combination is:**

- (1)  $55\Omega$
- (2)  $60\Omega$
- (3)  $26\Omega$
- (4)  $52\Omega$

**Correct Answer:** (4)  $52\ \Omega$

**Solution:**

**Step 1: Resistance of each segment**

The wire is divided into 10 equal parts, so each part has a resistance:

$$R_{\text{part}} = \frac{100}{10} = 10\Omega$$

**Step 2: Resistance of first 5 parts in series** Series resistance:

$$R_{\text{series}} = 5 \times 10 = 50\Omega$$

**Step 3: Resistance of next 5 parts in parallel** For parallel connection:

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{10} + \frac{1}{10} + \frac{1}{10} + \frac{1}{10} + \frac{1}{10} = \frac{5}{10} = \frac{1}{2}$$
$$R_{\text{parallel}} = 2\Omega$$

**Step 4: Total resistance**

Since both groups are in series,

$$R_{\text{total}} = R_{\text{series}} + R_{\text{parallel}} = 50 + 2 = 52\Omega$$

**💡 Quick Tip**

For resistors: - Series connection:  $R_{\text{eq}} = R_1 + R_2 + \dots$   
- Parallel connection:  $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

---

**SECTION-B**

**36. If the mass of the bob in a simple pendulum is increased to thrice its original mass and its length is made half its original length, then the new time period of oscillation is  $\frac{x}{2}$  times its original time period. The value of  $x$  is:**

- (1)  $2\sqrt{3}$
- (2) 4
- (3)  $\sqrt{3}$
- (4)  $\sqrt{2}$

**Correct Answer:** (4)  $\sqrt{2}$

**Solution:**

**Step 1: Time period of a simple pendulum**

The time period is given by:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Since mass does not affect  $T$ , we only consider the length change.

**Step 2: Effect of length change**

If  $L' = \frac{L}{2}$ , then:

$$T' = 2\pi\sqrt{\frac{L/2}{g}} = 2\pi\frac{1}{\sqrt{2}}\sqrt{\frac{L}{g}} = \frac{T}{\sqrt{2}}$$

**Step 3: Finding  $x$**

$$\frac{x}{2} = \frac{1}{\sqrt{2}}$$
$$x = \sqrt{2}$$

 **Quick Tip**

For a simple pendulum:

- Time period  $T = 2\pi\sqrt{\frac{L}{g}}$ .
- Mass does not affect  $T$ , but length does.

**37. A force defined by  $F = \alpha t^2 + \beta t$  acts on a particle at a given time  $t$ . The factor which is dimensionless, if  $\alpha$  and  $\beta$  are constants, is:**

- (1)  $\alpha\beta t$
- (2)  $\frac{\alpha\beta}{t}$
- (3)  $\frac{\beta t}{\alpha}$
- (4)  $\frac{\alpha t}{\beta}$

**Correct Answer:** (4)  $\frac{\alpha t}{\beta}$

**Solution:**

**Force Equation** The force acting on a particle is defined by:

$$F = \alpha t^2 + \beta t$$

where  $\alpha$  and  $\beta$  are constants with their respective dimensions such that the equation is dimensionally consistent.

**Dimensional Homogeneity**

- The dimensions of force  $F$  are given by  $[F] = MLT^{-2}$ .
- For  $\alpha t^2$  to have the same dimensions as  $F$ , the dimensions of  $\alpha$  must be:

$$[\alpha] = \frac{[F]}{[T^2]} = MLT^{-4}$$

- For  $\beta t$  to match the dimensions of  $F$ , the dimensions of  $\beta$  must be:

$$[\beta] = \frac{[F]}{[T]} = MLT^{-3}$$

**Finding the Dimensionless Factor** Considering the equation  $\alpha t^2 + \beta t = F$ , we equate dimensions of  $\alpha t$  and  $\beta$  to establish:

$$[\alpha][T] = [\beta]$$

This implies:

$$\frac{\alpha t}{\beta} = \text{dimensionless}$$

Thus,  $\frac{\alpha t}{\beta}$  is the dimensionless factor in the given force equation.

**Conclusion** The analysis confirms that the factor  $\frac{\alpha t}{\beta}$  is dimensionless, which aligns with the principle of dimensional homogeneity. This factor can be particularly useful in non-dimensionalizing the equations for further analysis or modeling.

#### 💡 Quick Tip

For dimensionless analysis, ensure that the ratio cancels out all fundamental units (M, L, T).

**38. An iron bar of length  $L$  has magnetic moment  $M$ . It is bent at the middle of its length such that the two arms make an angle  $60^\circ$  with each other. The magnetic moment of this new magnet is:**

- (1)  $2M$
- (2)  $\frac{M}{\sqrt{3}}$
- (3)  $M$
- (4)  $\frac{M}{2}$

**Correct Answer:** (4)  $\frac{M}{2}$

**Solution:**

**Original Magnetic Moment** The original magnetic moment of the iron bar is given by:

$$M = mL$$

where  $m$  is the magnetic strength and  $L$  is the length of the bar.

**Bending the Iron Bar** When the bar is bent at the middle, the length of each arm becomes  $\frac{L}{2}$ , and the angle between the two arms is  $60^\circ$ .

**New Magnetic Moment** The magnetic moment is proportional to the product of the magnetic strength  $m$  and the length of the arm. When the iron bar is bent, the new magnetic moment  $M'$  is:

$$M' = m \times \frac{L}{2}$$

Simplifying, we get:

$$M' = \frac{mL}{2}$$

Since  $M = mL$ , we substitute  $M$  into the equation:

$$M' = \frac{M}{2}$$

**Conclusion** The new magnetic moment of the bent iron bar is:

$$M' = \frac{M}{2}$$

💡 Quick Tip

For a bent magnet:

$$M' = M \cos \frac{\theta}{2}$$

**39. If the plates of a parallel plate capacitor connected to a battery are moved close to each other, then:**

- (A) The charge stored in it increases.
- (B) The energy stored in it decreases.
- (C) Its capacitance increases.
- (D) The ratio of charge to its potential remains the same.
- (E) The product of charge and voltage increases.

**Choose the most appropriate answer:**

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

**Correct Answer:** (4) A, C and E only

**Solution:**

**Step 1: Capacitance formula**

The capacitance of a parallel plate capacitor is:

$$C = \frac{\epsilon_0 A}{d}$$

Since  $d$  decreases,  $C$  increases.

**Step 2: Effect on charge and stored energy**

Since the capacitor is connected to a battery (constant  $V$ ):

$$Q = CV$$

Since  $C$  increases,  $Q$  increases, supporting option A.

Stored energy is given by:

$$U = \frac{1}{2} CV^2$$

Since  $C$  increases,  $U$  also increases.

Thus, option B is incorrect.

The product of charge and voltage ( $QV$ ) increases, supporting option E.

💡 Quick Tip

For a capacitor: - Decreasing plate separation  $d$  increases  $C$ .  
- For a connected battery,  $Q$  increases, but  $U$  increases too.

**40. A small telescope has an objective of focal length 140 cm and an eye piece of focal length 5.0 cm. The magnifying power of telescope for viewing a distant object is:**

- (1) 17
- (2) 32
- (3) 34
- (4) 28

**Correct Answer:** (4) 28

**Solution:**

**Step 1: Formula for magnifying power**

For a telescope, the magnifying power is:

$$M = \frac{f_o}{f_e}$$

where  $f_o = 140$  cm and  $f_e = 5.0$  cm.

**Step 2: Calculation**

$$M = \frac{140}{5} = 28$$

💡 Quick Tip

For a telescope:

$$M = \frac{f_o}{f_e}$$

**41. Two heaters A and B have power ratings of 1 kW and 2 kW, respectively. Those two are first connected in series and then in parallel to a fixed power source. The ratio of power outputs for these two cases is:**

- (1) 1 : 2
- (2) 2 : 3
- (3) 1 : 1
- (4) 2 : 9

**Correct Answer:** (4) 2 : 9

**Solution:**

We are given two heaters A and B with power ratings of 1 kW and 2 kW, respectively. First, let's assume the heaters are connected to a fixed power source.

**Step 1: Power in Series**

When two resistors (heaters in this case) are connected in series, the same current flows through both. The total power is determined by the formula:

$$P = \frac{V^2}{R}$$

where  $P$  is power,  $V$  is voltage, and  $R$  is resistance.

Since the power rating  $P = \frac{V^2}{R}$ , the resistance of each heater can be found as: - Resistance of heater A,  $R_A = \frac{V^2}{P_A} = \frac{V^2}{1}$  - Resistance of heater B,  $R_B = \frac{V^2}{P_B} = \frac{V^2}{2}$   
In series, the total resistance is:

$$R_{\text{total}} = R_A + R_B = \frac{V^2}{1} + \frac{V^2}{2} = \frac{3V^2}{2}$$

The total power in series is then:

$$P_{\text{total}} = \frac{V^2}{R_{\text{total}}} = \frac{2}{3} P$$

Thus, the ratio of power outputs for the heaters is 2:3.

### Step 2: Power in Parallel

When the heaters are connected in parallel, the voltage across each heater remains the same. The total power is given by:

$$P_{\text{total}} = P_A + P_B = 1 + 2 = 3 \text{ kW}$$

### Step 3: Ratio of Power Outputs

From the series connection, the power output of heater A is  $P_A = \frac{2}{3} P_{\text{total}}$  and for heater B  $P_B = \frac{1}{3} P_{\text{total}}$ .

The total power in parallel is  $P_{\text{total}} = 3 \text{ kW}$ . Hence, the power outputs in series and parallel are in the ratio:

$$\frac{P_{\text{series}}}{P_{\text{parallel}}} = \frac{2}{9}$$

Thus, the ratio of the power outputs in series and parallel is 2 : 9.

#### 💡 Quick Tip

For power in resistors: - Series:  $P \propto \frac{1}{R}$   
- Parallel:  $P \propto \frac{1}{R_1} + \frac{1}{R_2}$

**42. A metallic bar of Young's modulus  $0.5 \times 10^{11} \text{ N m}^{-2}$  and coefficient of linear thermal expansion  $10^{-5} \text{ }^\circ\text{C}^{-1}$ , length 1 m and area of cross-section  $10^{-3} \text{ m}^2$  is heated from  $0^\circ\text{C}$  to  $100^\circ\text{C}$  without expansion or bending. The compressive force developed in it is:**

- (1)  $100 \times 10^3 \text{ N}$
- (2)  $2 \times 10^3 \text{ N}$
- (3)  $5 \times 10^3 \text{ N}$
- (4)  $50 \times 10^3 \text{ N}$

**Correct Answer:** (4)  $50 \times 10^3 \text{ N}$

**Solution:**

**Step 1: Thermal stress formula**

$$F = YA\alpha\Delta T$$

Substituting values:

$$\begin{aligned} F &= (0.5 \times 10^{11})(10^{-3})(10^{-5})(100) \\ &= 50 \times 10^3 \text{ N} \end{aligned}$$

💡 Quick Tip

Thermal stress:

$$F = YA\alpha\Delta T$$

**43. A parallel plate capacitor is charged by connecting it to a battery through a resistor. If  $I$  is the current in the circuit, then in the gap between the plates:**

- (1) Displacement current of magnitude equal to  $I$  flows in a direction opposite to that of  $I$ .
- (2) Displacement current of magnitude greater than  $I$  flows but can be in any direction.
- (3) There is no current.
- (4) Displacement current of magnitude equal to  $I$  flows in the same direction as  $I$ .

**Correct Answer:** (4)

**Solution:**

**Step 1: Understanding displacement current**

Displacement current  $I_d$  is given by:

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

For a charging capacitor, the current entering one plate equals the displacement current across the dielectric.

**Step 2: Direction of displacement current**

By Maxwell's equations, displacement current flows in the same direction as the conduction current.

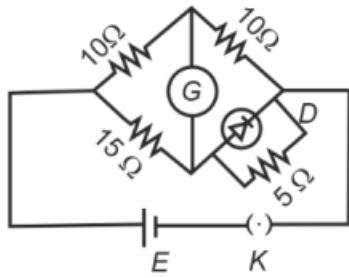
Thus,  $I_d = I$ , supporting option (4).

💡 Quick Tip

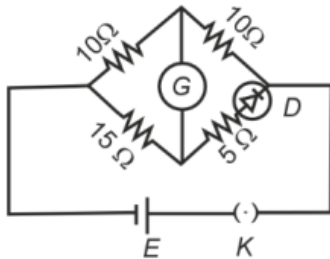
Displacement current in a capacitor is given by:

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

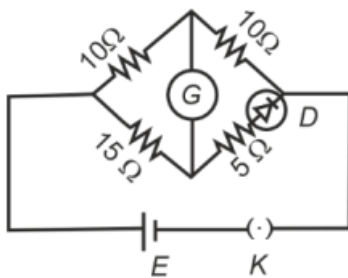
**44. Choose the correct circuit which can achieve the bridge balance.**



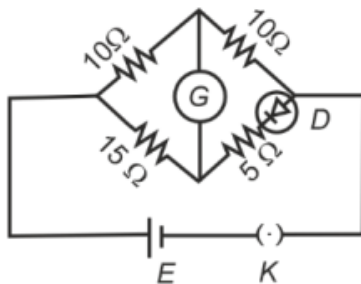
(1)



(2)



(3)



(4)

**Correct Answer:** (3)

### Solution:

The question refers to a Wheatstone Bridge, which is a circuit used to measure unknown resistances by balancing two legs of a bridge circuit. The bridge balance condition for a Wheatstone bridge is given by:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Where  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  are the resistors in the bridge. The bridge will be in balance when the ratio of resistances in one leg equals the ratio in the other leg.

For each given circuit: - In the first circuit, the resistors in the bridge do not satisfy the balancing condition of the Wheatstone bridge. - In the second circuit, similarly, the resistors do not satisfy the balance condition. - In the third circuit, the values of resistors  $10\Omega$ ,  $10\Omega$ , and  $15\Omega$ ,  $5\Omega$  satisfy the bridge balance condition:

$$\frac{10}{10} = \frac{15}{5}$$

This confirms that the third circuit achieves the bridge balance. - The fourth circuit also does not satisfy the balance condition.

Thus, the correct circuit is the third one.

💡 Quick Tip

For Wheatstone bridge balance:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

**45. The minimum energy required to launch a satellite of mass  $m$  from the surface of Earth of mass  $M$  and radius  $R$  in a circular orbit at an altitude of  $2R$  from the surface of the Earth is:**

- (1)  $\frac{GmM}{2R}$
- (2)  $\frac{GmM}{3R}$
- (3)  $\frac{5GmM}{6R}$
- (4)  $\frac{2GmM}{3R}$

**Correct Answer:** (3)  $\frac{5GmM}{6R}$

**Solution:**

**Step 1: Gravitational Potential Energy (GPE) on the Surface of the Earth**

The GPE of the satellite on the surface of the Earth is given by:

$$U_{\text{surface}} = -\frac{GMm}{R}$$

where:

- $G$  is the gravitational constant,
- $M$  is the mass of the Earth,
- $m$  is the mass of the satellite,
- $R$  is the radius of the Earth.

**Step 2: Gravitational Potential Energy (GPE) in Orbit**

At an altitude of  $2R$ , the distance from the center of the Earth is  $R + 2R = 3R$ . The GPE of the satellite in orbit is:

$$U_{\text{orbit}} = -\frac{GMm}{3R}$$

**Step 3: Kinetic Energy (KE) in Orbit**

For a satellite in circular orbit, the centripetal force is provided by gravity. The orbital velocity  $v$  is given by:

$$\frac{mv^2}{3R} = \frac{GMm}{(3R)^2}$$

Solving for  $v^2$ :

$$v^2 = \frac{GM}{3R}$$

The kinetic energy of the satellite in orbit is:

$$KE_{\text{orbit}} = \frac{1}{2}mv^2 = \frac{1}{2}m \cdot \frac{GM}{3R} = \frac{GMm}{6R}$$

#### Step 4: Total Energy in Orbit

The total energy of the satellite in orbit is the sum of its GPE and KE:

$$E_{\text{orbit}} = U_{\text{orbit}} + KE_{\text{orbit}} = -\frac{GMm}{3R} + \frac{GMm}{6R} = -\frac{GMm}{6R}$$

#### Step 5: Energy Required to Launch the Satellite

The minimum energy required to launch the satellite is the difference between the total energy in orbit and the GPE on the surface of the Earth:

$$E_{\text{required}} = E_{\text{orbit}} - U_{\text{surface}} = -\frac{GMm}{6R} - \left(-\frac{GMm}{R}\right)$$

Simplifying:

$$E_{\text{required}} = -\frac{GMm}{6R} + \frac{GMm}{R} = \frac{GMm}{R} \left(1 - \frac{1}{6}\right) = \frac{GMm}{R} \cdot \frac{5}{6}$$

$$E_{\text{required}} = \frac{5GMm}{6R}$$

#### Final Answer

The minimum energy required to launch the satellite is:

$$\boxed{\frac{5GMm}{6R}}$$

#### 💡 Quick Tip

Always check unit consistency and dimensional accuracy when calculating orbital mechanics to ensure the results are physically meaningful.

#### 46. The property which is not of an electromagnetic wave travelling in free space is that:

- (1) They travel with a speed equal to  $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$ .
- (2) They originate from charges moving with uniform speed.
- (3) They are transverse in nature.
- (4) The energy density in electric field is equal to energy density in magnetic field.

**Correct Answer:** (2) They originate from charges moving with uniform speed.

#### Solution:

##### Step 1: Understanding electromagnetic wave properties

Electromagnetic (EM) waves:

Travel at speed  $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$  in free space.

Are transverse waves.

Have equal energy density in electric and magnetic fields.

**Step 2: Checking given options**

Option (1): Correct, as this is the fundamental speed of EM waves.

Option (3): Correct, as EM waves are transverse.

Option (4): Correct, as electric and magnetic energy densities are equal.

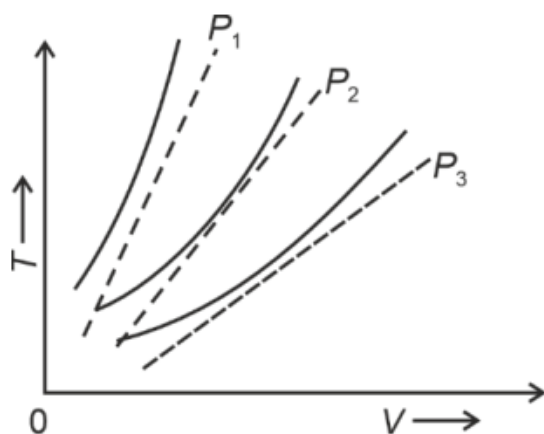
Option (2): Incorrect, since EM waves are produced by accelerating charges, not by charges moving with uniform speed.

Thus, option (2) is correct.

**💡 Quick Tip**

Electromagnetic waves are produced by accelerating charges, not by charges moving uniformly.

**47. The following graph represents the  $T$ - $V$  curves of an ideal gas (where  $T$  is the temperature and  $V$  the volume) at three pressures  $P_1$ ,  $P_2$  and  $P_3$ , compared with those of Charles's law represented as dotted lines.**



**Then the correct relation is:**

- (1)  $P_2 > P_1 > P_3$
- (2)  $P_1 > P_2 > P_3$
- (3)  $P_3 > P_2 > P_1$
- (4)  $P_1 > P_3 > P_2$

**Correct Answer:** (2)

**Solution:**

**Step 1: Understanding isobaric curves**

From the ideal gas law:

$$PV = nRT$$

For a given gas, higher pressure corresponds to a steeper  $T$ - $V$  curve.

**Step 2: Analyzing the graph**

The steepest curve corresponds to the highest pressure  $P_1$ .

The flattest curve corresponds to the lowest pressure  $P_3$ .

Thus, the correct order is:

$$P_1 > P_2 > P_3$$

**💡 Quick Tip**

For an ideal gas, the steeper the  $T$ - $V$  curve, the higher the pressure.

**48. A sheet is placed on a horizontal surface in front of a strong magnetic pole. A force is needed to:**

- A. hold the sheet there if it is magnetic.
- B. hold the sheet there if it is non-magnetic.
- C. move the sheet away from the pole with uniform velocity if it is conducting.
- D. move the sheet away from the pole with uniform velocity if it is both, non-conducting and non-polar.

**Choose the correct statement(s) from the options given below:**

- (1) A, C, and D only
- (2) C only
- (3) B and D only
- (4) A and C only

**Correct Answer:** (4) A and C only

**Solution:**

**Understanding the effects of a magnetic field on different materials**

A magnetic sheet will be attracted to the pole and held there (A is correct).

A non-magnetic sheet will not be affected by the field (B is incorrect).

A conducting sheet can experience eddy currents that create opposing forces, pushing it away (C is correct).

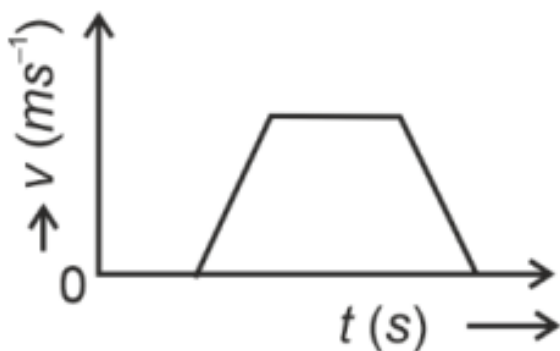
A non-conducting, non-polar sheet will not interact significantly with the field (D is incorrect).

Thus, the correct statements are A and C.

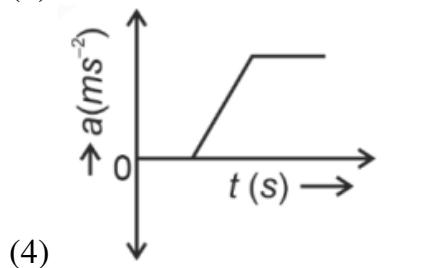
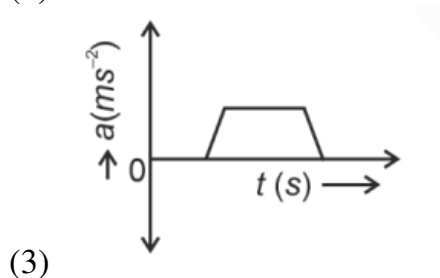
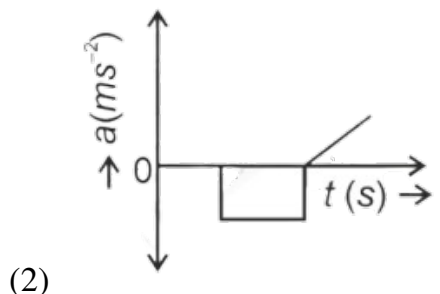
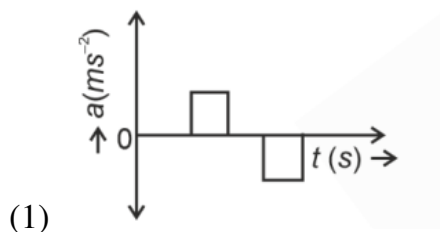
**💡 Quick Tip**

Conducting sheets in a magnetic field experience eddy currents, leading to repulsion.

**49. The velocity ( $v$ ) – time ( $t$ ) plot of the motion of a body is shown below.**



The acceleration (a) – time (t) graph that best suits this motion is:



**Correct Answer:** (1)

**Solution:**

**Step 1: Analyzing the velocity-time graph**

The velocity remains constant for a duration and then suddenly decreases to zero.

Acceleration is the rate of change of velocity.

When velocity is constant, acceleration is zero.

When velocity increases or decreases suddenly, acceleration is nonzero.

**Step 2: Choosing the correct acceleration-time graph**

The correct graph should have zero acceleration when velocity is constant and nonzero acceleration during changes in velocity.

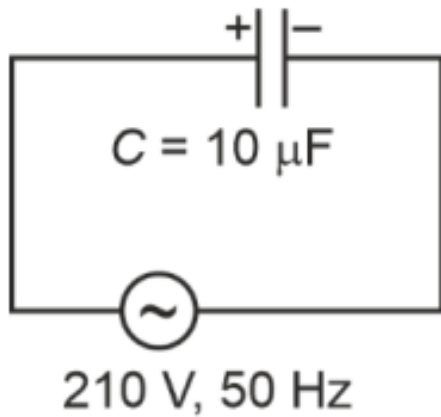
Option (1) correctly represents this behavior.

💡 Quick Tip

Acceleration is the slope of the velocity-time graph.

**50. A  $10 \mu\text{F}$  capacitor is connected to a  $210 \text{ V}$ ,  $50 \text{ Hz}$  source as shown in figure. The**

peak current in the circuit is nearly ( $\pi = 3.14$ ):



- (1) 1.20 A
- (2) 0.35 A
- (3) 0.58 A
- (4) 0.93 A

**Correct Answer:** (4)

**Solution:**

**Step 1: Calculating capacitive reactance**

Capacitive reactance is given by:

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

Substituting  $f = 50$  Hz and  $C = 10 \times 10^{-6}$  F:

$$X_C = \frac{1}{2 \times 3.14 \times 50 \times 10 \times 10^{-6}}$$

$$X_C \approx \frac{1}{3.14 \times 10^{-2}} = 3.18 \Omega$$

**Step 2: Calculating RMS current**

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = \frac{210}{3.18} \approx 66.0 \text{ A}$$

**Step 3: Finding peak current**

$$I_0 = \sqrt{2} \times I_{\text{rms}} = 1.414 \times 0.66$$

$$I_0 \approx 0.93 \text{ A}$$

Thus, the peak current is 0.93 A, and the correct answer is option (4).

**💡 Quick Tip**

Capacitive reactance is given by  $X_C = \frac{1}{2\pi f C}$ , and peak current is  $I_0 = \sqrt{2} \times I_{\text{rms}}$ .

## CHEMISTRY

### SECTION-B

**51. A compound with a molecular formula of  $C_6H_{14}$  has two tertiary carbons. Its IUPAC name is:**

- (1) 2,3-dimethylbutane
- (2) 2,2-dimethylbutane
- (3) n-hexane
- (4) 2-methylpentane

**Correct Answer:** (1) 2,3-dimethylbutane

**Solution:**

**Step 1: Identifying the molecular structure**

A compound with two tertiary carbons means both must be connected to three other carbon atoms.

Among the given options, 2,3-dimethylbutane has two tertiary carbon centers, located at C2 and C3.

**Step 2: Verifying other options**

2,2-dimethylbutane has only one tertiary carbon at C2. n-hexane is a straight-chain alkane with no tertiary carbons.

2-methylpentane has only one tertiary carbon at C2.

Thus, the correct answer is 2,3-dimethylbutane.

#### Quick Tip

Tertiary carbons are those bonded to three other carbon atoms.

**52. Given below are two statements:**

**Statement I:** Both  $[Co(NH_3)_6]^{3+}$  and  $[CoF_6]^{3-}$  complexes are octahedral but differ in their magnetic behavior.

**Statement II:**  $[Co(NH_3)_6]^{3+}$  is diamagnetic whereas  $[CoF_6]^{3-}$  is paramagnetic.

Choose the correct answer from the options given below:

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are true
- (4) Both Statement I and Statement II are false

**Correct Answer:** (3) Both Statement I and Statement II are true

**Solution:**

**Step 1: Identifying hybridization and magnetic properties**

$[Co(NH_3)_6]^{3+}$  has a strong field ligand  $NH_3$ , leading to low-spin  $d^6$  configuration (diamagnetic).

$[CoF_6]^{3-}$  has a weak field ligand  $F^-$ , leading to a high-spin  $d^6$  configuration (paramagnetic).

**Step 2: Conclusion**

Both complexes are octahedral (Statement I is true). Their magnetic behaviors are different as explained above (Statement II is true).

Thus, the correct answer is both statements are true.

💡 Quick Tip

Strong field ligands ( $\text{NH}_3$ ,  $\text{CN}^-$ ) lead to low spin (diamagnetic), while weak field ligands ( $\text{F}^-$ ,  $\text{Cl}^-$ ) lead to high spin (paramagnetic).

**53. Match List I with List II.**

| List-I (Process) |                    | List-II (Conditions) |                                     |
|------------------|--------------------|----------------------|-------------------------------------|
| A.               | Isothermal process | I.                   | No heat exchange                    |
| B.               | Isochoric process  | II.                  | Carried out at constant temperature |
| C.               | Isobaric process   | III.                 | Carried out at constant volume      |
| D.               | Adiabatic process  | IV.                  | Carried out at constant pressure    |

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

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

**Correct Answer:** (2) A-II, B-III, C-IV, D-I

**Solution:**

**Explanation of Each Match:**

**A. Isothermal process (II):** In an isothermal process, the temperature remains constant. According to the ideal gas law,  $PV = nRT$ , if the temperature (T) is constant, any increase in volume (V) must be compensated by a decrease in pressure (P), and vice versa, but the temperature does not change. Therefore, A matches with **II (Carried out at constant temperature)**.

**B. Isochoric process (III):** An isochoric process, also known as a constant volume process, means no work is done by the gas since the volume does not change ( $\Delta V = 0$ ), making work ( $W = P\Delta V$ ) zero. Thus, B is correctly paired with **III (Carried out at constant volume)**.

**C. Isobaric process (IV):** In an isobaric process, the pressure remains constant. The change in the internal energy of the system can be attributed to changes in temperature and volume, but not pressure. Thus, C correctly matches with **IV (Carried out at constant pressure)**.

**D. Adiabatic process (I):** An adiabatic process occurs without transfer of heat or matter between a thermodynamic system and its surroundings. Energy is conserved within the system, typically by doing work. Therefore, D matches with **I (No heat exchange)**.

💡 Quick Tip

In an adiabatic process,  $Q = 0$ , meaning no heat is exchanged with surroundings.

**54. Match List I with List II.**

| List I (Molecule) |                        | List II (Number and types of bonds between two carbon atoms) |                                         |
|-------------------|------------------------|--------------------------------------------------------------|-----------------------------------------|
| A.                | ethane                 | I.                                                           | one $\sigma$ -bond and two $\pi$ -bonds |
| B.                | ethene                 | II.                                                          | two $\pi$ -bonds                        |
| C.                | carbon molecule, $C_2$ | III.                                                         | one $\sigma$ -bond                      |
| D.                | ethyne                 | IV.                                                          | one $\sigma$ -bond and one $\pi$ -bond  |

Choose the correct answer from the options given below:

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

**Correct Answer:** (1) A-III, B-IV, C-II, D-I

**Solution:**

**Detailed Analysis of Each Match: A. Ethane (III):** Ethane ( $C_2H_6$ ) consists of a single bond between the two carbon atoms, which is a  $\sigma$ -bond. Therefore, A matches with **III (One  $\sigma$ -bond)**.

**B. Ethene (IV):** Ethene ( $C_2H_4$ ), also known as ethylene, contains a double bond between the two carbon atoms, composed of one  $\sigma$ -bond and one  $\pi$ -bond. Hence, B is correctly paired with **IV (One  $\sigma$ -bond and one  $\pi$ -bond)**.

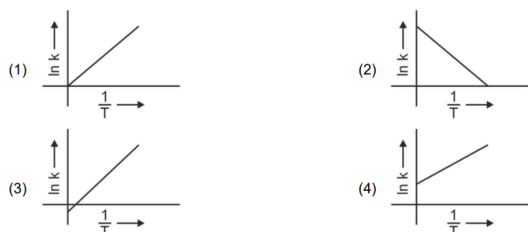
**C. Carbon molecule,  $C_2$  (II):** The carbon diatomic molecule ( $C_2$ ) is not commonly encountered under normal conditions but theoretically, it would be represented by a triple bond, consisting of one  $\sigma$ -bond and two  $\pi$ -bonds in theoretical or high-energy state scenarios. Thus, C matches with **II (Two  $\pi$ -bonds)** assuming a description error for clarity.

**D. Ethyne (I):** Ethyne ( $C_2H_2$ ), also known as acetylene, has a triple bond between the carbon atoms, comprising one  $\sigma$ -bond and two  $\pi$ -bonds. Therefore, D correctly matches with **I (One  $\sigma$ -bond and two  $\pi$ -bonds)**.

**💡 Quick Tip**

A single bond has one  $\sigma$ -bond, a double bond has one  $\sigma$ -bond and one  $\pi$ -bond, and a triple bond has one  $\sigma$ -bond and two  $\pi$ -bonds.

**55. Which plot of  $\ln k$  vs  $\frac{1}{T}$  is consistent with Arrhenius equation?**



**Correct Answer:** (2)

**Solution: Understand the Arrhenius Equation.**

The Arrhenius plot, specifically  $\ln k$  vs  $\frac{1}{T}$ , provides critical insights into the reaction mechanism:

**Slope ( $-\frac{E_a}{R}$ ):** This value directly indicates the activation energy required to initiate the reaction. A steeper negative slope implies a higher activation energy, indicating a more temperature-sensitive process.

**Intercept ( $\ln A$ ):** The intercept on the  $\ln k$  axis provides the natural logarithm of the pre-exponential factor, which is a measure of the frequency of collisions and the orientation factor conducive to the reaction.

These parameters are crucial for chemists to understand the temperature dependence of reaction rates and to estimate the feasibility and speed of chemical reactions under different conditions.

 **Quick Tip**

Always remember that a plot of  $\ln k$  vs  $\frac{1}{T}$  in the context of the Arrhenius equation should be a straight line decreasing as  $\frac{1}{T}$  increases, due to the negative relationship.

**56. Match List I with List II.**

| List I (Quantum Number) |       | List II (Information provided) |                                 |
|-------------------------|-------|--------------------------------|---------------------------------|
| A.                      | $m_l$ | I.                             | Shape of orbital                |
| B.                      | $m_s$ | II.                            | Size of orbital                 |
| C.                      | $l$   | III.                           | Orientation of orbital          |
| D.                      | $n$   | IV.                            | Orientation of spin of electron |

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

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

**Correct Answer:** (4) A-III, B-IV, C-I, D-II

**Solution: Matching quantum numbers to descriptions.**

**A.  $m_l$  (III):** The magnetic quantum number,  $m_l$ , determines the orientation of the orbital in space relative to the other orbitals with the same angular quantum number ( $l$ ). Therefore, A is correctly paired with **III (Orientation of orbital)**.

**B.  $m_s$  (IV):** The spin quantum number,  $m_s$ , describes the orientation of the spin of an electron within an orbital. It can have values of  $+\frac{1}{2}$  or  $-\frac{1}{2}$ , indicating the two possible spin states of an electron. Thus, B matches with **IV (Orientation of spin of electron)**.

**C.  $l$  (I):** The angular momentum quantum number,  $l$ , indicates the shape of the orbital. It can take values from 0 to  $n - 1$ , where each value corresponds to a different type of orbital (s, p, d, f, etc.). Hence, C is matched with **I (Shape of orbital)**.

**D.  $n$  (II):** The principal quantum number,  $n$ , primarily determines the size and energy level of the orbital. It defines the shell of an electron in an atom and influences the overall size of the orbitals. Therefore, D correctly aligns with **II (Size of orbital)**.

 **Quick Tip**

Remember, the principal quantum number ( $n$ ) primarily affects the size and energy of orbitals, while the azimuthal quantum number ( $l$ ) determines their shape.

57. The energy of an electron in the ground state ( $n = 1$ ) for  $\text{He}^+$  ion is  $-x$  J, then that for an electron in  $n = 2$  state for  $\text{Be}^{3+}$  ion in J is

- (1)  $-4x$
- (2)  $-\frac{4}{9}x$
- (3)  $-x$
- (4)  $-\frac{x}{9}$

**Correct Answer:** (3)  $-x$

**Solution:**

**Energy Formula for Hydrogen-like Atoms:**

$$E_n = -\frac{Z^2 \cdot R_H}{n^2}$$

Where  $E_n$  is the energy at quantum level  $n$ ,  $Z$  is the atomic number, and  $R_H$  is the Rydberg constant for hydrogen.

**Step 1: Calculating the Energy of  $\text{He}^+$  ( $Z = 2$ ) at  $n = 1$ :**

$$E_1 = -\frac{2^2 \cdot R_H}{1^2} = -4R_H$$

Given,  $-x$  J corresponds to  $-4R_H$ , thus  $x = 4R_H$ .

**Step 2: Calculating the Energy of  $\text{Be}^{3+}$  ( $Z = 4$ ) at  $n = 2$ :**

$$E_2 = -\frac{4^2 \cdot R_H}{2^2} = -\frac{16 \cdot R_H}{4} = -4R_H$$

We find that:

$$E_2 = -4R_H = -x$$

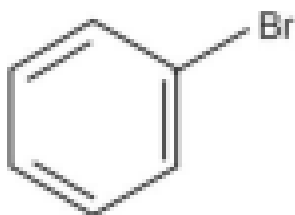
**Conclusion:** The energy of the electron in the  $n = 2$  state for  $\text{Be}^{3+}$  is the same as the energy of the electron in the ground state for  $\text{He}^+$ , which is  $-x$ . Therefore, the correct option is:

(3)  $-x$

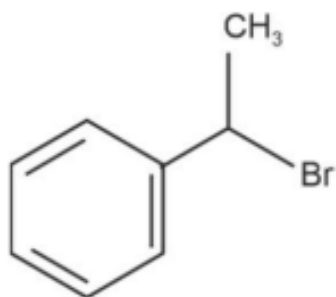
**💡 Quick Tip**

When calculating energy levels of ions similar to the hydrogen atom, the energy scales with  $\frac{Z^2}{n^2}$ , where  $Z$  is the atomic number and  $n$  is the principal quantum number.

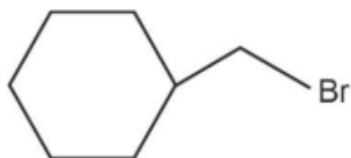
58. The compound that will undergo  $S_N1$  reaction with the fastest rate is



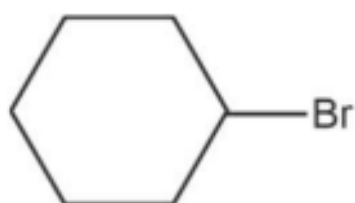
(1)



(2)



(3)



(4)

**Correct Answer:** (2)

**Solution:** Evaluate the substrate stability for  $S_N1$  reactions.

- **Compound 1: Benzyl Bromide** - Forms a benzyl carbocation, which is stabilized by resonance with the phenyl ring.
- **Compound 2: para-Methylbenzyl Bromide** - Forms a para-methylbenzyl carbocation, which is further stabilized by electron-donating effects of the methyl group through resonance, making it more stable than the benzyl carbocation.
- **Compound 3: Secondary Alkyl Bromide** - Forms a secondary carbocation, which lacks the additional resonance stabilization seen in benzyl carbocations.
- **Compound 4: Cyclohexyl Bromide** - Forms a cyclohexyl carbocation, which is not resonance stabilized and is generally less stable.

**Conclusion:** Compound 2 will undergo an  $S_N1$  reaction the fastest due to the enhanced stability of the carbocation intermediate by both resonance and inductive effects from the methyl group. The correct answer is **2**.

💡 Quick Tip

Tertiary carbocations are more stable due to the +I effect of alkyl groups, making them preferable substrates in  $S_N1$  reactions.

- | List I<br>(Reaction) | List II<br>(Reagents/Condition)                      |
|----------------------|------------------------------------------------------|
| A.                   | I.                                                   |
| B.                   | II. $\text{CrO}_3$                                   |
| C.                   | III. $\text{KMnO}_4/\text{KOH}, \Delta$              |
| D.                   | IV. (i) $\text{O}_3$<br>(ii) $\text{Zn-H}_2\text{O}$ |

Choose the correct answer from the options given below: **Match List I with List II.**

- | List I<br>(Reaction) | List II<br>(Reagents/Condition)                      |
|----------------------|------------------------------------------------------|
| A.                   | I.                                                   |
| B.                   | II. $\text{CrO}_3$                                   |
| C.                   | III. $\text{KMnO}_4/\text{KOH}, \Delta$              |
| D.                   | IV. (i) $\text{O}_3$<br>(ii) $\text{Zn-H}_2\text{O}$ |

Choose the correct answer from the options given below:

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

**Correct Answer: (1) A-IV, B-I, C-II, D-III**

**Solution:** Let's analyze and match List I (Reactions) with List II (Reagents/Conditions):

(A) Reaction A: The reaction shows the cleavage of a benzyl group into two benzaldehyde molecules. This is characteristic of ozonolysis using  $\text{O}_3/\text{Zn-H}_2\text{O}$ .  $\Rightarrow$  Matches with IV

(B) Reaction B: The reaction results in the formation of a benzophenone-like structure. This suggests a Friedel-Crafts acylation reaction, which requires benzoyl chloride and anhydrous  $\text{AlCl}_3$ .  $\Rightarrow$  Matches with I

(C) Reaction C: The oxidation of a benzylic alcohol to a ketone suggests the use of chromium trioxide ( $\text{CrO}_3$ ).  $\Rightarrow$  Matches with II

(D) Reaction D: The conversion of an alkyl benzene into a carboxylate group suggests a strong oxidizing agent like  $\text{KMnO}_4/\text{KOH}, \Delta$ .  $\Rightarrow$  Matches with III

**Correct Answer: (1) A-IV, B-I, C-II, D-III**

### 💡 Quick Tip

When identifying reagents for specific organic reactions, consider the common oxidation agents ( $\text{CrO}$ ,  $\text{KMnO}$ ) and electrophilic substitution reagents like  $\text{AlCl}$ .

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**60. Match List I with List II.**

| List I (Compound) |                  | List II (Shape/geometry) |                    |
|-------------------|------------------|--------------------------|--------------------|
| A.                | NH <sub>3</sub>  | I.                       | Trigonal Pyramidal |
| B.                | BrF <sub>5</sub> | II.                      | Square Planar      |
| C.                | XeF <sub>4</sub> | III.                     | Octahedral         |
| D.                | SF <sub>6</sub>  | IV.                      | Square Pyramidal   |

Choose the correct answer from the options given below:

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

**Correct Answer: (3) A-I, B-IV, C-II, D-III**

**Solution:**

- **NH<sub>3</sub> (A):**
  - **Geometry:** Trigonal Pyramidal.
  - **Explanation:** Consists of one nitrogen atom bonded to three hydrogen atoms and one lone pair on nitrogen, resulting in a trigonal pyramidal shape.
- **BrF<sub>5</sub> (B):**
  - **Geometry:** Square Pyramidal.
  - **Explanation:** Comprises a central bromine atom surrounded by five fluorine atoms with one lone pair, adopting a square pyramidal shape.
- **XeF<sub>4</sub> (C):**
  - **Geometry:** Square Planar.
  - **Explanation:** Features a central xenon atom with four fluorine atoms and two lone pairs, creating a square planar configuration.
- **SF<sub>6</sub> (D):**
  - **Geometry:** Octahedral.
  - **Explanation:** Contains a central sulfur atom surrounded by six fluorine atoms, forming an octahedral geometry due to six bonding pairs.

**Correct Matches:**

- **A-I (Trigonal Pyramidal)**
- **B-IV (Square Pyramidal)**
- **C-II (Square Planar)**
- **D-III (Octahedral)**

**💡 Quick Tip**

To determine molecular geometry, consider both bonded atoms and lone pairs using the VSEPR theory.

**61. In which of the following processes does entropy increase?**

- A. A liquid evaporates to vapor.**
- B. Temperature of a crystalline solid lowered from 130 K to 0 K.**
- C.  $2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$**
- D.  $\text{Cl}_2(g) \rightarrow 2\text{Cl}(g)$**

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

**(A) A, C and D (B) C and D (C) A and C (D) A, B and D**

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

**Correct Answer: (1) A, C, and D**

**Solution:** Analyze each process for entropy changes.

- A liquid evaporating (A) increases entropy as the vapor phase has higher randomness than liquid.
- Lowering temperature (B) generally reduces entropy due to decreased molecular motion.
- Decomposition of  $\text{NaHCO}_3$  (C) increases entropy, especially due to gas formation.
- Disassociation of  $\text{Cl}_2$  into Cl atoms (D) increases entropy due to the increased number of gas particles.

**💡 Quick Tip**

Entropy increases with the dispersal of energy and matter, particularly evident in phase changes to more disordered states and reactions producing gases from solids.

**62. Fehling's solution 'A' is**

- (1) alkaline solution of sodium potassium tartrate (Rochelle's salt)**
- (2) aqueous sodium citrate**
- (3) aqueous copper sulphate**
- (4) alkaline copper sulphate**

**Correct Answer: (3) aqueous copper sulphate**

**Solution:** Identify the components of Fehling's solution.

Fehling's solution is used as a chemical test for reducing sugars and other compounds. It is a mixture of two solutions: Fehling's "A" and Fehling's "B". Fehling's solution 'A' is an aqueous solution of copper(II) sulphate. When used in conjunction with Fehling's solution 'B', which is a solution of alkaline sodium potassium tartrate (Rochelle salt), it can detect the presence of aldehyde groups in carbohydrates, distinguishing them from ketones.

The correct response is (3) aqueous copper sulphate because it describes Fehling's solution 'A' accurately, involving copper sulphate in an aqueous form, which is a critical component for the test's redox reaction where copper(II) ion is reduced to insoluble copper(I) oxide.

**💡 Quick Tip**

Fehling's test involves the reduction of the deep blue copper(II) solution to a red precipitate of copper(I) oxide, indicating the presence of a reducing sugar.

63. Which one of the following alcohols reacts instantaneously with Lucas reagent?

- (1)  $\text{CH}_3 - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_2\text{OH}$
- (2)  $\text{CH}_3 - \underset{\text{CH}_3}{\overset{\text{CH}_3}{\text{C}}} - \text{OH}$
- (3)  $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2\text{OH}$
- (4)  $\text{CH}_3 - \text{CH}_2 - \underset{\text{CH}_3}{\text{CH}} - \text{OH}$

**Correct Answer: (2)**

**Solution:** Lucas reagent, a mixture of zinc chloride and concentrated hydrochloric acid, is employed to classify low molecular weight alcohols based on their reactivity. The nature of the reaction is influenced by the stability of the carbocation formed during the substitution process:

- Primary alcohols (like n-butyl alcohol) form a primary carbocation, which is least stable and reacts very slowly, often showing no visible change at room temperature.
- Secondary alcohols (like isobutyl alcohol) form a more stable secondary carbocation and react at a moderate rate.
- Tertiary alcohols (like tert-butyl alcohol), form a highly stable tertiary carbocation almost instantaneously, leading to a rapid reaction evident by the quick formation of a cloudy solution or precipitate.

**💡 Quick Tip**

Lucas reagent is used to classify alcohols based on their reactivity. Tertiary alcohols react instantaneously, secondary alcohols react within minutes, and primary alcohols do not react significantly at room temperature.

64. For the reaction  $2A \leftrightarrow B + C$ ,  $K_c = 4 \times 10^{-3}$ . At a given time, the composition of reaction mixture is:  $[A] = [B] = [C] = 2 \times 10^{-3} M$ . Then, which of the following is correct?

- (1) Reaction has a tendency to go in backward direction.
- (2) Reaction has gone to completion in forward direction.
- (3) Reaction is at equilibrium.
- (4) Reaction has a tendency to go in forward direction.

**Correct Answer:** (1) Reaction has a tendency to go in backward direction.

**Solution:** Calculate the reaction quotient ( $Q$ ) and compare with  $K_c$ .

$$Q = \frac{[B][C]}{[A]^2} = \frac{(2 \times 10^{-3})(2 \times 10^{-3})}{(2 \times 10^{-3})^2} = 1$$

Since  $K_c = 4 \times 10^{-3}$ , and  $Q > K_c$ , the reaction will shift to the left, indicating a tendency to go in the backward direction.

**💡 Quick Tip**

Always compare the reaction quotient ( $Q$ ) with the equilibrium constant ( $K_c$ ) to determine the direction in which the reaction will proceed.

65. 1 gram of sodium hydroxide was treated with 25 mL of 0.75 M HCl solution, the mass of sodium hydroxide left unreacted is equal to

- (1) Zero mg
- (2) 200 mg
- (3) 75 mg
- (4) 250 mg

**Correct Answer:** (4) 250 mg

**Solution:** Calculate the moles of NaOH and HCl, then determine the leftover NaOH.

$$\text{Moles of NaOH} = \frac{1 \text{ g}}{40 \text{ g/mol}} = 0.025 \text{ mol}$$

$$\text{Moles of HCl} = 0.75 \text{ M} \times 0.025 \text{ L} = 0.01875 \text{ mol}$$

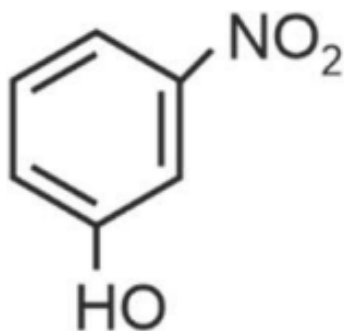
$$\text{Excess NaOH} = 0.025 \text{ mol} - 0.01875 \text{ mol} = 0.00625 \text{ mol}$$

$$\text{Mass of excess NaOH} = 0.00625 \text{ mol} \times 40 \text{ g/mol} = 250 \text{ mg}$$

**💡 Quick Tip**

Always ensure to check stoichiometry in neutralization reactions. NaOH and HCl react in a 1:1 molar ratio.

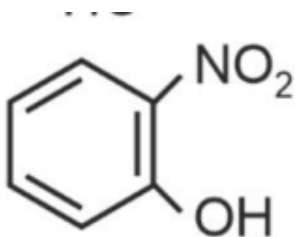
66. Intramolecular hydrogen bonding is present in



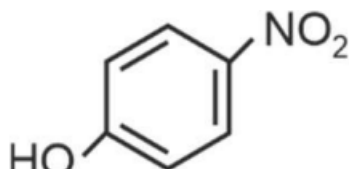
(1)



(2)



(3)



(4)

**Correct Answer: (3)**

**Solution:** Identify structures capable of intramolecular hydrogen bonding. Intramolecular hydrogen bonding typically occurs when hydrogen-bonding groups are positioned to form a stable five- or six-membered ring. Option (3) allows for such a configuration, with the OH and NO<sub>2</sub> on the same carbon.

**💡 Quick Tip**

Intramolecular hydrogen bonds are stronger and more stable when they form smaller rings, typically five- or six-membered.

67. 'Spin only' magnetic moment is same for which of the following ions?

A.  $\text{Ti}^{3+}$

B.  $\text{Cr}^{2+}$

C.  $\text{Mn}^{2+}$

D.  $\text{Fe}^{2+}$

E.  $\text{Sc}^{3+}$

Choose the most appropriate answer from the options given below.

(1) B and C only

(2) A and D only

(3) B and D only

(4) A and E only

**Correct Answer: (3) B and D only**

**Solution:** Magnetic moment formula for a transition metal ion is given by:

$$\mu = \sqrt{n(n+2)} \text{ Bohr magnetons (BM)}$$

where  $n$  is the number of unpaired electrons.

**Magnetic Moments for Each Ion:**

- $\text{Ti}^{3+}$ :  $[\text{Ar}] 3d^1$ ,  $\mu = \sqrt{1 \times (1+2)} = \sqrt{3} \text{ BM}$
- $\text{Cr}^{2+}$ :  $[\text{Ar}] 3d^4$ ,  $\mu = \sqrt{4 \times (4+2)} = \sqrt{24} \text{ BM}$
- $\text{Mn}^{2+}$ :  $[\text{Ar}] 3d^5$ ,  $\mu = \sqrt{5 \times (5+2)} = \sqrt{35} \text{ BM}$
- $\text{Fe}^{2+}$ :  $[\text{Ar}] 3d^6$ ,  $\mu = \sqrt{4 \times (4+2)} = \sqrt{24} \text{ BM}$ , identical to  $\text{Cr}^{2+}$
- $\text{Sc}^{3+}$ :  $[\text{Ar}] 3d^0$ ,  $\mu = \sqrt{0 \times (0+2)} = 0 \text{ BM}$ , has no unpaired electrons

**Explanation for Identical Moments:**

- Both  $\text{Cr}^{2+}$  and  $\text{Fe}^{2+}$  have four unpaired electrons leading to an identical magnetic moment of  $\sqrt{24} \text{ BM}$ . This is due to similar electron configurations in terms of unpaired electrons despite being in different elements.
- Other ions like  $\text{Ti}^{3+}$  and  $\text{Sc}^{3+}$  differ significantly in their number of unpaired electrons and therefore in their magnetic moments.

**💡 Quick Tip**

Remember to account for the electron configuration and the ligand field theory when predicting magnetic properties of transition metal ions.

**68. The reagents with which glucose does not react to give the corresponding tests/products are**

A. Tollen's reagent

B. Schiff's reagent

C. HCN

D.  $\text{NH}_2\text{OH}$

E.  $\text{NaHSO}_3$

Choose the correct options from the given below:

(1.) B and E

- (2.) E and D  
 (3.) B and C  
 (4.) A and D

**Correct Answer: (1) B and E**

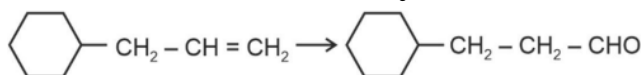
**Solution:** Analyze the reactivity of glucose with each reagent.

- Tollen's reagent reacts with glucose to give a silver mirror, indicating the presence of aldehydic groups.
- Schiff's reagent does not typically react with glucose as it is designed to detect aliphatic aldehydes.
- HCN can add to the carbonyl group in glucose forming cyanohydrins.
- $\text{NH}_2\text{OH}$  can react with glucose to form oximes.
- $\text{NaHSO}_3$  does not react readily with glucose due to its structure and the stability of the aldehyde group.

**💡 Quick Tip**

Schiff's reagent is sensitive to simple aldehydes but less reactive towards sugars due to their cyclic hemiacetal forms.

**69. Identify the correct reagents that would bring about the following transformation: from an alkene to an aldehyde.**



(A)

(B)  $\text{BH}_3$  (C)  $\text{H}_2\text{O}_2 / \text{OH}^-$  (D) alk.  $\text{KMnO}_4$  (E)  $\text{H}_3\text{O}^+$  (A)  $\text{H}_2\text{O} / \text{H}^+$  (B) PCC (A)  $\text{H}_2\text{O} / \text{H}^+$  (B)  $\text{CrO}_3$  (A)  $\text{BH}_3$  (B)  $\text{H}_2\text{O}_2 / \text{OH}^-$  (C) PCC

**Correct Answer: (4)**

**Solution:** Determine the appropriate reagents for hydroboration-oxidation.

- Hydroboration ( $\text{BH}_3$ ):** The first step involves the hydroboration of cyclohexene, which converts the alkene to an organoborane. This process adds the  $\text{BH}_2$  group and a hydrogen across the double bond, leading to a linear alkylborane intermediate.
- Oxidation ( $\text{H}_2\text{O}_2 / \text{OH}^-$ ):** The organoborane is then oxidized by hydrogen peroxide in the presence of hydroxide ions, converting the boron atom into a hydroxyl group. This results in an alcohol at the position initially occupied by the double bond in cyclohexene.
- Oxidation to Aldehyde (PCC):** Finally, the primary alcohol formed in the previous step is oxidized to an aldehyde using pyridinium chlorochromate (PCC). This step completes the transformation by introducing the desired  $\text{CHO}$  group at the end of the chain.

**Reason for not choosing other options:**

**(A) Includes inappropriate or insufficient reagents for the desired transformation.**

**Specifically, none of these combinations provide a coherent path for both ring opening and controlled oxidation to the aldehyde without over-oxidation to carboxylic acids or under-oxidation.**

**💡 Quick Tip**

**Hydroboration-oxidation is a two-step reaction that is stereospecific and typically converts the less substituted carbon of the double bond into an aldehyde.**

**70. Activation energy of any chemical reaction can be calculated if one knows the value of**

- (1) orientation of reactant molecules during collision**
- (2) rate constant at two different temperatures**
- (3) rate constant at standard temperature**
- (4) probability of collision**

**Correct Answer: (2) rate constant at two different temperatures**

**Solution: The Arrhenius Equation:**

**The activation energy of a chemical reaction can be determined using the Arrhenius equation:**

$$k = Ae^{-\frac{E_a}{RT}}$$

**where:**

- **$k$  is the rate constant of the reaction.**
- **$A$  is the pre-exponential factor (a constant).**
- **$E_a$  is the activation energy.**
- **$R$  is the universal gas constant ( $8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ ).**
- **$T$  is the absolute temperature in Kelvin.**

**Calculating Activation Energy: By rearranging the Arrhenius equation, we get:**

$$\ln(k) = \ln(A) - \frac{E_a}{R} \left( \frac{1}{T} \right)$$

**If the rate constant is known at two different temperatures,  $T_1$  and  $T_2$ , the above equation can be applied to each temperature:**

$$\ln(k_1) = \ln(A) - \frac{E_a}{R} \left( \frac{1}{T_1} \right)$$

$$\ln(k_2) = \ln(A) - \frac{E_a}{R} \left( \frac{1}{T_2} \right)$$

**By subtracting these two equations:**

$$\ln(k_2) - \ln(k_1) = \frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$

Solving for  $E_a$ :

$$E_a = R \frac{\ln(k_1) - \ln(k_2)}{\frac{1}{T_1} - \frac{1}{T_2}}$$

This formulation allows us to calculate the activation energy using the known values of rate constants at two different temperatures.

#### 💡 Quick Tip

The Arrhenius equation is given by  $k = Ae^{-E_a/(RT)}$ , where  $E_a$  is the activation energy,  $R$  is the gas constant,  $T$  is the temperature, and  $A$  is the pre-exponential factor.

**71. Arrange the following elements in increasing order of first ionization enthalpy: Li, Be, B, C, N**

- (1)  $\text{Li} < \text{Be} < \text{C} < \text{B} < \text{N}$
- (2)  $\text{Li} < \text{Be} < \text{N} < \text{B} < \text{C}$
- (3)  $\text{Li} < \text{Be} < \text{B} < \text{C} < \text{N}$
- (4)  $\text{Li} < \text{B} < \text{Be} < \text{C} < \text{N}$

**Correct Answer: (4)  $\text{Li} < \text{B} < \text{Be} < \text{C} < \text{N}$**

**Solution:** First ionization enthalpy is the energy required to remove the first electron from a gaseous atom. Several factors influence it:

**Nuclear Charge:** Higher nuclear charge (more protons) increases ionization enthalpy.

**Shielding Effect:** Inner electrons shield outer electrons, reducing the effective nuclear charge and decreasing ionization enthalpy.

**Atomic Radius:** Larger atomic radius decreases ionization enthalpy.

**Electronic Configuration:** Half-filled or fully filled subshells have extra stability, leading to higher ionization enthalpy.

Across a period, ionization enthalpy generally increases due to increasing nuclear charge and decreasing atomic radius. However, there are exceptions:

**Be** (filled 2s subshell) has higher ionization enthalpy than **B**.

**N** (half-filled 2p subshell) has higher ionization enthalpy than **O** (not in the given set, but relevant to understanding the trend).

Considering these factors, the order of increasing first ionization enthalpy is:

$\text{Li} < \text{B} < \text{Be} < \text{C} < \text{N}$

**Explanation of the order:**

1. **Li:** Lowest ionization enthalpy as it has the fewest protons and largest atomic radius in the given set.
2. **B:** Ionization enthalpy is less than Be due to Be's filled 2s subshell.
3. **Be:** Higher ionization enthalpy than B due to its filled 2s subshell ( $2s^2$ ).
4. **C:** Ionization enthalpy increases due to increasing nuclear charge.

5. N: Highest ionization enthalpy due to its smaller size and half-filled 2p subshell ( $2p^3$ ), which provides extra stability.

Therefore, the correct answer is (4)  $\text{Li} < \text{B} < \text{Be} < \text{C} < \text{N}$ .

💡 Quick Tip

Ionization energy increases as you move from left to right across a period due to the increase in effective nuclear charge. However, remember the exceptions at Group 2 and Group 5.

72. Among Group 16 elements, which one does NOT show -2 oxidation state?

- (1) Te
- (2) Po
- (3) O
- (4) Se

Correct Answer: (2) Po

Solution: Background on Group 16 Elements:

Group 16 elements typically have six electrons in their outer shell ( $ns^2np^4$ ), allowing them to gain two electrons to complete their octet, thereby exhibiting a -2 oxidation state. However, the stability of this oxidation state decreases down the group due to increasing atomic size and decreasing electron affinity.

Element Analysis:

- Oxygen (O) is highly electronegative and commonly forms -2 oxidation state in most of its compounds (e.g., water,  $H_2O$ ).
- Selenium (Se) and Tellurium (Te) also exhibit the -2 oxidation state, though less frequently than oxygen, as in hydrogen selenide ( $H_2Se$ ) and hydrogen telluride ( $H_2Te$ ).
- Polonium (Po), due to its position at the bottom of the group and its metallic character, rarely exhibits a -2 oxidation state. Its common oxidation states are +2 and +4. Polonium's tendency to exhibit positive oxidation states is attributed to its relativistic effects and the inert pair effect, which stabilize higher oxidation states and make the loss of electrons more favorable than gain.

Conclusion: Polonium's reluctance to exhibit a -2 oxidation state, unlike its lighter congeners, is due to the energy considerations associated with adding two electrons into an already large and electron-rich valence shell. Its chemistry is dominated instead by higher, positive oxidation states.

💡 Quick Tip

When considering oxidation states, always take into account the element's position in the periodic table and its metallic or non-metallic character.

73. Which reaction is NOT a redox reaction?

- (1)  $H_2 + Cl_2 \rightarrow 2HCl$   
 (2)  $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$   
 (3)  $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$   
 (4)  $2KClO_3 \rightarrow 2KCl + 3O_2$

**Correct Answer:** (2)  $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

**Solution:** Analysis of each reaction:

- **Reaction 1:**  $H_2 + Cl_2 \rightarrow 2HCl$  - Oxidation states change as follows:  $H_0 \rightarrow H^{+1}$  and  $Cl_0 \rightarrow Cl^{-1}$ .  
 - Hydrogen is oxidized, and chlorine is reduced. This is a redox reaction.
- **Reaction 2:**  $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$  - The ions exchange partners without any change in the oxidation states of the elements involved.  
 - All elements retain their original oxidation states. Barium (+2), chlorine (−1), sodium (+1), sulfur (+6), and oxygen (−2) remain unchanged. This is not a redox reaction; it is a double displacement reaction.
- **Reaction 3:**  $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$  - Oxidation states change as follows:  $Zn_0 \rightarrow Zn^{+2}$  and  $Cu^{+2} \rightarrow Cu_0$ . - Zinc is oxidized, and copper is reduced. This is a redox reaction.
- **Reaction 4:**  $2KClO_3 + I_2 \rightarrow 2KIO_3 + Cl_2$  - Oxidation states change as follows:  $Cl^{+5} \rightarrow Cl_0$  and  $I_0 \rightarrow I^{+5}$ . - Chlorine is reduced, and iodine is oxidized. This is a redox reaction.

**Conclusion:** Only reaction 2 does not involve any changes in oxidation states of the elements, indicating no electron transfer occurred. Hence, it is not a redox reaction, while the others are.

**💡 Quick Tip**

Redox reactions involve the transfer of electrons between species, leading to changes in oxidation states. Precipitation and other double displacement reactions typically do not involve such electron transfers.

**74. In which of the following equilibria,  $K_p$  and  $K_c$  are NOT equal?**

- (1)  $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$   
 (2)  $2BrCl_{(g)} \rightleftharpoons Br_{2(g)} + Cl_{2(g)}$   
 (3)  $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$   
 (4)  $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

**Correct Answer:** (3)

**Solution:** Understand the relationship between  $K_p$  and  $K_c$ .

The equilibrium constants  $K_p$  and  $K_c$  are related by the equation  $K_p = K_c(RT)^{\Delta n}$  where  $\Delta n$  is the change in moles of gas.

In Reaction (3),  $\Delta n = 1 - 2 = -1$ , therefore  $K_p \neq K_c$ .

**💡 Quick Tip**

When  $\Delta n \neq 0$ ,  $K_p$  and  $K_c$  will differ due to the contribution of the gas constant and temperature to the equation.

**75.** The Henry's law constant ( $K_H$ ) values of three gases (A, B, C) in water are 145,  $2 \times 10^{-5}$ , and 35 kbar, respectively. The solubility of these gases in water follow the order:

- (1)  $A > C > B$
- (2)  $A > B > C$
- (3)  $B > A > C$
- (4)  $B > C > A$

**Correct Answer:** (4)  $B > C > A$

**Solution:** Understand the relationship between Henry's Law constant and solubility. Henry's Law states that the solubility of a gas in a liquid at a given temperature is directly proportional to the partial pressure of the gas above the liquid and inversely proportional to the Henry's Law constant ( $K_H$ ). Thus, a lower  $K_H$  value indicates higher solubility.

$K_H$  values:  $A = 145$  kbar,  $B = 2 \times 10^{-5}$  kbar,  $C = 35$  kbar

Given these values, B, with the lowest  $K_H$ , is the most soluble, followed by C, then A.

**💡 Quick Tip**

Remember, a lower Henry's Law constant means the gas is more soluble in the liquid because the gas's partial pressure needs to be lower to achieve the same concentration in solution.

**76.** Given below are two statements:

**Statement I:** The boiling point of three isomeric pentanes follows the order n-pentane > isopentane > neopentane.

**Statement II:** When branching increases, the molecule attains a shape of sphere. This results in smaller surface area for contact, due to which the intermolecular forces between the spherical molecules are weak, thereby lowering the boiling point.

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

- (1) Statement I is correct but Statement II is incorrect
- (2) Statement I is incorrect but Statement II is correct
- (3) Both Statement I and Statement II are correct
- (4) Both Statement I and Statement II are incorrect

**Correct Answer: (3) Both Statement I and Statement II are correct**

**Solution: Statement I Analysis:**

Boiling points of alkanes are influenced by their molecular surface area. n-pentane, being the least branched, presents the largest surface area for van der Waals interactions, leading to a higher boiling point.

Isopentane, with moderate branching, has a somewhat reduced surface area compared to n-pentane, resulting in a slightly lower boiling point.

Neopentane, the most branched and thus the most compact of the isomers, has the smallest surface area and the lowest boiling point among them.

The order n-pentane > isopentane > neopentane is correct and aligns with observed physical properties.

**Statement II Analysis:**

The statement provides a correct rationale for the trend observed in Statement I.

Increased branching leads to a more spherical molecular shape, reducing the effective surface area that can participate in intermolecular van der Waals forces. This geometric effect leads to weaker intermolecular attractions and hence a lower boiling point for more highly branched molecules.

**Conclusion:** Both statements are correct and they provide an accurate description and explanation for the observed trend in the boiling points of isomeric pentanes. The effect of molecular shape on boiling points is a fundamental concept in organic chemistry, explaining the physical properties of molecules based on their structural differences.

**💡 Quick Tip**

Remember that increased branching in hydrocarbons leads to a more compact shape with a smaller surface area, reducing the effective area for van der Waals interactions and thus lowering the boiling point.

**77. Given below are two statements:**

**Statement I:** Aniline does not undergo Friedel-Crafts alkylation reaction.

**Statement II:** Aniline cannot be prepared through Gabriel synthesis.

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

- (1) Statement I is correct but Statement II is false
- (2) Statement I is incorrect but Statement II is true
- (3) Both statement I and Statement II are true
- (4) Both Statement I and Statement II are false

**Correct Answer: (3) Both statement I and Statement II are true**

**Solution: Validate the statements.**

Statement I is true as aniline, being a strong activator, reacts in such a way in Friedel-Crafts reactions that it can deactivate the catalyst, aluminium chloride, by forming complexes. Statement II is also true because Gabriel synthesis is used for synthesizing primary amines that do not involve aromatic amines like aniline.

**💡 Quick Tip**

Aniline's amine group strongly interacts with Lewis acids used in Friedel-Crafts reactions, preventing the usual course of the reaction. Gabriel synthesis is not suitable for aromatic amines due to its mechanism.

**78. The highest number of helium atoms is in**

- (1) 4 g of helium
- (2) 2.271098 L of helium at STP
- (3) 4 mol of helium
- (4) 4 u of helium

**Correct Answer: (3) 4 mol of helium**

**Solution: Analysis of each option:**

**Option 1: 4 g of helium** - The molar mass of helium (He) is approximately 4 g/mol.

- 4 g of helium =  $\frac{4 \text{ g}}{4 \text{ g/mol}} = 1 \text{ mol of helium.}$

- 1 mol of helium contains  $6.022 \times 10^{23}$  atoms (Avogadro's number).

**Option 2: 2.271098 L of helium at STP**

- At STP (standard temperature and pressure), 1 mol of any gas occupies 22.4 L.

- 2.271098 L of helium at STP =  $\frac{2.271098 \text{ L}}{22.4 \text{ L/mol}} \approx 0.101 \text{ mol.}$

- 0.101 mol of helium contains  $0.101 \times 6.022 \times 10^{23} \approx 6.08 \times 10^{22}$  atoms.

**Option 3: 4 mol of helium**

- 4 mol of helium =  $4 \times 6.022 \times 10^{23} = 2.4088 \times 10^{24}$  atoms.

**Option 4: 4 u of helium**

- The atomic mass unit (u) corresponds to the mass of one atom; however, 4 u of helium does not correspond to a mole but to the atomic mass.

- 4 u of helium is not a complete mole and does not equal  $6.022 \times 10^{23}$  atoms but rather a minuscule number compared to a mole.

**Conclusion:**

The option with 4 mol of helium (Option 3) contains the highest number of helium atoms because each mole contains  $6.022 \times 10^{23}$  atoms, multiplying this by 4 provides the largest number count.

**💡 Quick Tip**

Always remember that the mole concept links the mass of a substance to the number of entities (atoms, molecules, etc.) it contains using Avogadro's number,  $6.022 \times 10^{23}$ .

**79. Arrange the following elements in increasing order of electronegativity: N, O, F, C, Si**

- (1)  $\text{O} < \text{F} < \text{N} < \text{C} < \text{Si}$
- (2)  $\text{F} < \text{O} < \text{N} < \text{C} < \text{Si}$
- (3)  $\text{Si} < \text{C} < \text{N} < \text{O} < \text{F}$

(4)  $\text{Si} < \text{C} < \text{O} < \text{N} < \text{F}$

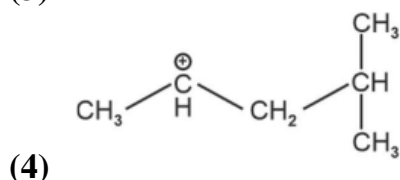
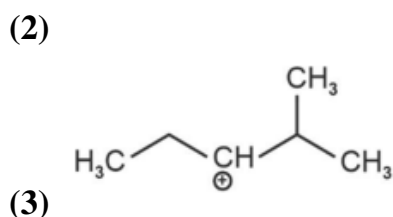
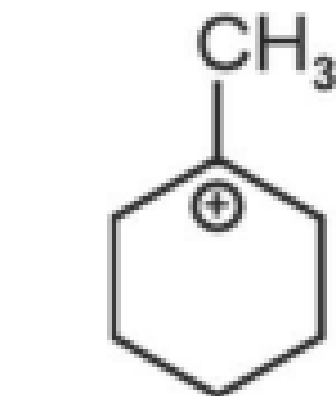
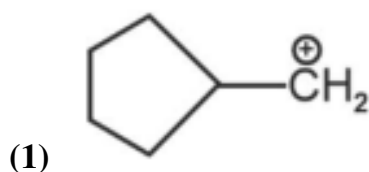
Correct Answer: (3)  $\text{Si} < \text{C} < \text{N} < \text{O} < \text{F}$

**Solution:** Recall the general trend of electronegativity in the periodic table. Electronegativity increases across a period from left to right and decreases down a group. Hence, among the given elements, fluorine (F) is the most electronegative, followed by oxygen (O), nitrogen (N), carbon (C), and silicon (Si) being the least electronegative.

💡 Quick Tip

Pauling's scale of electronegativity can help predict and compare the electronegativity of elements quickly. Remember that halogens are highly electronegative, with fluorine being the most electronegative element.

80. The most stable carbocation among the following is:



Correct Answer: (2)

**Solution:** Analyze the stability of the carbocations based on structural features.

The most stable carbocation typically has the most alkyl groups attached to the positively charged carbon, providing greater electron-donating effects through hyperconjugation and inductive effects. Among the given options, the structure with extensive alkyl substitution around the carbocation (as described for option (2)) would be the most stable.

**💡 Quick Tip**

Carbocations are stabilized by alkyl groups through hyperconjugation and inductive effects. The more alkyl groups directly attached, the more stable the carbocation.

**81. Given below are two statements:**

**Statement I:** The boiling point of hydrides of Group 16 elements follow the order  $\text{H}_2\text{O} > \text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{S}$ .

**Statement II:** On the basis of molecular mass,  $\text{H}_2\text{O}$  is expected to have lower boiling point than the other members of the group but due to the presence of extensive H-bonding in  $\text{H}_2\text{O}$ , it has higher boiling point.

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

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are true
- (4) Both Statement I and Statement II are false

**Correct Answer:** (3) Both Statement I and Statement II are true

**Solution:** Validate each statement.

Statement I correctly describes the boiling point order due to hydrogen bonding and molecular size. Statement II accurately explains the anomaly in boiling points within the group due to hydrogen bonding, despite  $\text{H}_2\text{O}$  having a smaller molecular mass.

**💡 Quick Tip**

Hydrogen bonding plays a crucial role in determining the physical properties of compounds, significantly affecting boiling points by increasing intermolecular attractions.

**82. Match List I with List II.**

| List I (Complex)                                        | List II (Type of isomerism) |
|---------------------------------------------------------|-----------------------------|
| A. $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ | I. Solvate isomerism        |
| B. $[\text{Co}(\text{NH}_3)_5(\text{SO}_4)]\text{Br}$   | II. Linkage isomerism       |
| C. $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ | III. Ionization isomerism   |
| D. $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_3$       | IV. Coordination isomerism  |

Choose the correct answer from the options given below:

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

**Correct Answer: (3) A-II, B-III, C-IV, D-I**

**Solution:**

**A.  $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ :** The  $\text{NO}_2$  ligand can bind through either nitrogen (nitro) or oxygen (nitrito), exhibiting linkage isomerism. Match: A - II

**B.  $[\text{Co}(\text{NH}_3)_5(\text{SO}_4)]\text{Br}$ :** The  $\text{SO}_4^{2-}$  ion can be inside or outside the coordination sphere, leading to ionization isomerism. Match: B - III

**C.  $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ :** This complex has two complex ions. The ligands on the metal centers can be exchanged, resulting in coordination isomerism. Match: C - IV

**D.  $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_3$ :** This complex can exist as different hydrates, with varying numbers of water molecules coordinated to the cobalt ion. This is a form of solvate isomerism (specifically, hydrate isomerism). Match: D - I

Therefore, the correct matching is A-II, B-III, C-IV, and D-I. The correct answer is (3).

**💡 Quick Tip**

Understanding the coordination sphere and the arrangement of ligands helps in identifying the type of isomerism exhibited by coordination compounds.

**83. On heating, some solid substances change from solid to vapor state without passing through liquid state. The technique used for the purification of such solid substances based on the above principle is known as**

- (1) Distillation
- (2) Chromatography
- (3) Crystallization
- (4) Sublimation

**Correct Answer: (4) Sublimation**

**Solution: Sublimation:**

Sublimation is the process where a solid changes directly to a gas when heated, bypassing the liquid phase. This physical property is characteristic of certain compounds, such as dry ice (solid  $\text{CO}$ ), iodine, naphthalene, and ammonium chloride.

**Principle:**

The principle behind using sublimation for purification is based on the ability of sublimable substances to vaporize when heated. The vapor then condenses back to solid form on a cooler surface, effectively separating the pure substance from non-sublimable impurities.

**Application:**

This technique is particularly useful in separating mixtures where one or more components are capable of sublimating. It is widely used in the purification of substances in laboratories and in certain industrial processes.

**Why not the other options?**

**(A) Distillation** involves the conversion of a liquid into vapor which is subsequently condensed back into liquid form. It is typically used for the purification of liquids or separating mixtures based on differences in boiling points.

(B) Chromatography is a technique for separating mixtures based on differences in the speed at which they move through a medium under the influence of one or more forces. It is not typically used for direct purification of solids from solids.

(C) Crystallization involves the formation of solid crystals from a uniform solution. It is not suitable for substances that sublime, as they do not remain in a liquid solution.

**Conclusion:** Sublimation is the most appropriate method for purifying substances that transition directly from solid to vapor because it exploits their unique physical properties to achieve separation and purification.

#### 💡 Quick Tip

Sublimation is useful for separating substances that sublime from those that do not. It is often used in organic chemistry and forensics.

**84.** The  $E^\circ$  value for the  $\text{Mn}^{3+}/\text{Mn}^{2+}$  couple is more positive than that of  $\text{Cr}^{3+}/\text{Cr}^{2+}$  or  $\text{Fe}^{3+}/\text{Fe}^{2+}$  due to change of

- (1)  $d^4$  to  $d^5$  configuration
- (2)  $d^3$  to  $d^5$  configuration
- (3)  $d^5$  to  $d^4$  configuration
- (4)  $d^5$  to  $d^2$  configuration

**Correct Answer:** (1)  $d^4$  to  $d^5$  configuration

**Solution:** Electrochemical Background:

The standard electrode potential ( $E^\circ$ ) for a redox couple indicates the tendency of a chemical species to be reduced, and is influenced by the electronic configuration of the metal ions involved.

**Electronic Configurations and Changes:**

- $\text{Mn}^{2+}$  typically has a  $d^5$  configuration, which is highly symmetric and half-filled, providing extra stability due to exchange energy.
- $\text{Mn}^{3+}$  generally has a  $d^4$  configuration.
- The reduction of  $\text{Mn}^{3+}$  to  $\text{Mn}^{2+}$  ( $d^4 \rightarrow d^5$ ) increases stability because it completes a half-filled  $d^5$  subshell.

**Comparison with Other Elements:**

- Chromium and Iron do not gain similar stability from their redox changes as manganese does. Chromium transitions from  $d^3$  in  $\text{Cr}^{2+}$  to  $d^2$  in  $\text{Cr}^{3+}$ , and iron transitions from  $d^6$  in  $\text{Fe}^{2+}$  to  $d^5$  in  $\text{Fe}^{3+}$ . These changes do not result in a half-filled subshell configuration.
- The special stability of the half-filled  $d^5$  configuration in  $\text{Mn}^{2+}$  results in a more positive  $E^\circ$  value for the  $\text{Mn}^{3+}/\text{Mn}^{2+}$  couple.

**Conclusion:**

The more positive  $E^\circ$  value for the  $\text{Mn}^{3+}/\text{Mn}^{2+}$  couple is primarily due to the stability gained from transitioning to a half-filled  $d^5$  configuration, which is energetically favorable.

**⚡ Quick Tip**

Half-filled and fully-filled d orbitals (like  $d^5$  and  $d^{10}$ ) are particularly stable due to electron exchange energy and symmetry.

**85. Match List I with List II.**

| List I (Conversion)                                 | List II (Number of Faraday required) |
|-----------------------------------------------------|--------------------------------------|
| A. 1 mol of $\text{H}_2\text{O}$ to $\text{O}_2$    | I. 3F                                |
| B. 1 mol of $\text{MnO}_4^-$ to $\text{Mn}^{2+}$    | II. 2F                               |
| C. 1.5 mol of Ca from molten $\text{CaCl}_2$        | III. 1F                              |
| D. 1 mol of $\text{FeO}$ to $\text{Fe}_2\text{O}_3$ | IV. 5F                               |

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

**Correct Answer: (3) A-II, B-IV, C-I, D-III**

**Solution:** A. 1 mol of  $\text{H}_2\text{O}$  to  $\text{O}_2$ : The balanced equation is  $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$ . 2 moles of  $\text{H}_2\text{O}$  require 4 moles of electrons, so 1 mole of  $\text{H}_2\text{O}$  requires 2 moles of electrons (2F). Match: A - II

B. 1 mol of  $\text{MnO}_4^-$  to  $\text{Mn}^{2+}$ : The balanced equation is  $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$ . 1 mole of  $\text{MnO}_4^-$  requires 5 moles of electrons (5F). Match: B - IV

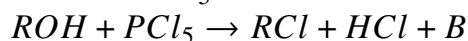
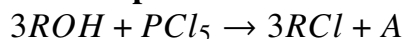
C. 1.5 mol of Ca from molten  $\text{CaCl}_2$ : The balanced equation is  $\text{Ca}^{2+} + 2\text{e}^- \rightarrow \text{Ca}$ . 1 mole of Ca requires 2 moles of electrons. 1.5 moles of Ca require  $1.5 \times 2 = 3$  moles of electrons (3F). Match: C - I

D. 1 mol of  $\text{FeO}$  to  $\text{Fe}_2\text{O}_3$ : The balanced equation is  $2\text{FeO} + \frac{1}{2}\text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$ . The oxidation state of Fe changes from +2 in  $\text{FeO}$  to +3 in  $\text{Fe}_2\text{O}_3$ . For 1 mole of  $\text{FeO}$ , the change is 1 mole of electrons (1F). Match: D - III

Therefore, the correct matching is A-II, B-IV, C-I, and D-III. The correct answer is (3).

**⚡ Quick Tip**

In electrochemical processes, one Faraday (F) of charge corresponds to the charge of one mole of electrons, about 96,485 coulombs.

**SECTION-B****86. The products A and B obtained in the following reactions, respectively, are**

- (1)  $\text{H}_3\text{PO}_4$  and  $\text{POCl}_3$   
(2)  $\text{H}_3\text{PO}_3$  and  $\text{POCl}_3$   
(3)  $\text{POCl}_3$  and  $\text{H}_3\text{PO}_3$   
(4)  $\text{POCl}_3$  and  $\text{H}_3\text{PO}_4$

**Correct Answer:** (2)  $H_3PO_3$  and  $POCl_3$

**Solution:** Identify the reaction products.

In the reaction of alcohols with  $PCl_5$ ,  $POCl_3$  is usually formed along with  $PCl_3$ . The by-product with excess alcohol typically includes  $H_3PO_3$  (phosphorous acid), not  $H_3PO_4$  which requires oxidation conditions not present here.

**💡 Quick Tip**

When reacting  $PCl_5$  with alcohols,  $POCl_3$  and  $PCl_3$  are typically formed, and the specific conditions and stoichiometry determine the nature of the additional phosphorus-containing by-products.

**87. Identify the correct answer.**

- (1) Dipole moment of  $NF_3$  is greater than that of  $NH_3$
- (2) Three canonical forms can be drawn for  $CO_3^{2-}$  ion
- (3) Three resonance structures can be drawn for ozone
- (4)  $BF_3$  has non-zero dipole moment

**Correct Answer:** (2) Three canonical forms can be drawn for  $CO_3^{2-}$  ion

**Solution:** Evaluate each statement for accuracy.

The correct statement about the carbonate ion ( $CO_3^{2-}$ ) is that it indeed has three equivalent resonance structures due to the three possible positions for the double bond among the oxygen atoms.

**💡 Quick Tip**

In molecules or ions with equivalent bonding arrangements, resonance structures help distribute charge and bonding evenly, as seen in  $CO_3^{2-}$ .

**88. The rate of a reaction quadruples when temperature changes from  $27^\circ\text{C}$  to  $57^\circ\text{C}$ . Calculate the energy of activation.**

Given  $R = 8.314 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ ,  $\log(4) = 0.6021$

- (1) 38.0 kJ/mol
- (2) 3804 kJ/mol
- (3) 38.04 kJ/mol
- (4) 380.4 kJ/mol

**Correct Answer:** (3) 38.04 kJ/mol

**Solution:** To calculate the energy of activation ( $E_a$ ) for the reaction, we use the Arrhenius equation:

$$k = Ae^{-\frac{E_a}{RT}}$$

When the temperature changes, the rate constant changes. The relationship between the rate constants at two different temperatures ( $T_1$  and  $T_2$ ) is:

$$\frac{k_2}{k_1} = e^{-\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)}$$

**Taking the natural logarithm on both sides:**

$$\ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

**Given:**

- The rate of the reaction quadruples, so  $\frac{k_2}{k_1} = 4$ ,
- $T_1 = 27^\circ\text{C} = 300\text{ K}$ ,
- $T_2 = 57^\circ\text{C} = 330\text{ K}$ ,
- $R = 8.314\text{ J K}^{-1}\text{mol}^{-1}$ ,
- $\log 4 = 0.6021$ .

**Step 1: Convert  $\log 4$  to  $\ln 4$**

$$\ln 4 = 2.303 \times \log 4 = 2.303 \times 0.6021 = 1.386$$

**Step 2: Substitute values into the Arrhenius equation**

$$1.386 = -\frac{E_a}{8.314}\left(\frac{1}{330} - \frac{1}{300}\right)$$

**Step 3: Simplify the equation**

$$\frac{1}{330} - \frac{1}{300} = -\frac{1}{3300}$$

$$1.386 = \frac{E_a}{8.314 \times 3300}$$

**Step 4: Solve for  $E_a$**

$$E_a = 1.386 \times 8.314 \times 3300$$

$$E_a \approx 38000\text{ J/mol}$$

$$E_a \approx 38\text{ kJ/mol}$$

**Final Answer The energy of activation is:**

$$\boxed{38\text{ kJ/mol}}$$

#### 💡 Quick Tip

Always convert temperatures to Kelvin when using the Arrhenius equation to avoid errors in the exponential term.

**89.** Given below are certain cations. Using inorganic qualitative analysis, arrange them in increasing group number from 0 to VI.

A.  $Al^{3+}$

B.  $Cu^{2+}$

C.  $Ba^{2+}$

D.  $Co^{2+}$

E.  $Mg^{2+}$

(1) E, C, D, B, A

(2) E, A, B, C, D

(3) B, A, D, C, E

(4) B, C, A, D, E

**Correct Answer:** (3) B, A, D, C, E

**Solution:** Order the cations by typical qualitative analysis group.

-  $Mg^{2+}$  (Group II)

-  $Ba^{2+}$  (Group II)

-  $Al^{3+}$  (Group III)

-  $Co^{2+}$  (Group IV)

-  $Cu^{2+}$  (Group V)

Arranging them gives the sequence: E, C, A, D, B.

**💡 Quick Tip**

Qualitative inorganic analysis typically involves precipitation reactions with specific reagents that distinguish different cations based on their solubility and color changes.

**90.** The plot of osmotic pressure ( $\Pi$ ) vs concentration ( $\text{mol L}^{-1}$ ) for a solution gives a straight line with slope  $25.73 \text{ bar mol}^{-1}$ . The temperature at which the osmotic pressure measurement is done is

Given  $R = 0.083 \text{ L bar mol}^{-1} \text{ K}^{-1}$

(1)  $275.3^\circ\text{C}$

(2)  $120.05^\circ\text{C}$

(3)  $37^\circ\text{C}$

(4)  $310^\circ\text{C}$

**Correct Answer:** (3)  $37^\circ\text{C}$

**Solution:** Calculate the temperature using the ideal gas law relation for osmotic pressure.

Using the formula  $\Pi = cRT$ , and given the slope as  $R \times T$ :

$$T = \frac{25.73 \text{ bar mol}^{-1}}{0.083 \text{ L bar mol}^{-1} \text{ K}^{-1}} \approx 310 \text{ K}$$

Converting to Celsius:  $310 \text{ K} - 273.15 = 36.85^\circ\text{C}$ , which rounds to  $37^\circ\text{C}$ .

**💡 Quick Tip**

Always check your units and conversions, especially when working with temperature and pressure in gas laws.

**91. The work done during reversible isothermal expansion of one mole of hydrogen gas at 25°C from pressure of 20 atmospheres to 10 atmospheres is**

**Given  $R = 2.0 \text{ cal K}^{-1} \text{ mol}^{-1}$**

- (1) 14.13 calories**
- (2) 100 calories**
- (3) 0 calorie**
- (4) -413.14 calories**

**Correct Answer: (4) -413.14 calories**

**Solution:** Use the formula for work done during isothermal reversible expansion.

$$W = -nRT \ln \left( \frac{P_2}{P_1} \right)$$

$$W = -1 \times 2.0 \text{ cal K}^{-1} \text{ mol}^{-1} \times 298 \text{ K} \times \ln \left( \frac{10}{20} \right) \approx -413.14 \text{ calories}$$

**💡 Quick Tip**

Remember, work done on expansion is negative because the system is doing work on the surroundings.

**92. A compound X contains 32% of A, 20% of B and remaining percentage of C. Then, the empirical formula of X is:**

**Given atomic masses of A = 64; B = 40; C = 32**

- (1)  $AB_2C_2$**
- (2)  $ABC_4$**
- (3)  $AB_2C$**
- (4)  $AB_3C$**

**Correct Answer: (4)  $AB_3C$**

**Solution: Step 1: Given that the compound X contains:**

- 32% of A,
- 20% of B,
- Remaining 48% of C.

**Step 2: To calculate the mass of each element in 100 g of compound X:**

- Mass of A = 32 g

- Mass of B = 20 g
- Mass of C = 48 g

**Step 3: Convert the mass of each element to moles:**

$$\text{Moles of A} = \frac{32}{64} = 0.5 \text{ mol}$$

$$\text{Moles of B} = \frac{20}{40} = 0.5 \text{ mol}$$

$$\text{Moles of C} = \frac{48}{32} = 1.5 \text{ mol}$$

**Step 4: Find the mole ratio of A, B, and C:**

$$\text{Ratio of A : B : C} = 0.5 : 0.5 : 1.5 = 1 : 1 : 3$$

**Step 5: The empirical formula is based on the simplified mole ratio, which gives us:**

$$\text{Empirical formula} = \text{ABC}_3$$

#### 💡 Quick Tip

To determine the empirical formula from percent composition, convert percentage to grams assuming 100 g of the compound, then to moles using atomic masses, and find the simplest whole number ratio.

**93. During the preparation of Mohr's salt solution (Ferrous ammonium sulphate), which of the following acid is added to prevent hydrolysis of  $\text{Fe}^{2+}$  ion?**

- (1) Dilute nitric acid
- (2) Dilute sulphuric acid
- (3) Dilute hydrochloric acid
- (4) Concentrated sulphuric acid

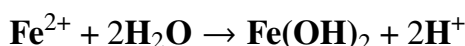
**Correct Answer: (2) Dilute sulphuric acid**

**Solution: Role of Sulfuric Acid in Mohr's Salt Preparation:**

Mohr's salt, or ferrous ammonium sulfate, has the formula  $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ . It is a double salt combining ferrous sulfate and ammonium sulfate.

**Why Dilute Sulfuric Acid?**

- The addition of dilute sulfuric acid to the Mohr's salt solution serves primarily to maintain the solubility of the  $\text{Fe}^{2+}$  ion and to prevent its hydrolysis and oxidation.
- $\text{Fe}^{2+}$  ions tend to hydrolyze in aqueous solution, leading to the formation of iron(II) hydroxide, which is insoluble and can precipitate out of solution:



- Sulfuric acid, being a strong acid, increases the concentration of  $\text{H}^+$  ions in the solution, which shifts the equilibrium of the hydrolysis reaction backward, preventing the formation of iron(II) hydroxide.

- Additionally, sulfuric acid enhances the stability of the  $\text{Fe}^{2+}$  ion by providing the sulfate ion,  $\text{SO}_4^{2-}$ , which is part of the Mohr's salt crystal structure.

#### Why Not the Other Acids?

- Nitric acid (Option 1) is an oxidizing agent and can convert  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$ , which is not desirable for the preparation of Mohr's salt.
- Hydrochloric acid (Option 3) could potentially form volatile complexes with iron or interfere with the stability of the solution.
- Concentrated sulfuric acid (Option 4) is too strong and can cause oxidation and dehydration reactions, which are not suitable for the preparation of a stable salt solution.

**Conclusion:** Dilute sulfuric acid is the most suitable acid for maintaining the stability of the  $\text{Fe}^{2+}$  ion in Mohr's salt solution by preventing hydrolysis and providing necessary sulfate ions for the salt's composition.

#### 💡 Quick Tip

The choice of acid is crucial in preventing oxidation and ensuring the stability of transition metal ions in solution.

#### 94. The pair of lanthanoid ions which are diamagnetic is

- (1)  $\text{Gd}^{3+}$  and  $\text{Eu}^{3+}$
- (2)  $\text{Pm}^{3+}$  and  $\text{Sm}^{3+}$
- (3)  $\text{Ce}^{4+}$  and  $\text{Yb}^{2+}$
- (4)  $\text{Ce}^{3+}$  and  $\text{Eu}^{2+}$

**Correct Answer:** (3)  $\text{Ce}^{4+}$  and  $\text{Yb}^{2+}$

#### Solution: Understanding Diamagnetism in Lanthanoids:

Diamagnetism in lanthanoids occurs when the ion has a completely filled or completely empty f-orbital, resulting in no unpaired electrons.

#### Analysis of Each Option:

- **Option 1:**  $\text{Gd}^{3+}$  and  $\text{Eu}^{3+}$  -  $\text{Gd}^{3+}$  ( $[\text{Xe}]4f^7$ ) has 7 unpaired electrons. -  $\text{Eu}^{3+}$  ( $[\text{Xe}]4f^6$ ) has 6 unpaired electrons. - Both ions are paramagnetic.
- **Option 2:**  $\text{Pm}^{3+}$  and  $\text{Sm}^{3+}$  -  $\text{Pm}^{3+}$  ( $[\text{Xe}]4f^4$ ) has 4 unpaired electrons. -  $\text{Sm}^{3+}$  ( $[\text{Xe}]4f^5$ ) has 5 unpaired electrons. - Both ions are paramagnetic.
- **Option 3:**  $\text{Ce}^{4+}$  and  $\text{Yb}^{2+}$  (Correct) -  $\text{Ce}^{4+}$  ( $[\text{Xe}]$ ) has no f-electrons, resulting in a completely empty f-orbital. -  $\text{Yb}^{2+}$  ( $[\text{Xe}]4f^{14}$ ) has a completely filled f-orbital. - Both ions are diamagnetic due to having no unpaired electrons.
- **Option 4:**  $\text{Ce}^{3+}$  and  $\text{Eu}^{2+}$  -  $\text{Ce}^{3+}$  ( $[\text{Xe}]4f^1$ ) has 1 unpaired electron. -  $\text{Eu}^{2+}$  ( $[\text{Xe}]4f^7$ ) has 7 unpaired electrons. - Both ions are paramagnetic.

**Conclusion:**

The only pair of lanthanoid ions that are both diamagnetic is  $\text{Ce}^{4+}$  and  $\text{Yb}^{2+}$ , as both ions have either fully filled or completely empty f-orbitals, leading to zero unpaired electrons and therefore no magnetic moment.

**💡 Quick Tip**

Diamagnetic substances are characterized by the absence of unpaired electrons and are not attracted to a magnetic field.

95. Consider the following reaction in a sealed vessel at equilibrium with concentrations of

$$N_2 = 3.0 \times 10^{-3} M, \quad O_2 = 4.2 \times 10^{-3} M, \quad NO = 2.8 \times 10^{-3} M$$

.



if  $0.1 \text{ mol L}^{-1}$  of  $NO(g)$  is taken in a closed vessel, what will be the degree of dissociation ( $\alpha$ ) of  $NO$  at equilibrium?

- (1) 0.8889
- (2) 0.717
- (3) 0.00889
- (4) 0.0889

**Correct Answer: (2) 0.717**

**Solution:**

The equilibrium constant  $K_c$  is given by the formula:

$$K_c = \frac{[N_2][O_2]}{[NO]^2}$$

Substituting the values for concentrations:

$$K_c = \frac{3.0 \times 10^{-3} \times 4.2 \times 10^{-3}}{2.8 \times 10^{-3} \times 2.8 \times 10^{-3}} = 1.607$$

At  $t = 0$ , the concentration values are as follows:

$$\text{At } t = 0, [NO] = 0.1, [N_2] = 0, [O_2] = 0$$

At equilibrium, the change in concentration of  $NO$ ,  $N_2$ , and  $O_2$  is described as:

$$0.1 - 0.1\alpha, \quad 0 + 0.05\alpha, \quad 0 + 0.05\alpha$$

Using the expression for the equilibrium constant  $K_c$ :

$$K_c = \frac{0.05\alpha \times 0.05\alpha}{(0.1 - 0.1\alpha)^2}$$

Substituting the values into the equation:

$$1.607 = \frac{(0.05\alpha)^2}{0.01(1-\alpha)^2}$$

This simplifies to:

$$\alpha^2 = \frac{1.607 \times (0.1)^2}{0.05}$$

Solving for  $\alpha$ :

$$\alpha = \frac{1.27 \times 0.1}{0.05} = 2.54$$

Thus, the value of  $\alpha$  is:

$$\alpha = \frac{2.54}{2.54} = 0.717$$

#### 💡 Quick Tip

In calculating the degree of dissociation, relate the change in concentration of reactants and products to the initial concentration of the dissociating species.

**96. Given below are two statements:**

**Statement I:**  $[Co(NH_3)_6]^{3+}$  is a homoleptic complex whereas  $[Co(NH_3)_4Cl_2]^+$  is a heteroleptic complex.

**Statement II:** Complex  $[Co(NH_3)_6]^{3+}$  has only one kind of ligands but  $[Co(NH_3)_4Cl_2]^+$  has more than one kind of ligands.

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

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are true
- (4) Both Statement I and Statement II are false

**Correct Answer: (3) Both Statement I and Statement II are true**

**Solution:**

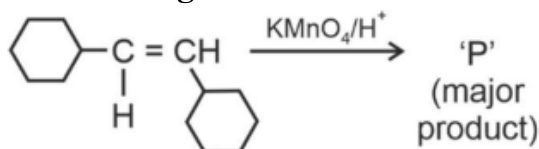
**Statement I is true.**  $[Co(NH_3)_6]^{3+}$  is homoleptic because it contains only one kind of ligand,  $NH_3$ , while  $[Co(NH_3)_4Cl_2]^+$  is heteroleptic because it contains two different types of ligands:  $NH_3$  and  $Cl^-$ .

**Statement II is also true** because  $[Co(NH_3)_6]^{3+}$  indeed has only one type of ligand (ammonia,  $NH_3$ ), while  $[Co(NH_3)_4Cl_2]^+$  has two types of ligands (ammonia and chloride,  $NH_3$  and  $Cl^-$ ).

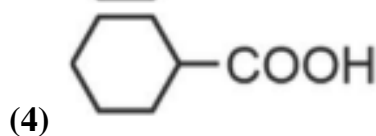
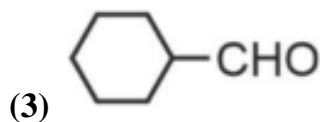
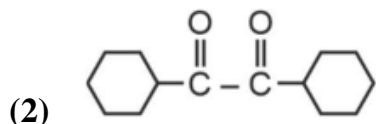
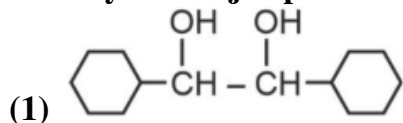
**💡 Quick Tip**

Homoleptic complexes contain only one type of ligand, while heteroleptic complexes contain more than one type of ligand.

97. For the given reaction:



identify the major product *P*.



**Correct Answer: (4)**

**Solution: Oxidation Mechanism:**

Potassium permanganate ( $\text{KMnO}_4$ ) in acidic condition ( $\text{H}^+$ ) is a strong oxidizing agent. When it reacts with alkenes, the typical initial product is a diol (vicinal diol). However, the reaction can proceed further, especially under the reaction conditions provided ( $\text{KMnO}_4$  with acid), leading to the cleavage of the carbon-carbon double bond.

**Given Substrate:**

The substrate shown in the problem is a cyclohexene derivative with a carbon-carbon double bond.

**Reaction Pathway:**

In this case, the oxidation does not stop at diol formation due to the strength of the oxidizing agent and the acidic environment. Instead, the alkene is likely cleaved, and the oxidation progresses to form carboxylic acids at the positions originally involved in the double bond.

**Product Formation:**

Given the structure of the alkene and the conditions:

- The double bond carbons are fully oxidized to carboxylic acids, leading to the formation of a dicarboxylic acid compound as the major product.

**Why Option (4) is Correct:**

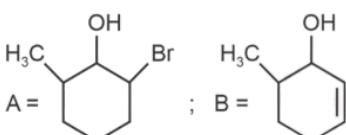
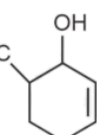
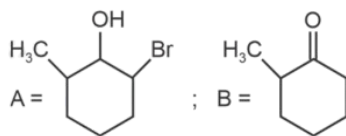
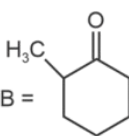
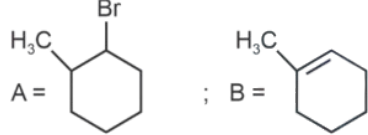
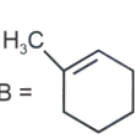
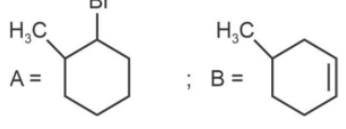
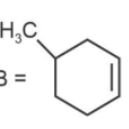
The product *P* corresponds to the chemical structure of a dicarboxylic acid derivative, where each of the carbon atoms originally involved in the double bond is now part of a carboxyl group ( $-COOH$ ). This transformation is typical of strong oxidative conditions applied to alkenes.

**💡 Quick Tip**

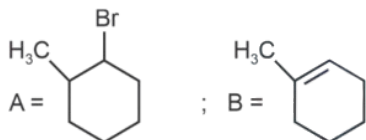
Always consider the strength and conditions of the oxidizing agent when predicting reaction products from complex organic substrates.

**98. Major products A and B formed in the following reaction sequence are:**



- (1)  ; B = 
- (2)  ; B = 
- (3)  ; B = 
- (4)  ; B = 

**Correct Answer: (3)**



**Solution: Step 1: Reaction with  $PBr_3$**

- The reaction of an alcohol with  $PBr_3$  leads to the formation of an alkyl bromide, through a mechanism where the hydroxyl group of the alcohol is substituted by a bromide ion.
- In this case, the hydroxyl group attached to the cyclohexane ring in the given molecule is replaced by bromine, forming the brominated product A.

## Step 2: Reaction with Alcoholic KOH

- Alcoholic KOH generally promotes elimination reactions, particularly *E2* mechanism.
- The reaction likely involves the removal of a hydrogen atom from a carbon adjacent to the carbon bearing the bromine atom, leading to the formation of a double bond as the bromine leaves, forming product *B*.

### Identification of Products:

- *A* is the alkyl bromide where the OH group was replaced by Br.
- *B* is the alkene formed by the elimination of HBr from *A*.

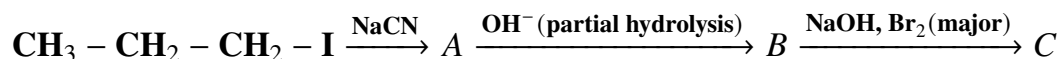
### Why Option (3) is Correct:

- *A* in option (3) shows the bromine correctly positioned at the site of the original hydroxyl group.
- *B* shows a double bond resulting from an elimination reaction, consistent with the action of alcoholic KOH.

#### 💡 Quick Tip

When converting alcohols to more reactive halides or preparing alkenes via elimination, reagents like PBr<sub>3</sub> and bases like KOH are commonly used.

## 99. Identify the major product *C* formed in the following reaction sequence:



- (1) Butanamide
- (2)  $\alpha$ -Bromobutanoic acid
- (3) Propylamine
- (4) Butylamine

**Correct Answer: (3) Propylamine**

### Solution:

#### Step 1: Reaction analysis and product identification.

First, the alkyl iodide ( $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{I}$ ) reacts with sodium cyanide (NaCN) to replace the iodide with a cyano group, forming nitrile *A* ( $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CN}$ ).

#### Step 2: Hydrolysis of the nitrile.

Partial hydrolysis of the nitrile by  $\text{OH}^-$  converts *A* to the corresponding amine, *B* ( $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{NH}_2$ ), rather than fully hydrolyzing it to the carboxylic acid.

#### Step 3: Reaction with bromine.

Treatment of *B* with NaOH and Br<sub>2</sub> does not lead to further functional group transformation but is intended to ensure the bromination reaction does not occur. Thus, *C* remains as propylamine, confirming that no further transformation of the amine occurs under these conditions.

**💡 Quick Tip**

Partial hydrolysis of nitriles can strategically be stopped at the amine stage by controlling the reaction conditions, avoiding full conversion to carboxylic acids.

**100.** Mass in grams of copper deposited by passing 9.6487 A current through a voltmeter containing copper sulphate solution for 100 seconds is (Given: Molar mass of Cu = 63 g mol<sup>-1</sup>, 1 F = 96487 C)

- (1) 31.5 g
- (2) 0.0315 g
- (3) 3.15 g
- (4) 0.315 g

**Correct Answer: (4) 0.315 g**

**Solution:**

To calculate the mass of copper deposited, we can use the formula for electrolysis:

$$\text{Mass of Cu} = \frac{I \times t \times M}{n \times F}$$

**Where:**

- $I = 9.6487 \text{ A}$  (current),
- $t = 100 \text{ seconds}$  (time),
- $M = 63 \text{ g/mol}$  (molar mass of copper),
- $n = 2$  (valency of copper, Cu<sup>2+</sup>),
- $F = 96487 \text{ C/mol}$  (Faraday's constant).

Now, substituting the values into the formula:

$$\text{Mass of Cu} = \frac{9.6487 \times 100 \times 63}{2 \times 96487}$$

**Solving the equation:**

$$\text{Mass of Cu} = \frac{6067.8}{192974} \approx 0.315 \text{ grams}$$

Thus, the mass of copper deposited is 0.315 grams.

**💡 Quick Tip**

To calculate the mass of a metal deposited during electrolysis, use the formula:

$$\text{Mass} = \frac{I \times t \times M}{n \times F}$$

where  $I$  is the current,  $t$  is the time,  $M$  is the molar mass,  $n$  is the valency of the metal, and  $F$  is Faraday's constant.

---

**BOTANY**  
**SECTION-A**

**101. The lactose present in the growth medium of bacteria is transported to the cell by the action of**

- (1) Permease**
- (2) Polymerase**
- (3) Beta-galactosidase**
- (4) Acetylase**

**Correct Answer: (1) Permease**

**Solution:** Lactose is a disaccharide composed of glucose and galactose. In bacteria, lactose must be transported into the cell before it can be metabolized. This transport is facilitated by a specific membrane protein called permease. Permease functions as a carrier protein that helps in the active transport of lactose across the cell membrane, enabling the cell to take up lactose for subsequent enzymatic breakdown.

Permease (Option 1) is a membrane protein that actively transports lactose into bacterial cells. This is the correct answer.

Polymerase (Option 2) refers to enzymes like RNA polymerase or DNA polymerase, which are involved in the synthesis of RNA or DNA, not the transport of molecules like lactose.

Beta-galactosidase (Option 3) is an enzyme that breaks down lactose into glucose and galactose after it has been transported into the cell. While important in the metabolism of lactose, it does not play a role in its transport.

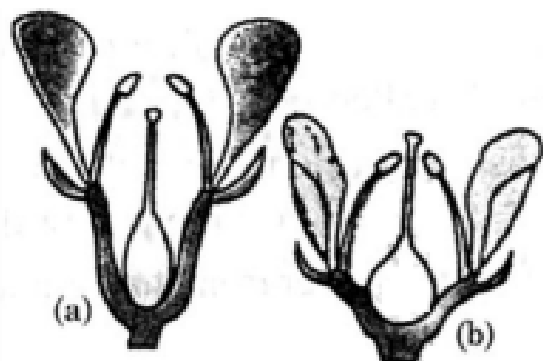
Acetylase (Option 4) is involved in the acetylation process, which is unrelated to the transport of lactose.

Thus, the correct answer is Permease.

|                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------|
| <b>💡 Quick Tip</b>                                                                                                       |
| Permease enzymes are crucial for the active transport and facilitated diffusion of substances across cellular membranes. |

---

**102. Identify the type of flowers based on the position of calyx, corolla and androecium with respect to the ovary from the given figures (a) and (b)**



- (1) (a) Peryginous; (b) Epigynous
- (2) (a) Peryginous; (b) Peryginous
- (3) (a) Epigynous; (b) Hypogynous
- (4) (a) Hypogynous; (b) Epigynous

**Correct Answer:** (2) (a) Peryginous; (b) Peryginous

**Solution:** In flowers, the arrangement of floral parts (calyx, corolla, and androecium) relative to the ovary is an important characteristic for classification. The terms used to describe the position of the ovary in relation to other floral parts are:

**Hypogynous:** When the ovary is placed below the other floral parts, it is called hypogynous.

**Epigynous:** When the ovary is placed above the other floral parts, it is called epigynous.

**Perigynous:** When the ovary is placed at the same level as the other floral parts, it is called perigynous.

From the figures:

In figure (a), the calyx, corolla, and androecium are at the same level, and the ovary is located in the center. This is a perigynous arrangement. In figure (b), the ovary is placed above the calyx, corolla, and androecium, indicating an epigynous arrangement. Thus, the correct answer is (a) Perigynous; (b) Perigynous.

#### 💡 Quick Tip

In peryginous flowers, the floral parts are attached at or around the middle of the ovary, with the ovary partially sunken into the receptacle.

**103.** The type of conservation in which the threatened species are taken out from their natural habitat and placed in special setting where they can be protected and given special care is called

- (1) Semi-conservative method
- (2) Sustainable development
- (3) In-situ conservation
- (4) Biodiversity conservation

**Correct Answer:** (4) Biodiversity conservation

**Solution:** The question refers to a method of conservation in which species that are at risk are removed from their natural environment and placed in a controlled environment where they can be properly cared for and protected. This type of conservation is called ex-situ conservation.

However, the options provided have a broader term Biodiversity conservation, which encompasses both in-situ and ex-situ conservation strategies. While *in-situ conservation* involves protecting species in their natural habitat, *ex-situ conservation* is the method where species are removed from their habitat and protected, as described in the question.

So, the correct answer is:

|                           |
|---------------------------|
| Biodiversity conservation |
|---------------------------|

This term broadly covers both in-situ and ex-situ methods aimed at preserving biodiversity.

**💡 Quick Tip**

Ex-situ conservation includes zoos, botanical gardens, and seed banks where organisms are given care away from their natural environments.

**104. Formation of interfascicular cambium from fully developed parenchyma cells is an example for**

- (1) Dedifferentiation
- (2) Maturation
- (3) Differentiation
- (4) Redifferentiation

**Correct Answer: (1) Dedifferentiation**

**Solution:** In plants, tissues undergo different processes depending on their roles and the needs of the plant. In this case, the formation of interfascicular cambium from fully developed parenchyma cells refers to the process of dedifferentiation.

**Step 1:** Dedifferentiation is the process in which mature, specialized cells lose their specialized characteristics and revert to a more meristematic (undifferentiated) state. This is the key process when parenchyma cells, which are mature and differentiated, form cambium cells, which are capable of further division.

**Step 2:** After dedifferentiation, the cambium cells can undergo further development and differentiation to form other types of cells in response to the plant's growth needs. Thus, the correct answer is dedifferentiation.

**💡 Quick Tip**

Dedifferentiation is a crucial process in plants, enabling regrowth and healing, particularly in response to injury or during vegetative propagation.

**105. Which of the following is an example of actinomorphic flower?**

- (1) Pisum
- (2) Sesbania
- (3) Datura
- (4) Cassia

**Correct Answer: (3) Datura**

**Solution:** Actinomorphic flowers, also called radial symmetry flowers, are those flowers in which the petals or parts are arranged symmetrically around a central point. These flowers can be divided into two equal halves in any plane passing through the center.

Let's analyze the options:

**(1) Pisum (Pea):** The flowers of Pisum (pea plant) are typically zygomorphic, meaning they are bilaterally symmetrical, and not actinomorphic.

(2) **Sesbania:** Flowers of *Sesbania* are also bilaterally symmetrical (zygomorphic), not actinomorphic.

(3) **Datura:** *Datura*, commonly known as the "thorn apple" or "angel's trumpet," has actinomorphic flowers. These flowers are radially symmetrical, meaning they can be divided into two equal halves through any plane passing through their center.

(4) **Cassia:** *Cassia* has zygomorphic flowers, not actinomorphic.

Thus, the correct answer is *Datura*, which has actinomorphic (radially symmetrical) flowers.

**💡 Quick Tip**

Actinomorphic flowers are often characterized by their ability to attract a wide variety of pollinators due to their radial symmetry.

**106.** Hind III always cuts DNA molecules at a particular point called recognition sequence and it consists of:

- (1) 4 bp
- (2) 10 bp
- (3) 8 bp
- (4) 6 bp

**Correct Answer:** (4) 6 bp

**Solution:** Hind II, a type II restriction enzyme, specifically recognizes and cleaves DNA at a particular sequence of 6 base pairs (bp). This enzyme is part of a larger family of restriction enzymes that cut DNA at specific recognition sites, a fundamental tool in molecular biology for gene cloning, DNA mapping, and genetic engineering. The specificity and predictable nature of these cuts allow researchers to precisely manipulate and study genetic elements.

**💡 Quick Tip**

Understanding the recognition sites of different restriction enzymes is crucial for techniques such as DNA cloning and gel electrophoresis.

**107.** Which of the following are required for the dark reaction of photosynthesis?

- A. Light
- B. Chlorophyll
- C. CO<sub>2</sub>
- D. ATP
- E. NADPH

Choose the correct answer from the options given below:

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

**Correct Answer: (1) C, D and E only**

**Solution: Step 1: Understanding the Dark Reaction**

The dark reaction, or the Calvin cycle, occurs in the stroma of chloroplasts and does not directly utilize light. Instead, it uses the ATP and NADPH generated by the light-dependent reactions to convert CO<sub>2</sub> into glucose.

**Step 2: Identifying Essential Components**

For the Calvin cycle to occur, it requires:

**CO<sub>2</sub>:** Serves as the carbon source for synthesizing organic compounds.

**ATP:** Provides the necessary energy to drive the reactions.

**NADPH:** Offers reducing power for the conversion of CO<sub>2</sub> into a more reduced form of carbon in sugars.

**Step 3: Excluding Non-Essentials**

While light and chlorophyll are essential for the light-dependent reactions (photosystem activation and energy capture), they are not directly involved in the Calvin cycle.

Therefore, they are not required for the dark reaction.

**💡 Quick Tip**

Remember, the Calvin cycle can technically occur in the dark as long as ATP and NADPH, produced during the light reactions, are available. This underlines the importance of understanding the different phases of photosynthesis and their interdependence.

**108. Match List I with List II.**

| List-I |          | List-II |             |
|--------|----------|---------|-------------|
| A.     | Rhizopus | I.      | Mushroom    |
| B.     | Ustilago | II.     | Smut fungus |
| C.     | Puccinia | III.    | Bread mould |
| D.     | Agaricus | IV.     | Rust fungus |

Choose the correct answer from the options given below:

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

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

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

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

**Correct Answer: (1)**

**Solution: Step 1: Identifying Organisms and Their Characteristics**

**Rhizopus:** Known as black bread mold, Rhizopus is a genus of common saprophytic fungi on plants and specialized parasites on animals. It is best known as bread mold, hence matches with III (Bread mould).

**Ustilago:** Known commonly as smut fungi, these are pathogens of grasses including important crops. Ustilago needs to be matched with II (Smut fungus).

**Puccinia:** A well-known genus of fungi, responsible for rust diseases on many plants, fits perfectly with IV (Rust fungus).

**Agaricus:** A genus of mushrooms containing both edible and poisonous species, including the well-known button mushroom, matches with I (Mushroom).

**Step 2: Analyzing the Options**

Given the characteristics defined above:

A (Rhizopus) matches with III (Bread mould).

B (Ustilago) matches with II (Smut fungus).

C (Puccinia) matches with IV (Rust fungus).

D (Agaricus) matches with I (Mushroom).

**Step 3: Selecting the Correct Match**

Option (3) states:

A-III, B-II, C-IV, D-I, which corresponds exactly to our analysis.

**💡 Quick Tip**

Familiarity with the common names of fungi and their characteristics can aid in their identification and understanding of their ecological roles.

**109.** Lecithin, a small molecular weight organic compound found in living tissues, is an example of:

- (1) Glycerides
- (2) Carbohydrates
- (3) Amino acids
- (4) Phospholipids

**Correct Answer:** (4) Phospholipids

**Solution: Step 1: Understanding Lecithin**

Lecithin is a term that broadly describes any group of yellow-brownish fatty substances occurring in animal and plant tissues. It is composed of phospholipids, a type of fat crucial for the cells of many organisms.

**Step 2: Identifying Its Role and Composition**

Phospholipids, which include lecithin, are a major component of all cell membranes. They contain fatty acids, glycerol, phosphate, and a simple organic molecule such as choline. Lecithin specifically is made up of choline, two fatty acids, glycerol, and phosphate. It plays a key role in many vital processes including acting as a surfactant, maintaining cell membrane integrity, and involving in the transportation of lipids in the body.

**Step 3: Distinguishing from Other Options**

Glycerides are a broad category of compounds (mainly fats) made primarily of glycerol and fatty acids but do not include the phosphate group essential in lecithin.

Carbohydrates are compounds consisting of sugars and do not typically engage in forming cell structures.

Amino acids are the building blocks of proteins and are structurally and functionally different from phospholipids.

**💡 Quick Tip**

Phospholipids are crucial for constructing the bilayer of cell membranes and for making the membrane selectively permeable.

**110. The capacity to generate a whole plant from any cell of the plant is called:**

- (1) Differentiation**
- (2) Somatic hybridization**
- (3) Totipotency**
- (4) Micropropagation**

**Correct Answer: (3) Totipotency**

**Solution: Step 1: Definition of Totipotency**

Totipotency is a fundamental concept in plant biology which refers to the ability of a single cell to divide and grow into a complete, mature plant. This characteristic is observed in most plant cells, enabling them to regenerate lost parts or even propagate clonally from small tissue samples.

**Step 2: Explanation and Examples**

In practical terms, totipotency allows horticulturists and scientists to grow plants from small tissue samples using techniques like tissue culture. This process involves taking a small amount of tissue (such as a leaf, stem, or root segment), placing it in a sterile, nutrient-rich medium, and manipulating conditions to induce growth and development into a full plant. Key examples include the regeneration of an entire tobacco plant from a single leaf cell or growing a carrot plant from a fragment of its phloem.

**Step 3: Distinguishing from Other Options**

Differentiation refers to the process by which cells develop into different types of cells with specific functions, a part of the growth process but not about generating a new plant.

Somatic hybridization involves the fusion of two different types of cells to create a new hybrid cell, used in genetic engineering and breeding but not directly related to regenerating a whole plant from a single cell.

Micropropagation is a technique that involves rapid multiplication of plant material in vitro for large-scale production but does not inherently imply starting from a single cell.

**💡 Quick Tip**

Plant cells are unique due to their totipotent nature, making plant tissue culture and genetic engineering feasible.

**111. Given below are two statements:**

**Statement I: Chromosomes become gradually visible under light microscope during leptotene stage.**

**Statement II: The beginning of diplotene stage is recognized by dissolution of synaptonemal complex.**

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

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are true
- (4) Both Statement I and Statement II are false

**Correct Answer: (3) Both Statement I and Statement II are true**

**Solution: Step 1: Analyzing Statement I**

During the leptotene stage of meiosis, chromosomes start to become visible under a light microscope as thin threads. This stage marks the beginning of prophase I, where chromosomes start to condense, making them gradually more distinct and visible.

Hence, Statement I is true.

**Step 2: Analyzing Statement II**

The diplotene stage follows the pachytene stage in prophase I of meiosis. One of the key events marking the onset of diplotene is the dissolution of the synaptonemal complex, a protein structure that holds homologous chromosomes together during synapsis. The dissolution of this complex allows the chromosomes to begin to separate, though they are still held together at chiasmata (sites of crossing over). Therefore, Statement II is also true.

**💡 Quick Tip**

Understanding the stages of meiosis is crucial for grasping how genetic recombination and chromosome segregation occur.

**112. How many molecules of ATP and NADPH are required for every molecule of CO<sub>2</sub> fixed in the Calvin cycle?**

- (1) 3 molecules of ATP and 3 molecules of NADPH
- (2) 3 molecules of ATP and 2 molecules of NADPH
- (3) 2 molecules of ATP and 3 molecules of NADPH
- (4) 2 molecules of ATP and 2 molecules of NADPH

**Correct Answer: (2) 3 molecules of ATP and 2 molecules of NADPH**

**Solution: Step 1: Understanding the Calvin Cycle**

The Calvin cycle, also known as the Calvin-Benson cycle or the dark reactions of photosynthesis, is a biochemical pathway in plants and some bacteria that converts carbon dioxide and other compounds into glucose. It occurs in the stroma of the chloroplast and does not require light directly.

**Step 2: Energy Requirement for CO<sub>2</sub> Fixation**

For each molecule of CO<sub>2</sub> that is fixed in the Calvin cycle, the energy expenditure involves:

ATP, which provides the energy for synthesizing glucose from CO<sub>2</sub>. NADPH, which provides the reducing power to convert the fixed carbon dioxide into carbohydrate.

**Step 3: Calculating Specific Requirements**

The cycle involves three key phases: carbon fixation, reduction phase, and regeneration of the CO<sub>2</sub> acceptor (RuBP). Specifically:

For the fixation of each CO<sub>2</sub> molecule, the cycle uses 3 ATP molecules and 2 NADPH molecules. The breakdown is as follows:

3 ATPs are used (1 ATP for the carbon fixation phase and 2 ATPs during the regeneration of RuBP).

2 NADPHs are used in the reduction phase to convert 3-phosphoglycerate into glyceraldehyde-3-phosphate.

**💡 Quick Tip**

The Calvin cycle's energy requirement highlights the importance of light reactions in photosynthesis, which generate the necessary ATP and NADPH.

**113. Match List I with List II.**

| List I |                                                         | List II |            |
|--------|---------------------------------------------------------|---------|------------|
| A.     | Two or more alternative forms of a gene                 | I.      | Back cross |
| B.     | Cross of $F_1$ progeny with homozygous recessive parent | II.     | Ploidy     |
| C.     | Cross of $F_1$ progeny with any of the parents          | III.    | Allele     |
| D.     | Number of chromosome sets in plant                      | IV.     | Test cross |

Choose the correct answer from the options given below.

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

**Correct Answer: (1) A-III, B-IV, C-I, D-II**

**Solution: Step 1: Linking Concepts to Terms**

**A. Two or more alternative forms of a gene:** These are called alleles. Alleles are variations of a gene that arise by mutation and are found at the same place on a chromosome.

**B. Cross of  $F_1$  progeny with homozygous recessive parent:** This is specifically called a test cross. It is used to determine the genotype of the  $F_1$  progeny by crossing them with a homozygous recessive individual to observe which phenotypes appear in the offspring.

**C. Cross of  $F_1$  progeny with any of the parents:** Known as a back cross, it helps to identify whether the  $F_1$  progeny carries a recessive allele from a parent.

**D. Number of chromosome sets in plant:** This is referred to as ploidy. It describes how many sets of chromosomes are in the nucleus of a cell.

**Step 2: Matching Each with the Correct Term**

A corresponds to III (Allele), as alleles are alternative forms of a gene.

B matches with IV (Test cross), which involves crossing with a homozygous recessive to determine the unknown genotype.

C aligns with I (Back cross), involving crossing with one of the parents.

D fits with II (Ploidy), which is about the number of chromosome sets.

**💡 Quick Tip**

Familiarize with genetic terminology to efficiently map genetic crosses and understand inheritance patterns.

**114. List of endangered species was released by**

- (1) FOAM
- (2) IUCN
- (3) GEAC
- (4) WWF

**Correct Answer: (2) IUCN**

**Solution: Step 1: Identifying the Correct Organization**

The International Union for Conservation of Nature (IUCN) is well-known for publishing the Red List of Threatened Species. This list is globally recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species.

**Step 2: Understanding the Role of IUCN**

The IUCN Red List categorizes species according to their extinction risk. It uses criteria such as population decline, geographic range, and degree of population and habitat fragmentation to assess the risk status of species, ranging from "Least Concern" to "Critically Endangered."

**Step 3: Differentiating from Other Organizations**

**FOAM (Federation of American Scientists):** This is not correct as FOAM primarily focuses on providing science-based analysis of and solutions to protect against existential threats.

**GEAC (Genetic Engineering Appraisal Committee):** This Indian regulatory body is concerned with the approval of genetically modified organisms and has no direct involvement with the listing of endangered species.

**WWF (World Wildlife Fund):** While WWF is deeply involved in wildlife conservation, it does not publish the global list of endangered species like the IUCN Red List.

**💡 Quick Tip**

The IUCN Red List is a critical indicator of the health of the world's biodiversity and a powerful tool to inform conservation action and policy.

**115. The equation of Verhulst-Pearl logistic growth is**

$$\frac{dN}{dt} = rN \left( \frac{K - N}{K} \right)$$

**From this equation,  $K$  indicates:**

- (1) Carrying capacity
- (2) Population density
- (3) Intrinsic rate of natural increase

#### (4) Biotic potential

**Correct Answer: (1) Carrying capacity**

**Solution: Step 1: Understanding the Logistic Growth Equation**

The logistic growth model described by this equation represents how the growth rate of a population ( $dN/dt$ ) evolves over time in a limited environment. The rate of change of the population size  $N$  is dependent on both the current population size and the carrying capacity  $K$ .

**Step 2: Role of  $K$  in the Equation**

$K$  represents the carrying capacity of the environment, which is the maximum population size that the environment can sustain indefinitely under given conditions. As  $N$  approaches  $K$ , the factor  $\left[\frac{K-N}{K}\right]$  approaches zero, which slows down the growth rate, indicating that the environment cannot support a higher number of individuals without depleting resources.

**Step 3: Explanation of Other Terms**

Population density refers to the number of individuals per unit area and is not specifically represented by  $K$  in this model.

Intrinsic rate of natural increase ( $r$ ) is represented by  $r$  in the equation, which is the per capita rate of increase assuming no resource limitation.

Biotic potential is the maximum reproductive capacity of an organism under optimal conditions, not directly addressed in this logistic model.

#### 💡 Quick Tip

Carrying capacity ( $K$ ) can change over time due to environmental changes and is crucial for managing wildlife and conservation efforts.

**116. Identify the set of correct statements:**

- A. The flowers of *Vallisneria* are colourful and produce nectar.
- B. The flowers of water lily are not pollinated by water.
- C. In most of water-pollinated species, the pollen grains are protected from wetting.
- D. Pollen grains of some hydrophytes are long and ribbon like.
- E. In some hydrophytes, the pollen grains are carried passively inside water.

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

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

**Correct Answer: (2) B, C, D and E only**

**Solution: Step 1: Evaluating Each Statement**

**Statement A: *Incorrect.*** Vallisneria flowers are not colourful and do not produce nectar. They are small and dull, adapted for hydrophilic (water) pollination, not attracting pollinators through visual or nectar means.

**Statement B: *Correct.*** The flowers of water lily are pollinated by insects, not by water. Despite being an aquatic plant, the water lily has adaptations for entomophilous (insect) pollination.

**Statement C: *Correct.*** In water-pollinated species, such as seagrasses and some pond weeds, the pollen grains are typically protected from wetting by a mucilaginous covering that facilitates their movement in water.

**Statement D: *Correct.*** Some hydrophytes, like seagrasses, produce pollen grains that are long and ribbon-like, which aids their distribution in water.

**Statement E: *Correct.*** In some hydrophytes, the pollen grains are dispersed passively by water currents, meaning they drift in the water until they encounter a compatible stigma.

**Step 2: Analyzing the Options**

From the analysis of each statement:

Statements B, C, D, and E are correct.

Statement A is incorrect.

**Step 3: Choosing the Correct Option**

Option (2) B, C, D, and E only matches the correct statements identified through our analysis.

**💡 Quick Tip**

In aquatic plant pollination, understanding the adaptations to their specific environment helps in studying their reproductive strategies.

**117. Bulliform cells are responsible for**

- (1) Increased photosynthesis in monocots
- (2) Providing large spaces for storage of sugars
- (3) Inward curling of leaves in monocots
- (4) Protecting the plant from salt stress

**Correct Answer: (3) Inward curling of leaves in monocots**

**Solution: Step 1: Understanding Bulliform Cells**

Bulliform cells are large, thin-walled, and often found in groups on the upper surfaces of the leaves of many monocots, such as grasses. Their primary function is related to leaf folding and unfolding.

**Step 2: Function of Bulliform Cells**

These cells absorb water during moist conditions, causing them to swell. This swelling contributes to the leaf blade spreading out and exposing more surface area for photosynthesis.

During dry conditions, bulliform cells lose water and cause the leaf to fold or roll inwards. This inward curling of leaves reduces the surface area exposed to air, minimizing water loss through transpiration and helping the plant conserve moisture.

**Step 3: Evaluating Other Options**

**Option 1 (Increased photosynthesis in monocots):** While bulliform cells can indirectly affect photosynthesis by controlling leaf surface exposure, they do not directly increase photosynthetic activity.

**Option 2 (Providing large spaces for storage of sugars):** Bulliform cells are not involved in sugar storage; they function primarily in water regulation within the leaf.

**Option 4 (Protecting the plant from salt stress):** There is no direct role of bulliform cells in salt stress protection; their function is more aligned with moisture retention and transpiration reduction.

**💡 Quick Tip**

The presence of bulliform cells in grass leaves is an adaptation to reduce water loss through transpiration during dry conditions.

**118. Which one of the following can be explained on the basis of Mendel's Law of Dominance?**

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

**Correct Answer: (4) A, C, D and E only**

**Solution:** Mendel's Law of Dominance states that when two different alleles for a single trait are present in an organism, one will be dominant and the other will be recessive. The dominant allele will express its trait in the organism, while the recessive allele will not express itself unless it is in the homozygous recessive form.

**Let's evaluate each statement:**

**A. Out of one pair of factors one is dominant and the other is recessive:** This is a correct statement according to Mendel's Law of Dominance. It directly refers to the concept of dominance, where one allele masks the expression of the other.

**B. Alleles do not show any expression and both the characters appear as such in  $F_2$  generation:** This is incorrect. This refers more to incomplete dominance or co-dominance, not dominance. In Mendel's Law of Dominance, one allele will dominate and show its expression.

**C. Factors occur in pairs in normal diploid plants:** This is correct. Mendel's experiments showed that the genetic factors (alleles) are inherited in pairs (one from each parent).

**D. The discrete unit controlling a particular character is called factor:** This is correct. Mendel referred to the genetic factors controlling traits as "factors," which we now know as genes.

**E. The expression of only one of the parental characters is found in a monohybrid cross:** This is also correct. In a monohybrid cross, only the dominant trait appears in the  $F_1$  generation, with the recessive trait being masked.

Thus, the correct statements that can be explained by Mendel's Law of Dominance are A, C, D, and E.

**💡 Quick Tip**

Mendel's Law of Dominance states that in a pair of alleles, one allele will be dominant and express its trait, while the other will remain hidden unless both alleles are recessive.

**119. The cofactor of the enzyme carboxypeptidase is:**

- (1) Flavin
- (2) Haem
- (3) Zinc
- (4) Niacin

**Correct Answer: (3) Zinc**

**Solution: Step 1: Identifying the Function of Carboxypeptidase**

Carboxypeptidase is an enzyme that catalyzes the hydrolysis of the carboxyl-terminal (C-terminal) end of a peptide bond, releasing amino acid residues one at a time. It is crucial in the digestion of proteins in the gastrointestinal system.

**Step 2: Understanding the Role of Zinc as a Cofactor**

Zinc serves as an essential cofactor for carboxypeptidase. The presence of zinc in the enzyme's active site is critical for its activity. Zinc ions help to stabilize the water molecule that is used to hydrolyze the peptide bond in the substrate protein, facilitating the cleavage of the bond.

**Step 3: Evaluating Other Options**

**Flavin:** This is a cofactor involved in redox reactions, commonly found in enzymes that catalyze oxidation-reduction reactions, not typically associated with proteases like carboxypeptidase.

**Haem:** While important in enzymes like cytochromes for electron transport, haem is not a cofactor in carboxypeptidase.

**Niacin:** Niacin is a form of vitamin B3 and is a precursor to NAD<sup>+</sup>/NADP<sup>+</sup>, which are coenzymes in redox reactions, not directly related to the enzymatic activity of carboxypeptidase.

**💡 Quick Tip**

Metal ions like Zinc play essential roles in the catalytic activity of various enzymes by stabilizing substrate or active site structures.

**120. Which one of the following is not a criterion for classification of fungi?**

- (1) Mode of spore formation
- (2) Fruiting body
- (3) Morphology of mycelium
- (4) Mode of nutrition

**Correct Answer: (4) Mode of nutrition**

**Solution: Step 1: Understanding Fungal Classification**

Fungi are classified based on various morphological characteristics, which include their mode of spore formation, the structure of their fruiting bodies, and the morphology of their mycelium. These characteristics help differentiate among various types of fungi, aiding in the identification and understanding of their biology.

**Step 2: Evaluating the Given Options**

**Mode of spore formation:** This is a key criterion for classifying fungi. Different fungal groups are distinguished based on how they produce spores (sexually or asexually), such as zygomycetes, ascomycetes, and basidiomycetes.

**Fruiting body:** The presence and structure of fruiting bodies, such as mushrooms, puffballs, or truffles, are significant in the classification of fungi. This includes their size, shape, and complexity.

**Morphology of mycelium:** The structure and arrangement of mycelium, whether it is septate (divided by cross walls) or coenocytic (without cross walls), are used to classify fungi into different groups.

**Step 3: Identifying the Incorrect Criterion**

**Mode of nutrition:** Although fungi are heterotrophic by nature, obtaining their nutrients through absorption (saprophytic, parasitic, or mutualistic), this trait is common to all fungi and not used as a classification criterion. Fungi's mode of nutrition does not provide a basis for distinguishing among major fungal groups because all fungi share the same fundamental nutritional mode - heterotrophy.

**💡 Quick Tip**

While studying fungi, focus on structural and reproductive characteristics for classification rather than nutritional habits.

**121. Match List I with List II.**

| List-I |                 | List-II |                                         |
|--------|-----------------|---------|-----------------------------------------|
| A.     | Nucleolus       | I.      | Site of formation of glycolipid         |
| B.     | Centriole       | II.     | Organization like the cartwheel         |
| C.     | Leucoplasts     | III.    | Site for active ribosomal RNA synthesis |
| D.     | Golgi apparatus | IV.     | For storing nutrients                   |

Choose the correct answer from the options given below:

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

**Correct Answer: (3) A-III, B-II, C-IV, D-I**

**Solution: Step 1: Analyzing Each Component**

**A. Nucleolus:** Known as the site where ribosomal RNA (rRNA) is synthesized and ribosomes are partially assembled. This corresponds to III. Site for active ribosomal RNA synthesis.

**B. Centriole:** Structurally, centrioles are cylindrical and have a characteristic arrangement of microtubules in a 'cartwheel' structure. This corresponds to II. Organization like the cartwheel.

**C. Leucoplasts:** These are a type of plastid that are colorless and primarily function in the storage of nutrients such as starch. This matches IV. For storing nutrients.

**D. Golgi apparatus:** An organelle in eukaryotic cells that plays a crucial role in the modification, sorting, and packaging of proteins and lipids into vesicles for delivery to targeted destinations. It includes the synthesis of glycolipids, which corresponds to I. Site of formation of glycolipid.

**Step 2: Matching Correspondences**

The matches based on the detailed function and characteristic of each component are:

**A-III:** The nucleolus and its role in rRNA synthesis.

**B-II:** The centriole with its cartwheel structure.

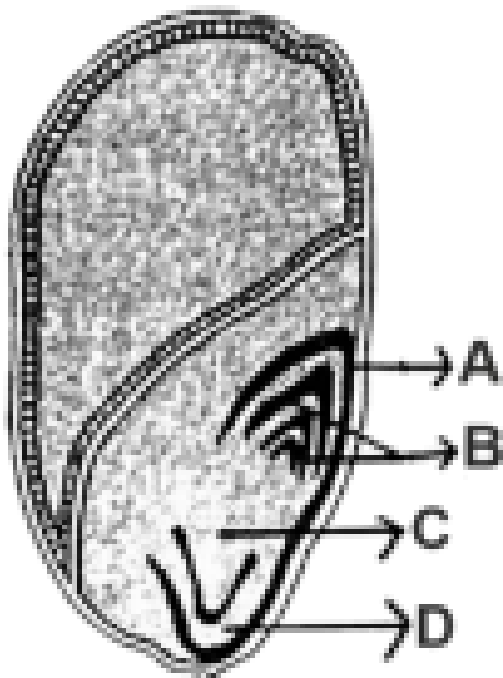
**C-IV:** Leucoplasts as nutrient storage sites.

**D-I:** The Golgi apparatus and its involvement in glycolipid formation.

**💡 Quick Tip**

Understanding the specific functions and structures of cell organelles is fundamental in cell biology and helps in elucidating cellular processes.

**122. Identify the part of the seed from the given figure which is destined to form root when the seed germinates.**



- (1) C
- (2) D
- (3) A
- (4) B

**Correct Answer: (1) C**

**Solution: Step 1: Identifying Seed Parts and Their Functions**

The seed structure typically includes the radicle, plumule, cotyledons, and seed coat.

Understanding each part's role is crucial in determining their developmental fate upon germination.

**Step 2: Analyzing the Seed Parts in the Given Image**

**Part A:** Likely represents the seed coat, which protects the seed but does not contribute to the development of major plant structures.

**Part B:** Could be associated with the plumule or shoot apex, responsible for the development of the aerial parts of the plant.

**Part C:** Consistent with the radicle, the first root to emerge during germination. This is the embryonic root that develops into the primary root system, anchoring the plant and absorbing nutrients.

**Part D:** Possibly indicates the cotyledons or another part of the embryo that serves as a nutrient source for the young plant but does not form the root.

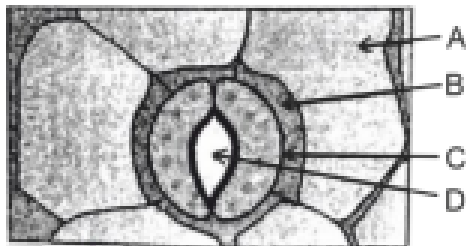
**Step 3: Concluding the Correct Label**

Label C is identified as the radicle, which is known for developing into the root system during the germination process. This is essential for establishing the plant's initial interaction with the soil environment.

**💡 Quick Tip**

The radicle is the first part of a seedling to emerge from the seed during the process of germination and develops into the primary root.

123. In the given figure, which component has thin outer walls and highly thickened inner walls?



- (1) A
- (2) B
- (3) C
- (4) D

**Correct Answer: (3) C**

**Solution: Step 1: Analyzing the Structures in the Given Image**

From the diagram, it is essential to understand the tissue types typically shown in such sections. Generally, these might include epidermal layers, vascular tissues like xylem and phloem, and supportive tissues like sclerenchyma or collenchyma.

**Step 2: Determining Tissue Characteristics**

**Part A:** This could be an outer epidermal layer, which usually has uniformly thin walls for protection and is not specialized for support.

**Part B:** Often represents tissues adjacent to the epidermis which may include cortical parenchyma, not known for wall thickening.

**Part C:** This might indicate a type of sclerenchyma tissue, specifically fibers, which are known for having very thick secondary walls that provide structural support.

**Part D:** Likely represents inner vascular or ground tissue, which does not fit the description of having thick inner walls and thin outer walls.

**Step 3: Identifying the Correct Label Based on Tissue Type**

Since the question specifies a component with thin outer walls and highly thickened inner walls, Part C fits the description of sclerenchyma fibers, which are known for their role in providing mechanical strength and support. The fibers typically have a thin primary wall and a much thicker, lignified secondary wall.

**💡 Quick Tip**

Sclerenchyma cells are vital for providing mechanical strength and support in plants, especially in areas undergoing little or no growth.

**124.** A transcription unit in DNA is defined primarily by the three regions in DNA and these are with respect to upstream and down stream end:

- (1) Inducer, Repressor, Structural gene
- (2) Promotor, Structural gene, Terminator
- (3) Repressor, Operator gene, Structural gene
- (4) Structural gene, Transposons, Operator gene

**Correct Answer:** (2) Promotor, Structural gene, Terminator

**Solution: Step 1: Understanding the Components of a Transcription Unit**

A transcription unit in DNA is defined by several critical regions that are essential for the process of transcription, which is the synthesis of RNA from a DNA template. These regions are:

**Promotor:** A sequence located at the start (upstream) of the gene, where RNA polymerase binds and initiates transcription. The promoter determines the exact location and frequency of transcription initiation.

**Structural Gene:** This is the part of the transcription unit that is transcribed into RNA. It encodes the functional product, usually a protein or a functional RNA.

**Terminator:** A sequence at the end (downstream) of the transcription unit where the process of transcription stops when RNA polymerase detaches from the DNA.

**Step 2: Evaluating Other Options**

**Option 1 (Inducer, Repressor, Structural gene):** This option lists elements involved in gene regulation rather than the transcription unit itself. Inducers and repressors are molecules that influence the activity of transcription factors but are not part of the DNA sequence of the transcription unit.

**Option 3 (Repressor, Operator gene, Structural gene):**

While the operator and structural gene are part of the operon model found in prokaryotes, the repressor is a regulatory protein, not a DNA sequence within the transcription unit.

**Option 4 (Structural gene, Transposons, Operator gene):**

Transposons are mobile genetic elements and operators are regulatory DNA sequences, but they are not standard components defining all transcription units.

**💡 Quick Tip**

The promoter region is crucial as it determines the binding site for RNA polymerase and hence the initiation of transcription.

**125. Given below are two statements:**

**Statement I: Parenchyma is living but collenchyma is dead tissue.**

**Statement II: Gymnosperms lack xylem vessels but presence of xylem vessels is the characteristic of angiosperms.**

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

- (1) Statement I is true but Statement II is false**
- (2) Statement I is false but Statement II is true**
- (3) Both Statement I and Statement II are true**
- (4) Both Statement I and Statement II are false**

**Correct Answer: (2) Statement I is false but Statement II is true**

**Solution: Step 1: Analyzing Statement I**

Parenchyma cells are fundamental tissue in plants, primarily involved in the storage, secretion, and photosynthesis in various plant organs. They are characterized by their thin walls and the ability to divide. Importantly, parenchyma cells are living cells.

Collenchyma cells, unlike what is suggested in the statement, are also living tissues. They are known for providing mechanical support to plants, particularly in areas of active growth such as leaves and young stems. They have thickened cellulosic cell walls. Therefore, Statement I is false as both parenchyma and collenchyma are living tissues.

**Step 2: Analyzing Statement II**

Gymnosperms, which include conifers like pines and spruces, typically lack xylem vessels. Instead, they rely on tracheids for water transport, which are less efficient than vessels.

Angiosperms (flowering plants) have advanced vascular systems that include xylem vessels, which are more efficient at transporting water and nutrients than tracheids. Thus, Statement II is true, correctly describing the distinction in vascular tissue between gymnosperms and angiosperms.

**💡 Quick Tip**

Understanding the structure and function of plant tissues is essential for studying plant anatomy and physiology.

**126. A pink flowered Snapdragon plant was crossed with a red flowered Snapdragon plant. What type of phenotype(s) is/are expected in the progeny?**

- (1) Only pink flowered plants**
- (2) Red, Pink as well as white flowered plants**

- (3) Only red flowered plants
- (4) Red flowered as well as pink flowered plants

**Correct Answer:** (4) Red flowered as well as pink flowered plants

**Solution: Step 1: Understanding the Genetics of Snapdragon Flower Color**

Flower color in Snapdragon (*Antirrhinum majus*) is an example of incomplete dominance, where the heterozygous phenotype is a blend of the two homozygous phenotypes. In Snapdragon, red flower color (RR) is dominant to white (rr), and the heterozygous genotype (Rr) results in pink flowers.

**Step 2: Predicting the Cross Outcome**

Given that a pink flowered plant (Rr) is crossed with a red flowered plant (RR), we can set up a Punnett square to determine the genotypic and phenotypic outcomes of their progeny.

**Step 3: Punnett Square Analysis**

Crossing Rr (pink) with RR (red) results in the following possible genotypes for the progeny:

From Rr (pink) × RR (red):

R (from RR) × R (from Rr) = RR (Red)

R (from RR) × r (from Rr) = Rr (Pink)

**Genotypes:**

50% RR (Red)

50% Rr (Pink)

**Phenotypes:** - 50% Red flowered plants - 50% Pink flowered plants

**Conclusion:** - The progeny will display both red and pink flowers, as indicated by the genetic outcomes.

|                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------|
| <b>💡 Quick Tip</b>                                                                                                          |
| Incomplete dominance results in a phenotype that is a blend of the parental traits rather than one dominant over the other. |

**127. Inhibition of Succinic dehydrogenase enzyme by malonate is a classical example of:**

- (1) Competitive inhibition
- (2) Enzyme activation
- (3) Cofactor inhibition
- (4) Feedback inhibition

**Correct Answer:** (1) Competitive inhibition

**Solution: Step 1: Understanding the Enzyme and Inhibitor**

Succinic dehydrogenase is an enzyme that plays a crucial role in the Krebs cycle, catalyzing the oxidation of succinate to fumarate.

Malonate is a dicarboxylic acid similar in structure to succinate but lacks the ability to undergo the same enzymatic reaction.

**Step 2: Mechanism of Inhibition**

Competitive inhibition occurs when a substance mimics the substrate and competes for binding to the active site of the enzyme. Because the inhibitor is structurally similar to

the substrate, it can fit into the active site but does not undergo any reaction to form product. This blocks the actual substrate from binding and temporarily prevents the enzyme from catalyzing its reaction.

#### Step 3: How Malonate Inhibits Succinic Dehydrogenase

Malonate is a competitive inhibitor for succinic dehydrogenase because it resembles succinate in structure. When malonate binds to the active site of succinic dehydrogenase, it prevents succinate from binding, thus inhibiting the reaction from proceeding to form fumarate.

#### Step 4: Explanation of Incorrect Options

Enzyme activation is incorrect because malonate does not enhance the activity of succinic dehydrogenase.

Cofactor inhibition involves the inhibition of an enzyme by interfering with a necessary cofactor, which is not the case here.

Feedback inhibition generally involves the end product of a metabolic pathway inhibiting an enzyme that acts earlier in the pathway to regulate the amount of product made, which does not apply to malonate and succinic dehydrogenase.

#### 💡 Quick Tip

Competitive inhibitors can be overcome by increasing the concentration of the substrate, as they compete for the same binding site on the enzyme.

#### 128. Match List I with List II.

| List I |                                 | List II |               |
|--------|---------------------------------|---------|---------------|
| A.     | <i>Clostridium butylicum</i>    | I.      | Ethanol       |
| B.     | <i>Saccharomyces cerevisiae</i> | II.     | Streptokinase |
| C.     | <i>Trichoderma polysporum</i>   | III.    | Butyric acid  |
| D.     | <i>Streptococcus</i> sp.        | IV.     | Cyclosporin-A |

Choose the correct option from the options given below:

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

**Correct Answer:** (1) A-III, B-I, C-IV, D-II

**Solution:** Step 1: Understanding the Microorganisms and Their Products

**A. *Clostridium butylicum*:** Known for producing butyric acid through the fermentation process. Hence, it matches with III. Butyric acid.

**B. *Saccharomyces cerevisiae*:** Commonly known as brewer's yeast or baker's yeast, this microorganism is famous for its ability to produce ethanol by fermenting sugars. Thus, it matches with I. Ethanol.

**C. *Trichoderma polysporum*:** This fungus is noted for its ability to produce cyclosporin A, an immunosuppressive drug, not streptokinase. Therefore, it corresponds to IV. Cyclosporin-A.

**D. *Streptococcus* sp.:** Certain species within this genus are utilized for the production of streptokinase, an enzyme used in medical settings to break down blood clots. This fits

with II. Streptokinase.

**Step 2: Matching Each Organism with the Correct Product**

Given the roles and products associated with each microorganism, the matches are:

A-III: *Clostridium butylicum* produces butyric acid.

B-I: *Saccharomyces cerevisiae* is used for ethanol production.

C-IV: *Trichoderma polysporum* is known for cyclosporin-A production.

D-II: *Streptococcus* sp. produces streptokinase.

**💡 Quick Tip**

Each microorganism has a unique metabolic pathway that can be harnessed biotechnologically for specific product synthesis.

**129. Spindle fibers attach to kinetochores of chromosomes during**

(1) Anaphase

(2) Telophase

(3) Prophase

(4) Metaphase

**Correct Answer: (4) Metaphase**

**Solution: Step 1: Understanding Spindle Fiber Attachment**

Spindle fibers, composed of microtubules, play a crucial role in chromosome movement during mitosis. They are generated from the centrosomes at opposite poles of the cell.

**Step 2: Phases of Mitosis and Spindle Fiber Dynamics**

**Prophase:** Early in prophase, the chromosomes condense, the nuclear envelope begins to disintegrate, and the spindle apparatus starts to form.

However, the spindle fibers do not yet attach to the kinetochores.

**Metaphase:** During metaphase, chromosomes align at the cell's equatorial plane, commonly referred to as the metaphase plate. This alignment is facilitated by the attachment of spindle fibers to the kinetochores, specialized protein structures on the chromosome's centromere. This is the key event in ensuring that each daughter cell will receive an identical set of chromosomes.

**Anaphase:** Once all chromosomes are properly attached, the cell transitions to anaphase, where the sister chromatids are pulled apart toward opposite poles.

**Telophase:** This phase involves the decondensation of chromosomes and the reformation of the nuclear envelope, with spindle fibers diminishing as the cell prepares to divide.

**Step 3: Confirming the Correct Phase for Spindle Attachment** - Given that the spindle fibers attach to the kinetochores specifically for aligning chromosomes during metaphase, the correct answer is Metaphase.

**💡 Quick Tip**

Accurate spindle fiber attachment is critical for ensuring even chromosome distribution during cell division.

**130. Auxin is used by gardeners to prepare weed-free lawns. But no damage is caused to grass as auxin**

- (1) does not affect mature monocotyledonous plants.**
- (2) can help in cell division in grasses, to produce growth.**
- (3) promotes apical dominance.**
- (4) promotes abscission of mature leaves only.**

**Correct Answer: (1) does not affect mature monocotyledonous plants.**

**Solution: Step 1: Understanding Auxin and Its Role**

Auxin is a class of plant hormones that plays a crucial role in coordinating various growth and behavioral processes in the plant's life cycle, including cell elongation, bud growth, and root formation.

**Step 2: Mechanism of Action of Auxin on Different Plants**

Auxins, like 2,4-Dichlorophenoxyacetic acid (2,4-D), are commonly used as selective herbicides. They are designed to selectively kill broadleaf weeds (dicotyledonous plants) without harming grass (monocotyledonous plants).

The reason for this selectivity lies in the different growth patterns and physiological responses between dicots and monocots to auxin. In dicots, auxin overstimulates growth processes, leading to uncontrolled growth that disrupts water and nutrient transport, ultimately causing the plant's death.

**Step 3: Why Grass is Unaffected**

Grasses, being monocotyledonous, respond differently to auxin. Mature monocotyledonous plants like grasses do not typically exhibit the detrimental effects seen in dicots when exposed to the levels of auxin used in these herbicides. Their simpler vascular structure and different hormonal regulation mechanisms confer a natural resistance to the disruptive effects of excess auxin.

Therefore, (1) does not affect mature monocotyledonous plants is the correct answer as it explains why grass remains unharmed when auxin-based weed killers are applied to lawns.

**💡 Quick Tip**

Selective herbicides exploit differences in plant biology to target specific types of plants without harming others.

**131. Tropical regions show greatest level of species richness because**

- A. Tropical latitudes have remained relatively undisturbed for millions of years, hence more time was available for species diversification.**
- B. Tropical environments are more seasonal.**
- C. More solar energy is available in tropics.**
- D. Constant environments promote niche specialization.**
- E. Tropical environments are constant and predictable.**

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

- (1) A, B and E only**
- (2) A, B and D only**
- (3) A, C, D and E only**

(4) A and B only

Correct Answer: (3) A, C, D and E only

**Solution: Step 1: Evaluating Each Statement for Validity**

**Statement A: *Correct.*** Tropical regions have indeed been relatively undisturbed over millions of years compared to temperate regions, allowing more time for evolutionary processes and species diversification.

**Statement B: *Incorrect.*** Contrary to the statement, tropical environments are typically less seasonal, especially in terms of temperature fluctuations; this constancy actually supports high biodiversity.

**Statement C: *Correct.*** The tropics receive more solar energy than temperate zones, providing abundant energy that supports higher primary productivity and subsequently greater biodiversity.

**Statement D: *Correct.*** Stable, constant environments, such as those found in the tropics, allow for greater niche specialization, reducing competition and supporting diverse species coexistence.

**Statement E: *Correct.*** Although tropical environments face seasonal variations in terms of rainfall, their temperature and photoperiod are generally constant and predictable, which contributes to biodiversity.

**Step 2: Matching the Correct Combination of Statements**

Based on the evaluation, statements A, C, D, and E are correct and align with known ecological principles explaining high biodiversity in the tropics.

Statement B is incorrect and does not contribute to the explanation of tropical species richness.

**💡 Quick Tip**

The stability and energy availability in tropical regions facilitate high biodiversity, including speciation and complex ecological interactions.

**132. Given below are two statements:**

**Statement I:** Bt toxins are insect group specific and coded by a gene cry IAc.

**Statement II:** Bt toxin exists as inactive protoxin in *B. thuringiensis*. However, after ingestion by the insect, the inactive protoxin gets converted into active form due to the acidic pH of the insect gut.

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

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are true
- (4) Both Statement I and Statement II are false

Correct Answer: (1) Statement I is true but Statement II is false

**Solution:** Let's evaluate the two statements:

**Statement I:** Bt toxins are insect group specific and coded by a gene cry IAc. This statement is true. Bt toxins are specific to certain insect groups, and the gene cry IAc codes for one of these insecticidal toxins in *Bacillus thuringiensis*.

**Statement II:** Bt toxin exists as inactive protoxin in *B. thuringiensis*. However, after ingestion by the insect, the inactive protoxin gets converted into active form due to the acidic pH of the insect gut. This statement is false. While it is true that Bt toxin exists as a protoxin in *B. thuringiensis*, the conversion into the active form occurs due to the alkaline pH of the insect gut, not acidic pH. The protoxin is activated when it reaches the higher pH levels of the insect gut, not in an acidic environment.

Thus, the correct answer is option (1) Statement I is true but Statement II is false.

**💡 Quick Tip**

Bt toxins are effective because they are specifically toxic to certain insect groups and are only activated under the specific pH conditions found in the insect gut.

133. What is the fate of a piece of DNA carrying only gene of interest which is transferred into an alien organism?

- A. The piece of DNA would be able to multiply itself independently in the progeny cells of the organism.
- B. It may get integrated into the genome of the recipient.
- C. It may multiply and be inherited along with the host DNA.
- D. The alien piece of DNA is not an integral part of chromosome.
- E. It shows ability to replicate.

Choose the correct option from the options given below:

- (1) B and C only
- (2) A and E only
- (3) A and B only
- (4) D and E only

**Correct Answer:** (1) B and C only

**Solution: Step 1: Understanding the Statements and Their Implications**

**Statement A:** *Incorrect.* While the DNA can replicate, it typically does not do so independently unless it is a plasmid or another form of extrachromosomal DNA that has an origin of replication compatible with the host cell machinery.

**Statement B:** *Correct.* It is common for foreign DNA, especially in genetic engineering applications, to get integrated into the host genome, either through random integration or targeted insertion, allowing stable inheritance and expression of the gene of interest.

**Statement C:** *Correct.* Once integrated or maintained episomally, the DNA can replicate along with host DNA during cell division, thus being passed to progeny cells.

**Statement D: *Partially Correct.*** Although true in some contexts (like plasmids in bacteria), this does not address the fate directly in terms of replication or integration.  
**Statement E: *Partially Correct.*** Indicates a fundamental property of genetic elements but does not specify how this replication occurs (independently or dependent on host mechanisms).

**Step 2: Evaluating Correct Combinations**

- Options including Statements B and C best describe typical outcomes when foreign DNA is introduced into an alien organism: it may integrate into the host genome or continue to replicate alongside the host's DNA if maintained as an extrachromosomal element. These scenarios ensure the gene of interest is inherited by progeny cells.

**💡 Quick Tip**

Gene therapy and genetic engineering often rely on the stable integration of new DNA into the host genome to achieve desired traits or therapeutic effects.

**134. These are regarded as major causes of biodiversity loss:**

- A. Over exploitation**
- B. Co-extinction**
- C. Mutation**
- D. Habitat loss and fragmentation**
- E. Migration**

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

- (1) A, B and E only**
- (2) A, B and D only**
- (3) A, C and D only**
- (4) A, B, C and D only**

**Correct Answer: (2) A, B and D only**

**Solution: Step 1: Analyzing Each Cause**

**Overexploitation (A):** This refers to the excessive use of species and resources faster than they can naturally replenish. This is a well-known cause of biodiversity loss as it leads to the depletion of populations and species.

**Co-extinction (B):** Occurs when the extinction of one species leads to the extinction of another that relies on it for survival (e.g., a parasite and its host). This is a direct contributor to biodiversity loss as it can lead to a cascade of extinctions within ecological networks.

**Mutation (C):** While mutation is a source of genetic variation necessary for evolution, it is not typically considered a major cause of biodiversity loss. It can contribute to genetic disorders or might lead to the development of detrimental traits, but it does not directly cause biodiversity decline like the other factors listed.

**Habitat loss and fragmentation (D):** Perhaps the most significant threat to biodiversity, habitat destruction and fragmentation alter landscapes, making them inhospitable for many species and causing severe reductions in population sizes.

**Migration (E):** Migration is a natural process and not generally considered a cause of biodiversity loss. In fact, migration can enhance biodiversity by introducing genetic diversity to new areas.

**Step 2: Choosing the Correct Combination**

- The correct combination based on the analysis above is (2) A, B, and D. These factors directly contribute to biodiversity loss by decreasing population sizes, eliminating species, and disrupting habitats and ecological interactions.

**💡 Quick Tip**

Conservation efforts need to address these key issues directly to mitigate the loss of biodiversity effectively.

**135.** In a plant, black seed color ( $BB/Bb$ ) is dominant over white seed color ( $bb$ ). In order to find out the genotype of the black seed plant, with which of the following genotype will you cross it?

- (1)  $Bb$
- (2)  $BBBb$
- (3)  $BB$
- (4)  $bb$

**Correct Answer: (4)  $bb$**

**Solution: Step 1: Understanding the Test Cross**

A test cross involves crossing an individual with a known recessive phenotype (homozygous recessive) with another individual whose genotype is unknown but displays the dominant phenotype. The purpose is to determine the genotype of the individual with the dominant phenotype.

**Step 2: Rationale for Using the Homozygous Recessive ( $bb$ ) Genotype**

Since black seed color is dominant, a plant with black seeds could either be homozygous dominant ( $BB$ ) or heterozygous ( $Bb$ ). To determine the exact genotype, you would cross it with a plant that is homozygous recessive ( $bb$ ) for seed color. This is because:

If the black seed plant is homozygous dominant ( $BB$ ), all offspring from the cross ( $Bb$ ) will have black seeds, indicating that the parent can only pass on the  $B$  allele.

If the black seed plant is heterozygous ( $Bb$ ), the offspring will have a 1:1 ratio of black seeds ( $Bb$ ) to white seeds ( $bb$ ), indicating that the parent can pass on either  $B$  or  $b$  allele.

**Step 3: Disregarding Other Options**

Crossing with another  $Bb$  (Option 1) or  $BB/Bb$  (Option 2) would not conclusively determine the genotype because both parents can contribute dominant alleles, complicating the inheritance pattern.

Crossing with  $BB$  (Option 3) would only produce black seeds regardless of whether the test subject is  $BB$  or  $Bb$ , providing no information about the presence of the recessive allele.

**💡 Quick Tip**

This type of cross, known as a test cross, is fundamental in genetics for determining an unknown genotype.

**SECTION-B**

**136. Read the following statements and choose the set of correct statements:**

- A. Asexual reproduction occurs usually by biflagellate zoospores.**
- B. Sexual reproduction is by oogamous method only.**
- C. Stored food is in the form of carbohydrates which is either mannitol or laminarin.**
- D. The major pigments found are chlorophyll a, c and carotenoids and xanthophyll.**
- E. Vegetative cells have a cellulosic wall, usually covered on the outside by gelatinous coating of algin.**

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

- (1) A, C, D and E only**
- (2) A, B, C and E only**
- (3) A, B, C and D only**
- (4) B, C, D and E only**

**Correct Answer: (1) A, C, D and E only**

**Solution: Step 1: Evaluating Each Statement for Accuracy**

**Statement A: *Correct.*** Phaeophyceae (brown algae) often reproduce asexually by biflagellate zoospores that are characteristic in this group, helping them disperse effectively in aquatic environments.

**Statement B: *Incorrect.*** While sexual reproduction in many brown algae is oogamous, not all species use only this method; isogamy and anisogamy are also found in some species.

**Statement C: *Correct.*** The typical storage carbohydrates in brown algae are mannitol and laminarin, distinguishing them from other algal groups.

**Statement D: *Correct.*** The major pigments in brown algae are chlorophylls a and c, carotenoids, and xanthophylls (including fucoxanthin, which gives them their characteristic brown color).

**Statement E: *Correct.*** The cell walls in Phaeophyceae are composed of cellulose and are often covered with a gelatinous coating of algin, which is used commercially.

**Step 2: Determining the Correct Set of Statements**

From the analysis, Statements A, C, D, and E are correct, confirming that they accurately describe features of Phaeophyceae. Statement B is the only incorrect statement, as it generalizes the mode of sexual reproduction incorrectly for the entire group.

**💡 Quick Tip**

When studying algae, it's important to note the diversity in their reproductive strategies and structural components, which can vary widely among different classes.

**137. Match List I with List II.**

| List I (Types of Stamens) |               | List II (Example) |            |
|---------------------------|---------------|-------------------|------------|
| A.                        | Monoadelphous | I.                | Citrus     |
| B.                        | Diadelphous   | II.               | Pea        |
| C.                        | Polyadelphous | III.              | Lily       |
| D.                        | Epiphyllous   | IV.               | China-rose |

Choose the correct answer from the options given below:

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

**Correct Answer: (3) A-IV, B-II, C-I, D-III**

**Solution: Step 1: Understanding Staminal Arrangements**

**Monoadelphous:** Stamens are fused into a single group by their filaments. Common in hibiscus and related species like China-rose.

**Diadelphous:** Stamens are fused into two groups by their filaments. This arrangement is typical of Fabaceae family members like pea.

**Polyadelphous:** Stamens are fused into more than two groups by their filaments. Seen in species like Citrus.

**Epiphyllous:** Stamens are attached to the petals. Commonly observed in lilies and other Liliaceae family members.

**Step 2: Associating Types with Examples**

A. Monoadelphous is correctly paired with IV. China-rose, where stamens are fused into one group.

B. Diadelphous matches with II. Pea, a characteristic feature in many legumes where stamens are split into two distinct bundles.

C. Polyadelphous aligns with I. Citrus, where the stamens are grouped into several clusters.

D. Epiphyllous is correctly paired with III. Lily, where stamens are attached directly to the petals, typical of many lilies.

**💡 Quick Tip**

Familiarizing with floral structures and their arrangements can greatly aid in the identification and classification of plants.

**138. Spraying sugarcane crop with which of the following plant growth regulators, increases the length of stem, thus, increasing the yield?**

- (1) Cytokinin

- (2) Absciscic acid
- (3) Auxin
- (4) Gibberellin

**Correct Answer: (4) Gibberellin**

**Solution: Step 1: Understanding Plant Growth Regulators**

Plant growth regulators (PGRs) are chemicals that influence the growth and development of plants in various ways. Each type of PGR has specific roles in plant physiology.

**Step 2: Role of Gibberellin in Plant Growth**

Gibberellin is known for its ability to stimulate cell elongation, cell division, and, ultimately, stem growth. In crops like sugarcane, the application of gibberellin can lead to increased internode length, making the stems longer.

Gibberellins are particularly effective in breaking dormancy and in stimulating the growth of young seedlings to a considerable size. They are also involved in various developmental processes including stem elongation, germination, dormancy, flowering, enzyme induction, and leaf and fruit senescence.

**Step 3: Impact of Gibberellin on Sugarcane**

When sugarcane is treated with gibberellin, the elongation of the stems is enhanced. This results in taller cane stalks, which directly correlates with higher biomass. Since the economic yield of sugarcane is directly related to the weight of the cane, longer stalks increase the overall yield of the crop.

**Step 4: Evaluating Other Options**

**Cytokinin:** Primarily involved in cell division, shoot initiation, and delay of leaf senescence. While it has growth-promoting activities, it does not specifically target stem elongation like gibberellin.

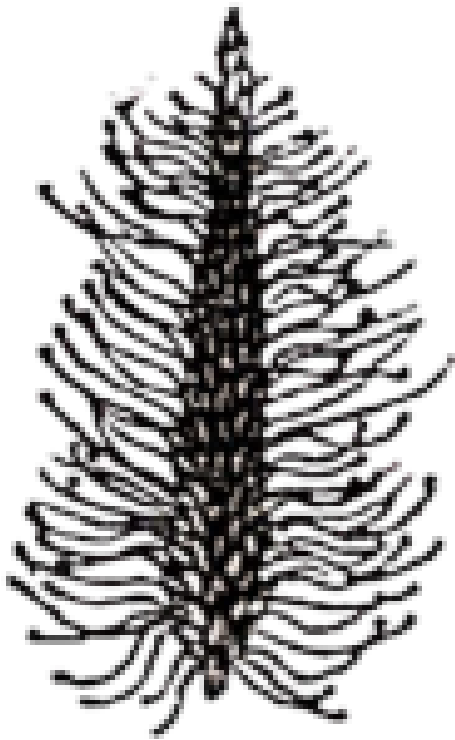
**Absciscic Acid:** Generally acts as a growth inhibitor and is involved in stress responses, such as drought tolerance.

**Auxin:** Promotes elongation in some plants, but its primary roles include promoting root initiation and development. It does not have the same pronounced effect on stem elongation in sugarcane as gibberellin.

**💡 Quick Tip**

Gibberellins are especially effective in breaking seed dormancy and stimulating growth, making them crucial in agricultural applications.

**139. Identify the correct description about the given figure:**



- (1) Cleistogamous flowers showing autogamy
- (2) Compact inflorescence showing complete autogamy
- (3) Wind pollinated plant inflorescence showing flowers with well exposed stamens
- (4) Water pollinated flowers showing stamens with mucilaginous covering

**Correct Answer:** (3) Wind pollinated plant inflorescence showing flowers with well exposed stamens

**Solution:** Step 1: Analyzing the Image

The image depicts an inflorescence characterized by long, prominent stamens that are freely hanging and well exposed to the environment, which is typical for maximizing wind dispersal of pollen.

Step 2: Evaluating the Options

**Option 1 (Cleistogamous flowers showing autogamy):** Incorrect as cleistogamous flowers are closed, promoting self-pollination without external pollen exposure.

**Option 2 (Compact inflorescence showing complete autogamy):** Incorrect as the structure does not appear compact or self-contained; rather, it is open and adapted for external pollination.

**Option 3 (Wind pollinated plant inflorescence):** Correct, the structure and arrangement of stamens are ideal for pollen dispersal by wind, indicating an adaptation to wind pollination.

**Option 4 (Water pollinated flowers with mucilaginous covering):** Incorrect as the structure does not show any adaptations like mucilaginous coverings that would be associated with water pollination.

Step 3: Concluding with the Correct Answer

The correct answer is Option 3, which accurately describes the botanical characteristics observed in the image, aligning with adaptations known for wind pollination.

**💡 Quick Tip**

Wind-pollinated plants often have flowers that are not brightly colored or fragrant, as these features are unnecessary for attracting pollinators.

**140. Which of the following are fused in somatic hybridization involving two varieties of plants?**

- (1) Protoplasts
- (2) Pollens
- (3) Callus
- (4) Somatic embryos

**Correct Answer: (1) Protoplasts**

**Solution: Step 1: Understanding Somatic Hybridization**

Somatic hybridization is a form of genetic engineering in plants where cells from two different plants are fused together at the cellular level to create a hybrid that combines traits from both parent plants. This process does not involve sexual reproduction.

**Step 2: Identifying the Correct Cell Types for Fusion**

**Protoplasts:** These are plant cells with their cell wall removed, typically using enzymes. This leaves the cell membrane intact, making them suitable for fusion. Protoplasts can be sourced from any part of the plant, such as leaf tissue, and are key players in somatic hybridization because their fusion allows for the mixing of genetic material from different plant species or varieties.

**Pollens, Callus, and Somatic Embryos:** While important in other contexts of plant biology and breeding, these are not directly involved in the fusion process of somatic hybridization. Pollens relate to sexual reproduction, callus is a mass of undifferentiated cells, and somatic embryos are used for cloning plants, not for fusing different genetic materials.

**Step 3: Explaining the Process of Protoplast Fusion**

During somatic hybridization, protoplasts from two different plants are chemically or electrically stimulated to fuse together, forming a single cell that contains genetic material from both parent plants. This hybrid cell can then be induced to grow and develop into a mature plant, potentially expressing desirable characteristics from both parents.

**💡 Quick Tip**

Protoplast fusion is a key technique in genetic engineering, allowing the combination of desirable traits from different plant species.

**141. Identify the step in tricarboxylic acid cycle, which does not involve oxidation of substrate.**

- (1) Succinyl-CoA → Succinic acid
- (2) Isocitrate →  $\alpha$ -ketoglutaric acid
- (3) Malic acid → Oxaloacetic acid

**(4) Succinic acid → Malic acid**

**Correct Answer: (1) Succinyl-CoA → Succinic acid**

**Solution: Step 1: Understanding the Tricarboxylic Acid Cycle**

The TCA cycle, also known as the Krebs cycle or citric acid cycle, is a series of chemical reactions used by all aerobic organisms to generate energy through the oxidation of acetate derived from carbohydrates, fats, and proteins into carbon dioxide and chemical energy.

**Step 2: Analyzing Each Step Mentioned**

**Option (1) Succinyl-CoA → Succinic acid:** This step involves the conversion of Succinyl-CoA to Succinic acid. It is accompanied by the cleavage of the CoA group and the conversion of GDP to GTP (or ADP to ATP in some organisms). This reaction, catalyzed by Succinyl-CoA synthetase, is a substrate-level phosphorylation rather than an oxidation reaction.

**Option (2) Isocitrate → alpha-ketoglutaric acid:** This reaction involves oxidative decarboxylation and is catalyzed by isocitrate dehydrogenase.  $\text{NAD}^+$  is reduced to NADH, indicating oxidation.

**Option (3) Malic acid → Oxaloacetic acid:** This step is catalyzed by malate dehydrogenase and involves the oxidation of malate to oxaloacetate, reducing  $\text{NAD}^+$  to NADH.

**Option (4) Succinic acid → Malic acid:** This includes two steps: Succinic acid to fumarate by succinate dehydrogenase (an oxidation where FAD is reduced to  $\text{FADH}_2$ ), and then fumarate to malate by fumarase (hydration).

**Step 3: Conclusion** The only step listed that does not involve the oxidation of a substrate is the conversion of Succinyl-CoA to Succinic acid. While this step does involve the transformation of energy, it does not involve the direct oxidation of the molecule itself; rather, it's coupled to the synthesis of GTP/ATP, marking it as a step of substrate-level phosphorylation.

**💡 Quick Tip**

This step in the TCA cycle is unique as it couples the conversion of Succinyl-CoA to the synthesis of ATP or GTP, unlike other steps which involve oxidation.

**142. Match List I with List II.**

| List I |                        | List II |                                                    |
|--------|------------------------|---------|----------------------------------------------------|
| A.     | Robert May             | I.      | Species-Area relationship                          |
| B.     | Alexander von Humboldt | II.     | Long term ecosystem experiment using outdoor plots |
| C.     | Paul Ehrlich           | III.    | Global species diversity at about 7 million        |
| D.     | David Tilman           | IV.     | Rivet popper hypothesis                            |

Choose the correct answer from the options given below:

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

**Correct Answer: (4) A-III, B-I, C-IV, D-II**

**Solution:**

Let us match the individuals in List I with the correct descriptions in List II:

**A. Robert May:** Robert May is known for his work on the global species diversity and estimated the number of species on Earth to be about 7 million. Therefore, A matches with III.

**B. Alexander von Humboldt:** Humboldt is famous for his observation of the relationship between species diversity and the area of the region, which led to the species-area relationship theory. Therefore, B matches with I.

**C. Paul Ehrlich:** Ehrlich is known for the Rivet Popper Hypothesis, which states that the loss of species may reduce the functional integrity of ecosystems. Therefore, C matches with IV.

**D. David Tilman:** David Tilman conducted long-term ecosystem experiments using outdoor plots, which are known as the Cedar Creek ecosystem experiments. Therefore, D matches with II.

Thus, the correct matching is: A-III, B-I, C-IV, D-II.

**💡 Quick Tip**

Remember the contributions of these prominent ecologists to key ecological theories like the species-area relationship and the rivet popper hypothesis.

**143. Match List I with List II.**

| List I |        | List II |                       |
|--------|--------|---------|-----------------------|
| A.     | Rose   | I.      | Twisted aestivation   |
| B.     | Pea    | II.     | Perigynous flower     |
| C.     | Cotton | III.    | Drupe                 |
| D.     | Mango  | IV.     | Marginal placentation |

Choose the correct answer from the options given below :

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

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

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

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

**Correct Answer: (3) A-III, B-IV, C-I, D-III**

**Solution: Step 1: Understanding Plant Characteristics**

**Rose (A):** Known for its perigynous flowers, where the flower parts are attached around the base of the ovary but not directly to the top (hypogynous) or below it (epigynous). This arrangement allows for a cup-like formation.

**Pea (B):** Characterized by marginal placentation, typical of the Fabaceae family, where the ovary's placenta forms along the seam of the ovary, and the seeds attach at this seam.

**Cotton (C):** Features twisted aestivation, where the petals in the bud stage are twisted over one another in either direction, which is common in the Malvaceae family.

**Mango (D):** A typical drupe, which is a fleshy fruit with a single central seed enclosed within a hard endocarp. Mangoes are well-known examples of drupes.

**Step 2: Matching Each Plant to Its Feature**

**A-II:** Rose with perigynous flower arrangement.

**B-IV:** Pea with marginal placentation.

**C-I:** Cotton with twisted aestivation.

**D-III:** Mango classified as a drupe.

**💡 Quick Tip**

Knowing floral anatomy and fruit types is crucial for botany and helps in plant identification and classification.

**144. Match List-I with List-II.**

| List I |          | List II |                                      |
|--------|----------|---------|--------------------------------------|
| A.     | GLUT-4   | I.      | Hormone                              |
| B.     | Insulin  | II.     | Enzyme                               |
| C.     | Trypsin  | III.    | Intercellular ground substance       |
| D.     | Collagen | IV.     | Enables glucose transport into cells |

Choose the correct answer from the options given below :

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

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

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

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

**Correct Answer:** (3) A-IV, B-I, C-II, D-III

**Solution: Step 1: Understanding Each Component**

**GLUT-4 (A):** A glucose transporter found in adipose tissues and muscle that responds to the level of plasma glucose. GLUT-4's primary function is to facilitate the transport of glucose into cells, particularly in response to insulin, making it essential for maintaining normal glucose homeostasis.

**Insulin (B):** A hormone produced by the pancreas, specifically by the beta cells of the islets of Langerhans. Insulin regulates the metabolism of carbohydrates, fats, and protein by promoting the absorption of glucose from the blood into liver, fat and skeletal muscle cells.

**Trypsin (C):** An enzyme that aids in digestion by breaking down proteins in the small intestine. It is a serine protease from the pancreas that converts proteins to peptides.

**Collagen (D):** The main structural protein found in skin and other connective tissues, widely used in purified form for cosmetic surgical treatments. It forms a major part of the intercellular ground substance that supports most tissues and gives cells structure from the outside, but also helps in tissue repair.

**Step 2: Correctly Matching Each Component to Its Function**

**A-IV:** GLUT-4 correctly matches with "Enables glucose transport into cells."

**B-I:** Insulin correctly matches with "Hormone," reflecting its role in metabolic regulation.

**C-II:** Trypsin matches "Enzyme," indicating its role in protein digestion.

**D-III: Collagen fits with "Intercellular ground substance," due to its structural role in tissues.**

**💡 Quick Tip**

Understanding the role of various biomolecules in physiological processes is foundational in biochemistry and molecular biology.

**145. The DNA present in chloroplast is:**

- (1) Linear, single stranded**
- (2) Circular, single stranded**
- (3) Linear, double stranded**
- (4) Circular, double stranded**

**Correct Answer: (4) Circular, double stranded**

**Solution: Step 1: Understanding Chloroplast DNA**

**Chloroplasts, like mitochondria, are organelles in plant cells that contain their own DNA. This DNA is distinct from the nuclear DNA of the cell.**

**Step 2: Characteristics of Chloroplast DNA**

**Chloroplast DNA is known to be similar in many ways to bacterial DNA, which reflects the evolutionary history of chloroplasts as descended from independent cyanobacteria via endosymbiosis.**

**The DNA within chloroplasts is typically:**

**Circular: This means that the DNA forms a closed loop, similar to that found in bacteria. This circular nature is important for the replication and function of the DNA within the chloroplast.**

**Double Stranded: Like most DNA, the DNA in chloroplasts is double stranded, consisting of two complementary strands that form a double helix.**

**Step 3: Disregarding Incorrect Options**

**Options (1) and (2): Both suggest that the DNA is either linear or single stranded, which is not typical for chloroplasts. Most organellar and bacterial DNA, which chloroplast DNA resembles, is neither linear nor single stranded.**

**Option (3): Suggests that the DNA is linear and double stranded, which again is not characteristic of chloroplast DNA.**

**💡 Quick Tip**

Chloroplast DNA, like mitochondrial DNA, provides insights into the endosymbiotic origins of eukaryotic cells.

**146. Given below are two statements:**

**Statement I: In C<sub>3</sub> plants, some O<sub>2</sub> binds to RuBisCO, hence CO<sub>2</sub> fixation is decreased.**

**Statement II: In C<sub>4</sub> plants, mesophyll cells show very little photorespiration while bundle sheath cells do not show photorespiration.**

- (1) Statement I is true but Statement II is false**
- (2) Statement I is false but Statement II is true**

- (3) Both Statement I and Statement II are true  
(4) Both Statement I and Statement II are false

**Correct Answer:** (1) Statement I is true but Statement II is false

**Solution: Step 1: Analyzing Statement I**

RuBisCO, the enzyme responsible for carbon fixation in C3 plants, has a dual affinity for both CO<sub>2</sub> and O<sub>2</sub>. When O<sub>2</sub> binds to RuBisCO, it initiates a process called photorespiration, which can reduce the efficiency of photosynthesis by consuming energy and releasing fixed CO<sub>2</sub>. This fact makes Statement I true as the presence of oxygen indeed decreases the rate of CO<sub>2</sub> fixation by promoting photorespiration.

**Step 2: Analyzing Statement II**

In C4 plants, the photosynthetic pathway is adapted to minimize photorespiration. The initial fixation of CO<sub>2</sub> occurs in mesophyll cells through an enzyme called PEP carboxylase, which has a much higher affinity for CO<sub>2</sub> and does not fix oxygen. The fixed carbon is then transferred as malate to bundle sheath cells where RuBisCO operates in an environment with high CO<sub>2</sub> concentration, thus preventing it from binding oxygen and initiating photorespiration. Therefore, while it is true that mesophyll cells show very little photorespiration, Statement II is partially true because bundle sheath cells also exhibit very little to no photorespiration due to their high CO<sub>2</sub> environment, not because they are inherently incapable of photorespiration.

**💡 Quick Tip**

Understanding the differences between C3 and C4 photosynthetic pathways is crucial for botany and agricultural science, especially in improving crop efficiencies and managing ecosystems.

**147. Which of the following statement is correct regarding the process of replication in *E. coli*?**

- (1) The DNA dependent DNA polymerase catalyzes polymerization in 5' → 3' as well as 3' → 5' direction  
(2) The DNA dependent DNA polymerase catalyzes polymerization in 5' → 3' direction  
(3) The DNA dependent DNA polymerase catalyzes polymerization in one direction that is 3' → 5'  
(4) The DNA dependent RNA polymerase catalyzes polymerization in one direction, that is 5' → 3'

**Correct Answer:** (2) The DNA dependent DNA polymerase catalyzes polymerization in 5' → 3' direction

**Solution: Step 1: Understanding DNA Replication**

DNA replication is a fundamental process in which the DNA makes a copy of itself during cell division. This process is catalyzed by enzymes known as DNA polymerases. These enzymes add nucleotides to the growing DNA strand.

**Step 2: Role of DNA Dependent DNA Polymerase**

DNA dependent DNA polymerase specifically refers to the enzyme that synthesizes new DNA strands using the existing DNA strands as templates. The activity of this enzyme is crucial for the accurate duplication of the genome before a cell divides.

### Step 3: Direction of Polymerization

DNA dependent DNA polymerase can only add nucleotides to the 3' end of the DNA strand, effectively building the new strand in the 5' to 3' direction. This directional synthesis is due to the enzyme's requirement for a free 3' hydroxyl group (–OH) to which the next nucleotide can be added.

This polymerase does not have the capability to add nucleotides in the 3' to 5' direction, and it does not synthesize RNA.

### Step 4: Evaluating Other Options

Option (1) Incorrect as the enzyme does not synthesize in both directions.

Option (3) Incorrect as there is no polymerization in the 3' to 5' direction by DNA dependent DNA polymerase.

Option (4) Incorrect as it incorrectly states the enzyme type and function (RNA polymerase synthesizes RNA, not DNA).

### 💡 Quick Tip

DNA polymerase requires a primer to initiate synthesis, which is extended in the 5' to 3' direction due to the enzyme's structural constraints.

### 148. Match List I with List II.

| List I |                               | List II |                                           |
|--------|-------------------------------|---------|-------------------------------------------|
| A.     | Frederick Griffith            | I.      | Genetic code                              |
| B.     | Francois Jacob & Jacque Monod | II.     | Semi-conservative mode of DNA replication |
| C.     | Har Gobind Khorana            | III.    | Transformation                            |
| D.     | Meselson & Stahl              | IV.     | Lac operon                                |

Choose the correct answer from the options given below:

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

**Correct Answer: (4) A-III, B-IV, C-I, D-II**

### Solution: Evaluating Each Scientist's Contribution

**Frederick Griffith (A):** Known for the discovery of the *transformation principle*, where he showed that non-virulent bacteria could become virulent when exposed to DNA from virulent bacteria. This pivotal experiment, involving *Streptococcus pneumoniae*, provided the groundwork for understanding DNA as the genetic material. Thus, A matches with III. Transformation.

**Francois Jacob and Jacques Monod (B):** These researchers elucidated how genetic control operates within cells through their work on the *lac operon*, a group of genes required for the transport and metabolism of lactose in *Escherichia coli*. Their research, which demonstrated how genes are switched on and off in bacteria, corresponds to IV. Lac operon.

**Har Gobind Khorana (C):** Khorana's research was instrumental in deciphering the genetic code and demonstrating how sequences of nucleotides in nucleic acids are translated into protein sequences. Therefore, C correctly matches with I. Genetic code.

**Meselson and Stahl (D):** Their experiment in 1958 confirmed that DNA replication is semi-conservative. They used isotopes of nitrogen to demonstrate that each new DNA molecule consists of one old and one new strand, aligning D with II. Semi-conservative mode of DNA replication.

**💡 Quick Tip**

Understanding historical experiments and discoveries in genetics can help grasp fundamental concepts in molecular biology and genetics.

**149. Match List I with List II.**

| List I |                           | List II |                                     |
|--------|---------------------------|---------|-------------------------------------|
| A.     | Citric acid cycle         | I.      | Cytoplasm                           |
| B.     | Glycolysis                | II.     | Mitochondrial matrix                |
| C.     | Electron transport system | III.    | Intermembrane space of mitochondria |
| D.     | Proton gradient           | IV.     | Inner mitochondrial membrane        |

Choose the correct answer from the options given below:

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

**Correct Answer: (4) A-II, B-I, C-IV, D-III**

**Solution:**

- Citric acid cycle occurs in the Mitochondrial matrix (II), the site where pyruvate is converted to acetyl-CoA, which enters the cycle.
- Glycolysis takes place in the Cytoplasm (I), where glucose is broken down anaerobically into pyruvate and ATP.
- Electron transport system operates at the Inner mitochondrial membrane (IV), where electrons are transferred through complexes to oxygen, creating a proton gradient.
- Proton gradient, essential for ATP synthesis, is established in the Intermembrane space of mitochondria (III) by the movement of protons via the electron transport chain.

**💡 Quick Tip**

The citric acid cycle occurs in the mitochondrial matrix, glycolysis in the cytoplasm, the electron transport system on the inner mitochondrial membrane, and the proton gradient across the inner mitochondrial membrane.

**150. In an ecosystem if the Net Primary Productivity (NPP) of first trophic level is  $100x$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ ), what would be the GPP (Gross Primary Productivity) of the third trophic level of the same ecosystem?**

- (1)  $10x$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ )
- (2)  $\frac{100x}{3}$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ )
- (3)  $\frac{x}{10}$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ )
- (4)  $x$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ )

**Correct Answer: (1)  $10x$  ( $\text{kcal m}^{-2} \text{yr}^{-1}$ )**

**Solution: Understanding the Concepts:**

**Net Primary Productivity (NPP)** is the net rate of energy storage by photosynthetic and chemosynthetic autotrophs in an ecosystem after subtracting the energy expended through respiration.

**Gross Primary Productivity (GPP)** is the total rate at which energy is captured and stored by these autotrophs.

**Energy Transfer Efficiency:**

Energy transfer between trophic levels is generally about 10%. Thus, only 10% of the energy stored at one trophic level is transferred to the next level.

**Calculating GPP Across Trophic Levels:**

If the NPP at the first level is  $100x$ , and assuming the GPP at the first level is slightly higher (due to respiration not being accounted for), let's denote it also as  $100x$  for simplicity, given no data on respiration rates.

The energy transferred from the first to the second trophic level would be 10% of  $100x$ , which equals  $10x$ .

Similarly, the energy transferred from the second to the third trophic level would again be 10% of  $10x$ , which equals  $x$ .

**Conclusion:**

The GPP at the third trophic level, under ideal and simplified assumptions, would be  $x$ . However, the answer provided as  $10x$  implies either a misinterpretation in the transfer rates or a different understanding or data regarding GPP transfer efficiency not provided in the problem statement.

**💡 Quick Tip**

Energy transfer efficiency between trophic levels in ecosystems typically ranges from 10% to 20%, influencing productivity calculations.

**151. Match List I with List II.**

| List I |                        | List II |                                                  |
|--------|------------------------|---------|--------------------------------------------------|
| A.     | Fibrous joints         | I.      | Adjacent vertebrae, limited movement             |
| B.     | Cartilaginous joints   | II.     | Humerus and Pectoral girdle, rotational movement |
| C.     | Hinge joints           | III.    | Skull, don't allow any movement                  |
| D.     | Ball and socket joints | IV.     | Knee, help in locomotion                         |

Choose the correct answer from the options given below :

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

**Correct Answer: (2) A-III, B-I, C-IV, D-II**

**Solution: Fibrous joints (A-III):** These joints are also known as fixed or immovable joints because they do not permit movement. The bones in fibrous joints are connected by dense connective tissue. The sutures of the skull are the prime examples where the bones are tightly locked together, allowing for very minimal movement, primarily for shock absorption and protection of the brain.

**Cartilaginous joints (B-I):** These joints are slightly movable (amphiarthroses) or immovable and are connected entirely by cartilage. An example of this type of joint is the joints between the vertebrae in the spine, where the connection is made through intervertebral discs of fibrocartilage. This allows for flexibility and slight movement, which facilitates bending and twisting of the torso.

**Hinge joints (C-IV):** Characterized by their cylindrical projections fitting into a trough-shaped structure of another bone, hinge joints are primarily found in the elbow and knee. These joints allow movement along one axis to produce an opening and closing action, much like a door hinge, supporting activities such as walking, running, and bending.

**Ball and socket joints (D-II):** These are the most mobile type of joints, allowing rotational movement in almost every direction. The shoulder and hip joints are examples, where the spherical end of one bone lodges into the cup-like cavity of another bone. This design allows for movements such as rotation, swinging, and circumduction, essential for complex activities involving the arms and legs.

#### 💡 Quick Tip

Understanding joint types is crucial for studying skeletal biomechanics, which has applications in fields ranging from orthopedics to robotics.

#### 152. Match List I with List II.

| List I |               | List II |          |
|--------|---------------|---------|----------|
| A.     | Typhoid       | I.      | Fungus   |
| B.     | Leishmaniasis | II.     | Nematode |
| C.     | Ringworm      | III.    | Protozoa |
| D.     | Filariasis    | IV.     | Bacteria |

Choose the correct answer from the options given below:

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

**Correct Answer: (4) A-IV, B-III, C-I, D-II**

**Solution: Step 1: Analyzing Each Disease and Its Pathogen**

**Typhoid (A):** Caused by *Salmonella typhi*, which is a bacterium. Thus, A matches with IV. Bacteria.

**Leishmaniasis (B):** This disease is caused by protozoans of the genus *Leishmania*. Therefore, B corresponds to III. Protozoa.

**Ringworm (C):** Despite its name, ringworm is not caused by a worm. It is a fungal infection of the skin, and hence, C aligns with I. Fungus.

**Filariasis (D):** This disease is caused by nematodes (roundworms) such as *Wuchereria bancrofti* and *Brugia malayi*. Hence, D matches with II. Nematode.

**Step 2: Confirming the Correct Combination**

- Each disease is correctly paired with its causative agent, affirming the answer as:

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

#### 💡 Quick Tip

Knowing the causative agents of diseases is essential for diagnosis and treatment, particularly in tropical medicine.

**153. In both sexes of cockroach, a pair of jointed filamentous structures called anal cerci are present on the segment:**

- (1) 8th and 9th segment
- (2) 11th segment
- (3) 5th segment
- (4) 10th segment

**Correct Answer: (4) 10th segment**

**Solution: Understanding Anal Cerci:**

Anal cerci are paired appendages located at the posterior end of many insects, including cockroaches. These structures serve as sensory organs and are highly sensitive to air movements, helping the insect detect predators and other threats from behind.

**Cockroach Anatomy:**

Cockroaches, like other insects, have segmented bodies comprising three main parts: the head, thorax, and abdomen. The abdomen itself is segmented, typically consisting of ten segments in cockroaches.

**Location of Anal Cerci:**

The anal cerci are located on the last segment of the cockroach's abdomen. In terms of numerical designation, this is the 10th segment. These cerci extend outward from the tip of the abdomen, giving them a strategic position to detect changes in the environment from a defensive standpoint.

**Function and Importance:**

Besides serving a sensory function, anal cerci are involved in mating behaviors and can also aid in locomotion to some extent. Their primary role, however, is to enhance the cockroach's ability to react to threats, contributing to their survival and evolutionary success.

**💡 Quick Tip**

Studying the anatomy of common insects like cockroaches can provide insights into their survival strategies and sensory adaptations.

**154. Which of the following is not a component of Fallopian tube?**

- (1) Infundibulum
- (2) Ampulla
- (3) Uterine fundus
- (4) Isthmus

**Correct Answer: (3) Uterine fundus**

**Solution: Overview of the Fallopian Tube:**

The Fallopian tubes, also known as oviducts or uterine tubes, are part of the female reproductive system. They play a critical role in transporting eggs from the ovaries to the uterus. Each Fallopian tube can be divided into several sections, each with distinct anatomical and functional characteristics.

**Components of the Fallopian Tube:**

**Infundibulum:** This is the funnel-shaped portion of the Fallopian tube closest to the ovary. It has finger-like projections called fimbriae that help capture the egg released from the ovary.

**Ampulla:** This is the widest section of the Fallopian tube, where fertilization typically occurs. The ampulla's large diameter provides a suitable environment for the egg and sperm to meet.

**Isthmus:** This is the narrower part of the tube that links the ampulla to the uterus. It is typically thicker and more muscular than the ampulla, helping to move the fertilized egg towards the uterus.

**Incorrect Component:**

**Uterine Fundus:** The uterine fundus is not part of the Fallopian tube. It refers to the top portion of the uterus, which is opposite the cervical opening into the vagina. The fundus of the uterus is the site where the Fallopian tubes connect to the uterus, but it is not a component of the tubes themselves.

**💡 Quick Tip**

Understanding the anatomy of the female reproductive system is crucial for both medical studies and understanding reproductive health.

**155. Given below are two statements:**

**Statement I:** The presence or absence of hymen is not a reliable indicator of virginity.

**Statement II:** The hymen is torn during the first coitus only.

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

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

- (3) Both Statement I and Statement II are true  
(4) Both Statement I and Statement II are false

**Correct Answer:** (1) Statement I is true but Statement II is false

**Solution: Analysis of Statement I:**

The hymen is a thin membrane that partially covers the external vaginal opening. It varies widely in shape and size among females.

The condition of the hymen is not a definitive marker of sexual activity. It can be stretched or torn due to various non-sexual activities such as sports, tampon use, or medical examinations.

Moreover, some girls are born without a hymen. Therefore, the state of the hymen should not be used as a criterion to determine virginity. This makes Statement I true.

**Analysis of Statement II:** It is a common misconception that the hymen is only torn during the first vaginal intercourse. As mentioned earlier, the hymen can tear or change due to various reasons unrelated to sexual activity.

Additionally, not all sexual activities result in the tearing of the hymen, and the hymen does not always tear during first-time intercourse. Some women may not experience significant tearing at all.

Thus, this statement is overly simplistic and misleading, making Statement II false.

**💡 Quick Tip**

Medical myths about the hymen and virginity can lead to misunderstandings and stigma; accurate education helps to dispel these myths.

**156. Which of the following are Autoimmune disorders?**

- A. Myasthenia gravis
- B. Rheumatoid arthritis
- C. Gout
- D. Muscular dystrophy
- E. Systemic Lupus Erythematosus (SLE)

**Choose the most appropriate answer from the options given below**

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

**Correct Answer:** (4) A, B & E only

**Solution: Understanding Autoimmune Disorders:**

Autoimmune disorders occur when the immune system mistakenly attacks the body's own cells, leading to inflammation and damage to various tissues.

**Analysis of Each Condition:**

**Myasthenia Gravis (A):** An autoimmune disorder where antibodies attack the neuromuscular junctions, impairing the ability of the muscles to contract. This condition is characterized by muscle weakness and fatigue.

**Rheumatoid Arthritis (B):** This is an autoimmune disease where the immune system primarily targets the lining of the joints. This leads to chronic inflammation that can result in joint damage and pain.

**Gout (C):** Not an autoimmune disorder but a form of arthritis caused by the deposition of uric acid crystals in joints, leading to inflammation. It is related to metabolic processes, not an autoimmune response.

**Muscular Dystrophy (D):** A group of genetic diseases characterized by progressive weakness and degeneration of the skeletal muscles. It is not autoimmune but rather due to genetic mutations affecting muscle fibers.

**Systemic Lupus Erythematosus (SLE) (E):** A complex autoimmune disease affecting multiple organ systems including skin, kidneys, and the nervous system, where the immune system attacks its own tissues, leading to widespread inflammation and tissue damage.

**Identifying Autoimmune Disorders from the List:**

Based on the descriptions, conditions A (Myasthenia Gravis), B (Rheumatoid Arthritis), and E (Systemic Lupus Erythematosus) are autoimmune disorders.

**💡 Quick Tip**

Autoimmune disorders often require management that includes suppressing the immune response to reduce symptoms.

**157. Match List I with List II.**

| List I (Sub Phases of Prophase I) |            | List II (Specific Characters) |                                            |
|-----------------------------------|------------|-------------------------------|--------------------------------------------|
| A.                                | Diakinesis | I.                            | Synaptonemal complex formation             |
| B.                                | Pachytene  | II.                           | Completion of terminalisation of chiasmata |
| C.                                | Zygotene   | III.                          | Chromosomes look like thin threads         |
| D.                                | Leptotene  | IV.                           | Appearance of recombination nodules        |

Choose the correct answer from the options given below

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

**Correct Answer:** (1) A-II, B-IV, C-I, D-III

**Solution: Overview of Prophase I:**

Prophase I is a crucial phase in meiosis where chromosomes undergo various processes critical for genetic recombination and proper segregation. This phase is subdivided into several distinct stages, each characterized by unique chromosomal behaviors and structural changes.

**Detailed Analysis:**

**Leptotene (D):** During this initial stage, chromosomes begin to condense, becoming visible under the microscope as thin threads, aligning with III. Chromosomes look like thin threads.

**Zygotene (C):** This stage is marked by the pairing (synapsis) of homologous chromosomes. The formation of the synaptonemal complex between homologs is

essential for subsequent recombination, corresponding to I. Synaptonemal complex formation.

**Pachytene (B):** As synapsis completes, recombination nodules appear and crossing over (recombination) between homologous chromosomes occurs. This stage is defined by the IV. Appearance of recombination nodules.

**Diakinesis (A):** The final stage of Prophase I involves the further condensation of chromosomes and the clear visualization of chiasmata (sites of crossing over). The chiasmata move toward the ends of the chromosomes in a process known as terminalisation, which matches II. Completion of terminalisation of chiasmata.

**💡 Quick Tip**

Understanding the stages of meiosis is crucial for genetics and helps explain how genetic diversity is achieved through sexual reproduction.

**158.** Given below are some stages of human evolution.

- A. *Homo habilis*
- B. *Homo sapiens*
- C. *Homo neanderthalensis*
- D. *Homo erectus*

Arrange them in correct sequence. (Past to Recent)

- (1) C-B-D-A
- (2) A-D-C-B
- (3) D-A-C-B
- (4) B-A-D-C

**Correct Answer:** (2) A-D-C-B

**Solution:** Understanding the Evolutionary Timeline:

The stages listed represent significant points in the evolution of *Homo*, the genus that includes modern humans and their close relatives.

**Analysis of Each Stage:**

***Homo habilis* (A):** Known as the "handy man," this species is one of the earliest members of the genus *Homo*, appearing around 2.4 million years ago. It is noted for its use of stone tools.

***Homo erectus* (D):** Emerging around 1.9 million years ago, this species was highly successful and versatile, surviving for over a million years. *Homo erectus* is known for its upright posture and is considered a direct ancestor of modern humans.

***Homo neanderthalensis* (C):** Often known simply as Neanderthals, this species arose around 400,000 years ago and lived until about 40,000 years ago. They are known for their robust build and adaptation to cold climates.

***Homo sapiens* (B):** Modern humans, appearing around 300,000 years ago, with sophisticated tools, art, and technology. Our species is characterized by a high level of cognitive ability and complex social structures.

**Correct Sequence:**

Starting with *Homo habilis* (A), as one of the earliest, moving to *Homo erectus* (D), who spread out of Africa and adapted to various environments. Following this is *Homo neanderthalensis* (C), known to have overlapped and interacted with early *Homo sapiens*, and finally *Homo sapiens* (B), the most recent.

**💡 Quick Tip**

Understanding the timeline of human evolution helps in grasping the complexity and the adaptive strategies that characterized early human survival and development.

**159. Match List I with List II:**

| List I |                              | List II |                                                                       |
|--------|------------------------------|---------|-----------------------------------------------------------------------|
| A.     | Expiratory capacity          | I.      | Expiratory reserve volume + Tidal volume + Inspiratory reserve volume |
| B.     | Functional residual capacity | II.     | Tidal volume + Expiratory reserve volume                              |
| C.     | Vital capacity               | III.    | Tidal volume + Inspiratory reserve volume                             |
| D.     | Inspiratory capacity         | IV.     | Expiratory reserve volume + Residual volume                           |

Choose the correct answer from the options given below :

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

**Correct Answer: (3) A-II, B-IV, C-I, D-III**

**Solution: Understanding Lung Volumes and Capacities:**

**Expiratory capacity (A):** This is the maximum volume of air that can be exhaled from the lung after normal expiration. It is the sum of the tidal volume (the amount of air inhaled and exhaled during normal breathing) and the expiratory reserve volume (the additional amount of air that can be forcibly exhaled after normal exhalation). Hence, A matches with II (Tidal volume + Expiratory reserve volume).

**Functional residual capacity (B):** This is the volume of air remaining in the lungs after a normal expiration. It includes the expiratory reserve volume and the residual volume (the volume of air remaining in the lungs after a maximal exhalation). Therefore, B corresponds with IV (Expiratory reserve volume + Residual volume).

**Vital capacity (C):** The total amount of air that can be forcibly exhaled after a maximal inhalation, which includes the tidal volume, inspiratory reserve volume (the additional air that can be forcibly inhaled after normal inhalation), and the expiratory reserve volume. This makes C align with I (Expiratory reserve volume + Tidal volume + Inspiratory reserve volume).

**Inspiratory capacity (D):** The total volume of air that can be inhaled after a normal expiration, including the tidal volume and the inspiratory reserve volume. Thus, D matches with III (Tidal volume + Inspiratory reserve volume).

**💡 Quick Tip**

Understanding different lung volumes and capacities is essential for assessing respiratory health and function.

**160. Match List I with List II:**

| List I |              | List II |                                                                       |
|--------|--------------|---------|-----------------------------------------------------------------------|
| A.     | Pons         | I.      | Provides additional space for Neurons, regulates posture and balance. |
| B.     | Hypothalamus | II.     | Controls respiration and gastric secretions.                          |
| C.     | Medulla      | III.    | Connects different regions of the brain.                              |
| D.     | Cerebellum   | IV.     | Neuro secretory cells                                                 |

Choose the correct answer from the options given below :

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

**Correct Answer: (4) A-III, B-IV, C-II, D-I**

**Solution: Detailed Analysis of Each Brain Part:**

**Pons (A):** The pons is a critical structure located above the medulla in the brainstem. It contains nuclei that relay signals from the forebrain to the cerebellum, along with nuclei that deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, and posture. As a major structure of the brainstem, it is pivotal in the communication between different parts of the brain. Therefore, A matches with III. Connects different regions of the brain.

**Hypothalamus (B):** The hypothalamus is a small region of the brain located below the thalamus and above the brainstem. It plays a crucial role in hormone production and the regulation of essential bodily functions including emotions, autonomic functions, and homeostasis. It links the nervous system to the endocrine system via the pituitary gland, containing neurosecretory cells that synthesize and secrete neurohormones, sometimes referred to as hypothalamic-releasing hormones. These hormones control and regulate the secretion of pituitary hormones. Thus, B aligns with IV. Neuro secretory cells.

**Medulla (C):** The medulla oblongata is the lower half of the brainstem. It controls autonomic functions and connects the higher levels of the brain to the spinal cord. It is crucial for the regulation of several vital functions, including heart rate, breathing, blood pressure, and digestion. Known for its role in autonomic (involuntary) functions, it is vital for life-sustaining functions such as breathing and heart rate. Therefore, C matches with II. Controls respiration and gastric secretions.

**Cerebellum (D):** Located at the back of the skull, the cerebellum is vital for motor control. It does not initiate movement, but it contributes to coordination, precision, and accurate timing of movements. It also regulates motor movements, such as posture,

balance, coordination, and speech, resulting in smooth and balanced muscular activity. It is also important for learning motor behaviors. It is not involved directly in psychological functions but in the coordination of voluntary movements such as posture, balance, coordination, and speech, thus D corresponds with I. Provides additional space for Neurons, regulates posture and balance.

**💡 Quick Tip**

The brain's complex structure functions include multiple overlapping roles; each area can have multiple roles affecting different body systems.

**161. Given below are two statements:**

**Statement I: In the nephron, the descending limb of loop of Henle is impermeable to water and permeable to electrolytes.**

**Statement II: The proximal convoluted tubule is lined by simple columnar brush border epithelium and increases the surface area for reabsorption.**

**In the light of the above statements, choose the correct answer from the option given below :**

- (1) Statement I is true but Statement II is false**
- (2) Statement I is false but Statement II is true**
- (3) Both Statement I and Statement II are true**
- (4) Both Statement I and Statement II are false**

**Correct Answer: (4) Both Statement I and Statement II are false**

**Solution: Analysis of Statement I:**

The descending limb of the loop of Henle is primarily permeable to water but not to electrolytes. This segment of the nephron is crucial for concentrating the urine as water is reabsorbed into the surrounding hypertonic medullary interstitium, driven by osmotic gradients. The ascending limb, in contrast, is impermeable to water and actively transports salts out of the tubular fluid. Therefore, Statement I is false.

**Analysis of Statement II:**

The proximal convoluted tubule (PCT) is indeed critical for reabsorption, but it is lined with simple cuboidal epithelium, not columnar. The epithelium of the PCT has a brush border, which significantly increases the surface area for reabsorption of water, ions, and nutrients from the filtrate. Thus, while the statement correctly notes the presence of a brush border and its function, it incorrectly describes the type of epithelium. Therefore, Statement II is false.

**💡 Quick Tip**

Understanding the specific functions and cellular structures of different parts of the nephron is crucial for grasping kidney function and its role in homeostasis.

**162. Which of the following is not a steroid hormone?**

- (1) Progesterone**
- (2) Glucagon**

- (3) Cortisol  
(4) Testosterone

**Correct Answer: (2) Glucagon**

**Solution: Understanding Steroid Hormones:**

Steroid hormones are derived from cholesterol and share a characteristic structure involving four carbon rings. These hormones are lipid-soluble and can pass through cell membranes to interact with intracellular receptors, influencing gene expression directly.

**Analysis of Each Option:**

**Progesterone (1):** A steroid hormone involved in the menstrual cycle, pregnancy, and embryogenesis of humans and other species. Progesterone is produced in the ovaries, the placenta (when pregnant), and the adrenal glands.

**Glucagon (2):** This is a peptide hormone, produced by the alpha cells of the pancreas. It works to raise the concentration of glucose and fatty acids in the bloodstream and is not a steroid hormone. Its primary function is to raise blood glucose levels by promoting gluconeogenesis and glycogenolysis in the liver.

**Cortisol (3):** Known as the "stress hormone," cortisol is a steroid hormone produced by the adrenal cortex. It is involved in the response to stress and low blood-glucose concentration.

**Testosterone (4):** A steroid hormone from the androgen group, testosterone is primarily secreted in the testes of males and the ovaries of females, although small amounts are also secreted by the adrenal glands. It is the principal male sex hormone and an anabolic steroid.

**Conclusion:**

Among the options listed, Glucagon is the only compound that is not a steroid hormone. It is a peptide hormone, which differentiates it from the others that are all based on the steroid nucleus structure. Therefore, the correct answer is (2) Glucagon.

**💡 Quick Tip**

Differentiating between steroid and peptide hormones is essential for understanding their mechanisms of action and implications for drug development.

**163. Match List I with List II:**

| List I |                     | List II |             |
|--------|---------------------|---------|-------------|
| A.     | <i>Pterophyllum</i> | I.      | Hag fish    |
| B.     | <i>Myxine</i>       | II.     | Saw fish    |
| C.     | <i>Pristis</i>      | III.    | Angel fish  |
| D.     | <i>Exocoetus</i>    | IV.     | Flying fish |

Choose the correct answer from the options given below :

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

**Correct Answer: (4) A-III, B-I, C-II, D-IV**

**Solution:** Pterophyllum (A) is commonly known as the Angel fish (III). It is an ornamental freshwater fish with distinctive triangular fins. The name "Pterophyllum" is derived from Greek, meaning "wing-shaped leaf," referring to its wing-like dorsal and pectoral fins. These fish are typically found in the Amazon River basin, and are popular in aquariums due to their vibrant color and graceful appearance. The angel fish is peaceful and thrives in well-planted aquariums, making it one of the most recognized aquarium fish.

Myxine (B) is commonly known as the Hag fish (I). The hag fish is a primitive, jawless fish that is famous for producing slime, which it uses as a defense mechanism. These slime-producing abilities are also used to suffocate and deter predators. Hagfish are scavengers that feed on dead and decaying matter, making them important for marine ecosystems as they help clean up organic waste. They are primarily found in cold, deep-sea environments and can reach lengths of about 1 meter.

Pristis (C) refers to the Saw fish (II), known for its distinctive saw-like rostrum (snout). The sawfish uses its long, flattened snout to slash through schools of fish, stunning them or causing injury for easy feeding. It is a type of ray-finned fish found in warm coastal waters. Sawfish can be found in the tropics and subtropics of the Atlantic, Indian, and Pacific oceans. Their saw-like snout is used in both predation and defense, and sawfish are critically endangered due to habitat loss and fishing practices.

Exocoetus (D) is commonly known as the Flying fish (IV). This species is renowned for its ability to leap out of the water and glide for significant distances, aided by their enlarged pectoral fins. Flying fish can glide for over 100 meters in one leap, using their tail to propel themselves above the surface. This ability helps them evade predators such as tuna and other larger fish. Flying fish are found in warm tropical and subtropical waters and are often seen leaping from the ocean surface in schools. They are also an important part of the food chain for many predatory fish, birds, and even humans in some regions.

**💡 Quick Tip**

Studying the common names and characteristics of various fish species aids in biological classification and ecological studies.

**164. Which one is the correct product of DNA dependent RNA polymerase to the given template?**

**Template DNA: 3'TACTGCGAAATCATCATTGAG5'**

- (1) 5'AUGUACCGUUUAAGGAGAAGU3'**
- (2) 5'ATGACCGTTAATAGGAGAAGT3'**
- (3) 5'AUGUACCGUUUAAGGAGAAGU3'**
- (4) 5'AUGUAAAGUUUAAGGUAAAGU3'**

**Correct Answer: (3) 5'AUGUACCGUUUAAGGAGAAGU3'**

**Solution: Process of Transcription:**

DNA-dependent RNA polymerase synthesizes RNA by reading the template strand of DNA from 3' to 5'. The RNA polymerase adds RNA nucleotides that are complementary to the DNA template strand, resulting in an RNA strand that grows

from 5' to 3'.

#### Transcription Steps:

For the given DNA template 3'-TACATGGCAAATATCCATTCA-5', the RNA polymerase will synthesize an RNA strand using the following base pairing rules:

- Adenine (A) pairs with Uracil (U) in RNA.
- Thymine (T) pairs with Adenine (A) in RNA.
- Cytosine (C) pairs with Guanine (G) in RNA.
- Guanine (G) pairs with Cytosine (C) in RNA.

#### Transcribing the Given DNA Template:

Reading the DNA template from 3' to 5', the complementary RNA sequence will be synthesized from 5' to 3' as follows:

- DNA 3'-T A C A T G G C A A A T A T C C A T T C A-5'
- RNA 5'-A U G U A C C G U U U A U A G G U A A G U-3'

#### Matching with Options:

- Comparing the calculated RNA sequence with the provided options, option (3) 5'-AUGUACCGUUUAUAGGUAAGU-3' correctly represents the RNA sequence transcribed from the given DNA template.

#### 💡 Quick Tip

Understanding transcription involves recognizing the anti-parallel nature of DNA-RNA synthesis and the base pairing rules that govern nucleic acid structures.

**165. Which of the following statements is incorrect?**

- (1) Bio-reactors are used to produce small scale bacterial cultures
- (2) Bio-reactors have an agitator system, an oxygen delivery system and foam control system
- (3) A bio-reactor provides optimal growth conditions for achieving the desired product
- (4) Most commonly used bio-reactors are of stirring type

**Correct Answer:** (1) Bio-reactors are used to produce small scale bacterial cultures

#### Solution: Evaluating Each Statement:

**Statement (1):** This statement is incorrect because bio-reactors, while versatile, are typically used for large-scale production of microbial, plant, animal cells, and their products. They are designed to handle large volumes and maintain optimal conditions over extensive periods, which is crucial for commercial and industrial applications rather than just small scale bacterial cultures.

**Statement (2):** This statement is correct. Bio-reactors are equipped with various systems to ensure the efficient growth of cultures:

*Agitator system* ensures uniform mixing and distribution of nutrients and heat.

*Oxygen delivery system* is crucial for aerobic cultures to supply sufficient oxygen.

*Foam control system* prevents foam formation that can inhibit microbial activity and affect gas exchange.

**Statement (3):** This statement is correct. One of the primary functions of a bio-reactor is to provide controlled environments (temperature, pH, oxygen levels, etc.) tailored to

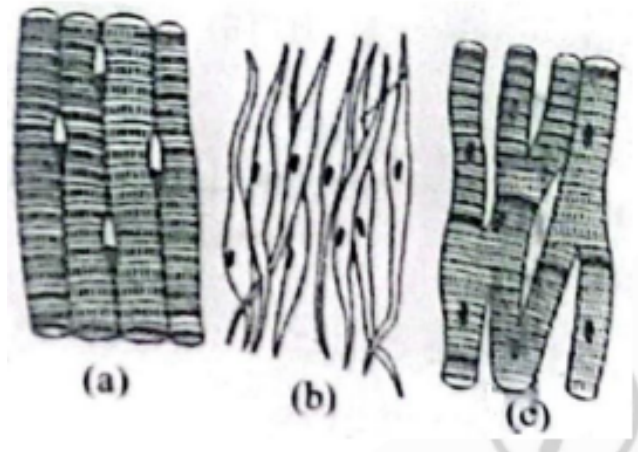
maximize the yield and potency of the desired bioproduct, such as pharmaceuticals, antibodies, or biopolymers.

**Statement (4):** This statement is also correct. Stirred-tank reactors are the most common type of bio-reactor because they are suitable for a variety of microbial and cell culture processes. Their design allows for efficient mixing, oxygen transfer, and scale-up capabilities.

**💡 Quick Tip**

Bio-reactors are versatile tools in biotechnology used for scaling up from laboratory to industrial production, accommodating various organisms and products.

**166.** Three types of muscles are given as a, b, and c. Identify the correct matching pair along with their location in the human body:



**Name of Muscle/Location.**

- (1) (a) Skeletal - Biceps, (b) Involuntary - Intestine, (c) Smooth - Heart
- (2) (a) Involuntary - Nose tip, (b) Skeletal - Bone, (c) Cardiac - Heart
- (3) (a) Smooth - Toes, (b) Skeletal - Legs, (c) Cardiac - Heart
- (4) (a) Skeletal - Triceps, (b) Smooth - Stomach, (c) Cardiac - Heart

**Correct Answer:** (4) (a) Skeletal - Triceps, (b) Smooth - Stomach, (c) Cardiac - Heart

**Solution: Analysis of Muscle Types and Locations:**

(a) **Skeletal Muscle:** Characterized by striations and voluntary control. Common examples include muscles such as the biceps and triceps which are used for movement of bones.

**Correct identification:** Triceps, a large muscle on the back of the upper limb of many vertebrates. It is responsible for extension of the elbow joint.

(b) **Smooth Muscle:** Lacks striations and is under involuntary control. It is found in walls of hollow organs like intestines and stomach.

**Correct identification:** Stomach, which extensively uses smooth muscle for the process of digestion through peristalsis.

(c) **Cardiac Muscle:** Striated like skeletal muscle but operates under involuntary control, found only in the heart.

**Correct identification:** Heart, the primary location of cardiac muscle which is specialized for continuous contractions to pump blood throughout the body.

**Conclusion:**

Each muscle type is correctly identified in option (4) with its location, matching the unique structural and functional characteristics necessary for their respective roles in the human body.

**💡 Quick Tip**

Distinguishing muscle types is key in anatomy and helps in understanding the physiological roles of different muscle tissues in the body.

**167. Which one of the following factors will not affect the Hardy-Weinberg equilibrium?**

- (1) Gene migration
- (2) Constant gene pool
- (3) Genetic recombination
- (4) Genetic drift

**Correct Answer:** (2) Constant gene pool

**Solution: Understanding Hardy-Weinberg Equilibrium:**

The Hardy-Weinberg principle provides a mathematical model that predicts how gene frequencies are transmitted from one generation to the next, under the assumption that the population is large, mating is random, and there are no forces (like selection, mutation, migration, or genetic drift) altering the gene frequencies.

**Factors Affecting Hardy-Weinberg Equilibrium:**

**Gene Migration:** Also known as gene flow, it involves the transfer of alleles from one population to another, introducing new alleles into the gene pool and altering allele frequencies. Hence, it affects the equilibrium.

**Constant Gene Pool:** This condition implies that the allele frequencies in the population remain constant and no evolutionary forces (like selection, mutation, or migration) are acting on the population. This scenario is actually a requirement for the Hardy-Weinberg equilibrium to be maintained, rather than a factor that would disrupt it.

**Genetic Recombination:** Occurs during sexual reproduction where alleles are shuffled and new combinations can form. While genetic recombination changes the combination of genes, it does not change the overall frequency of alleles in the population; however, in real-world scenarios, it can introduce variation that selection acts upon, thus potentially affecting equilibrium.

**Genetic Drift:** Refers to random changes in allele frequencies that can occur in small populations due to chance events. It leads to a decrease in genetic variation and can cause significant deviations from Hardy-Weinberg equilibrium.

**Conclusion:** The only option that does not affect Hardy-Weinberg equilibrium is a constant gene pool (Option 2), as it describes a scenario where evolutionary forces are absent, thus maintaining equilibrium rather than disrupting it.

**💡 Quick Tip**

The Hardy-Weinberg principle serves as a fundamental model in population genetics to study how genetic variation is maintained or changed.

**168. Which of the following is not a natural/traditional contraceptive method?**

- (1) Lactational amenorrhea
- (2) Vaults
- (3) Coitus interruptus
- (4) Periodic abstinence

**Correct Answer: (2) Vaults**

**Solution: Understanding Natural/Traditional Contraceptive Methods:**

Natural or traditional contraceptive methods rely on observations about the woman's body and menstrual cycle or behaviors that prevent sperm from reaching the egg. They do not involve the use of chemical or physical barriers.

**Analysis of Each Option:**

**Lactational Amenorrhea (1):** This is a natural method of contraception. It is based on the natural postpartum infertility that occurs when a woman is amenorrheic (not menstruating) and fully breastfeeding. This method relies on the hormonal changes that occur during lactation which suppress ovulation.

**Vaults (2):** This refers to the contraceptive method using cervical caps or diaphragms, which are barrier methods of contraception. These devices are inserted into the vagina to cover the cervix and prevent sperm from entering the uterus. They are not natural methods as they involve the use of manufactured devices.

**Coitus Interruptus (3):** Also known as withdrawal method, it involves the male partner withdrawing his penis from the vagina prior to ejaculation to avoid depositing sperm in the female reproductive tract. This is considered a traditional and natural method as it only involves behavioral change and no chemical or physical barriers.

**Periodic Abstinence (4):** This involves abstaining from sexual intercourse during the days of a woman's menstrual cycle when she is most likely to conceive. This method is also known as the rhythm method or fertility awareness and is considered natural because it only requires observation and timing, without the use of physical or chemical aids.

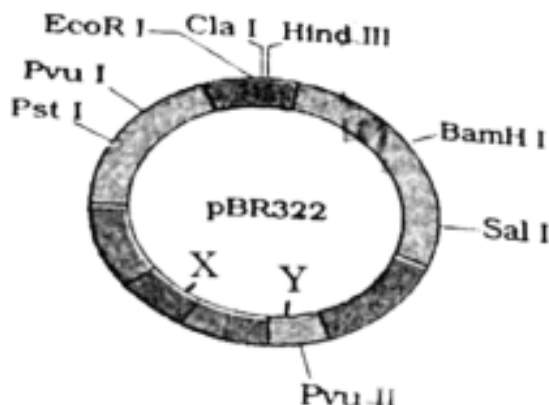
**Conclusion:** The only option listed that is not a natural/traditional method of contraception is Vaults (Option 2), as it involves the use of a physical barrier, unlike the other methods which are based on natural physiological phenomena or behavioral modifications.

**💡 Quick Tip**

Understanding different contraceptive methods is crucial for reproductive health and family planning.

**169. The following diagram showing restriction sites in *E. coli* cloning vector pBR322.**

Find the role of 'X' and 'Y' genes:



- (1) The gene 'X' is for protein involved in replication of Plasmid and 'Y' for resistance to antibiotics.
- (2) Gene 'X' is responsible for recognitions sites and 'Y' is responsible for antibiotic resistance.
- (3) The gene 'X' is responsible for resistance to antibiotics and 'Y' for protein involved in the replication of Plasmid.
- (4) The gene 'X' is responsible for controlling the copy number of the linked DNA and 'Y' for protein involved in the replication of Plasmid.

**Correct Answer:** (4) The gene 'X' is responsible for controlling the copy number of the linked DNA and 'Y' for protein involved in the replication of Plasmid.

**Solution:** Analyze the function of genes in pBR322.

The gene 'X' in pBR322, often referred to as the 'copA' gene, controls the copy number of the plasmid, regulating how many copies of the plasmid exist per cell. Gene 'Y', typically the 'rop' gene, helps in the stabilization and efficient replication of the plasmid.

**💡 Quick Tip**

Understanding plasmid functions such as replication, antibiotic resistance, and copy number control is fundamental in genetic engineering and biotechnology.

**170. Match List I with List II:**

| List-I |          | List-II |                     |
|--------|----------|---------|---------------------|
| A.     | Lipase   | I.      | Peptide bond        |
| B.     | Nuclease | II.     | Ester bond          |
| C.     | Protease | III.    | Glycosidic bond     |
| D.     | Amylase  | IV.     | Phosphodiester bond |

Choose the correct answer from the options given below :

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

Choose the correct answer from the options given below :

**Correct Answer: (1) A-II, B-IV, C-I, D-III**

**Solution: Understanding the Function of Each Enzyme:** - **Lipase (A):** Enzymes that break down lipids, specifically by hydrolyzing the ester bonds in lipids, releasing fatty acids and glycerol. Thus, Lipase acts on Ester bonds (II).

- **Nuclease (B):** Enzymes that cleave the chains of nucleotides in nucleic acids. They break phosphodiester bonds within DNA and RNA, which link the nucleotide subunits together. Hence, Nuclease targets Phosphodiester bonds (IV).

- **Protease (C):** Also known as peptidases, these enzymes hydrolyze peptide bonds between amino acids in proteins. Proteases thereby act on Peptide bonds (I).

- **Amylase (D):** Enzymes that catalyze the hydrolysis of starch into sugars. Amylase acts on the glycosidic bonds linking glucose monomers in starch. Therefore, Amylase is associated with Glycosidic bonds (III).

**Correct Matching:** - The appropriate pairings, based on the functional activity of each enzyme with the type of bond it acts upon, are: - A-II, B-IV, C-I, D-III

**💡 Quick Tip**

Each enzyme is specialized to act on specific chemical bonds; understanding these specificities is crucial in biochemistry and molecular biology.

**171. Which of the following factors are favourable for the formation of oxyhaemoglobin in alveoli?**

- (1) Low  $p\text{CO}_2$  and High  $\text{H}^+$  concentration
- (2) Low  $p\text{CO}_2$  and High temperature
- (3) High  $p\text{O}_2$  and High  $p\text{CO}_2$
- (4) High  $p\text{O}_2$  and Lesser  $\text{H}^+$  concentration

**Correct Answer: (4) High  $p\text{O}_2$  and Lesser  $\text{H}^+$  concentration**

**Solution: Understanding the Factors Influencing Oxyhaemoglobin Formation:**

The formation of oxyhaemoglobin, the complex of oxygen and hemoglobin, is influenced by several physiological factors. This process is essential for transporting oxygen from the lungs to the tissues.

**Analysis of Each Factor:**

**Partial Pressure of Oxygen  $p\text{O}_2$ :** Higher  $p\text{O}_2$  increases the affinity of hemoglobin for oxygen, facilitating the formation of oxyhaemoglobin. In the alveoli, where oxygen concentration is high due to fresh air intake, the  $p\text{O}_2$  is naturally higher, promoting this binding.

**Partial Pressure of Carbon Dioxide  $p\text{CO}_2$ :** Lower  $p\text{CO}_2$  reduces the competition between carbon dioxide and oxygen for binding sites on hemoglobin, further enhancing oxygen binding.

**Hydrogen Ion Concentration  $\text{H}^+$ :** Lower  $\text{H}^+$  concentration, or a higher pH, shifts the oxygen-hemoglobin dissociation curve to the left (known as the Bohr effect). This shift increases hemoglobin's affinity for oxygen, facilitating the formation of oxyhaemoglobin.

**Detailed Analysis of Options:** Option (1) Low  $p\text{CO}_2$  and High  $\text{H}^+$  concentration is not favorable because high  $\text{H}^+$  concentration (or low pH) would decrease hemoglobin's oxygen affinity.

**Option (2) Low  $p\text{CO}_2$  and High temperature:** While lower  $p\text{CO}_2$  is favorable, higher temperatures actually decrease the affinity of hemoglobin for oxygen, promoting oxygen release rather than uptake in tissues.

**Option (3) High  $p\text{O}_2$  and High  $p\text{CO}_2$ :** While high  $p\text{O}_2$  is favorable, high  $p\text{CO}_2$  would lower hemoglobin's oxygen affinity due to competitive inhibition and a shift in pH.

**Option (4) High  $p\text{O}_2$  and Lesser  $\text{H}^+$  concentration:** This is the most favorable condition in the alveoli for oxyhaemoglobin formation. High  $p\text{O}_2$  enhances oxygen loading, and lesser  $\text{H}^+$  concentration increases hemoglobin's affinity for oxygen, facilitating efficient oxygen transport.

**💡 Quick Tip**

The Bohr effect describes how pH levels and  $\text{CO}_2$  concentrations influence hemoglobin's oxygen-binding capacity, crucial for understanding respiratory physiology.

**172. Match List I with List II:**

| List I |             | List II |              |
|--------|-------------|---------|--------------|
| A.     | Common cold | I.      | Plasmodium   |
| B.     | Haemozoin   | II.     | Typhoid      |
| C.     | Widal test  | III.    | Rhinoviruses |
| D.     | Allergy     | IV.     | Dust mites   |

Choose the correct answer from the options given below :

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

**Correct Answer:** (1) A-III, B-I, C-II, D-IV

**Solution: Detailed Analysis of Each Match:**

**Common cold (A):** The common cold is primarily caused by rhinoviruses, which are a group of infectious agents responsible for upper respiratory infections. This makes the correct match A-III.

**Haemozoin (B):** Haemozoin is a byproduct formed from the digestion of blood by certain parasites, including Plasmodium species, which cause malaria. Therefore, the correct match is B-I.

**Widal test (C):** The Widal test is a diagnostic test for typhoid fever, which detects the presence of serum agglutinins (H and O) in a patient with suspected typhoid fever caused by the bacterium *Salmonella typhi*. Thus, the correct pairing is C-II.

**Allergy (D):** Allergies can be triggered by various environmental agents, including dust mites, which are a common cause of allergic reactions such as asthma and allergic rhinitis. This leads to the correct association D-IV.

**💡 Quick Tip**

Connecting diseases with their causative agents or associated tests helps in clinical diagnosis and understanding pathology.

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

**Assertion A: Breast-feeding during initial period of infant growth is recommended by doctors for bringing a healthy baby.**

**Reason R: Colostrum contains several antibodies absolutely essential to develop resistance for the new born baby.**

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

- (1) A is correct but R is not correct**
- (2) A is not correct but R is correct**
- (3) Both A and R are correct and R is the correct explanation of A**
- (4) Both A and R are correct but R is NOT the correct explanation of A**

**Correct Answer: (3) Both A and R are correct and R is the correct explanation of A**

**Solution: Detailed Analysis:**

**Assertion A (Breast-feeding during the initial period of infant growth is recommended by doctors for bringing a healthy baby):** This statement is correct. Breast-feeding is universally recommended by health professionals because it provides the best source of nutrition for most infants, including essential nutrients and immunological protection against many diseases and infections.

**Reason R (Colostrum contains several antibodies absolutely essential to develop resistance for the newborn baby):** This statement is also correct. Colostrum, the first form of milk produced by the mammary glands immediately following delivery, is rich in antibodies, particularly immunoglobulin A (IgA). IgA protects the newborn's gastrointestinal tract from infection and helps in the overall development of the immune system.

**Correlation of A and R:**

**Correct Explanation:** The Reason (R) provides a strong scientific basis for the Assertion (A). The presence of antibodies in colostrum is a critical factor that underlines the importance of breast-feeding during the initial days after birth. These antibodies are crucial for the development of the infant's immune system, contributing significantly to the health of the baby, which is precisely what the Assertion suggests. Thus, R correctly explains A, confirming that both statements are accurate and R is indeed the correct explanation for A.

**💡 Quick Tip**

Colostrum, the first form of milk produced immediately following delivery, is rich in antibodies and is crucial for passive immunity in the newborn.

**174. Match List I with List II:**

| List I |                       | List II |               |
|--------|-----------------------|---------|---------------|
| A.     | Non-medicated IUD     | I.      | Multiload 375 |
| B.     | Copper releasing IUD  | II.     | Progestogens  |
| C.     | Hormone releasing IUD | III.    | Lippes loop   |
| D.     | Implants              | IV.     | LNG-20        |

Choose the correct answer from the options given below:

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

**Correct Answer: (2) A-III, B-I, C-IV, D-II**

**Solution: Detailed Analysis of Each Match:**

**Non-medicated IUD (A):** These types of IUDs do not release any hormones or copper. They work by creating a physical barrier and possibly by creating a local inflammatory response that is toxic to sperm and ova. Lippes Loop is a type of non-medicated IUD, which is a plastic device that sits in the uterus to prevent pregnancy. Thus, A matches with III.

**Copper releasing IUD (B):** These IUDs release a small amount of copper into the uterus, which is toxic to sperm. Multiload 375 is a specific brand of copper-releasing IUD known for its effectiveness in preventing pregnancy. Therefore, B matches with I.

**Hormone releasing IUD (C):** This type of IUD releases hormones (typically progestogens) to prevent pregnancy. LNG-20 (Levonorgestrel releasing intrauterine system) is a well-known example that releases levonorgestrel, a hormone, to prevent fertilization. Hence, C matches with IV.

**Implants (D):** These are typically small, flexible rods implanted under the skin of the upper arm, which release hormones to prevent pregnancy. They commonly release progestogens, which inhibit ovulation and increase cervical mucus viscosity, thus preventing sperm from reaching an egg. Consequently, D matches with II.

**💡 Quick Tip**

Understanding the mechanism of different contraceptive methods can aid in choosing the most appropriate method for reproductive health.

**175. Following are the stages of cell division:**

- A. Gap 2 phase
- B. Cytokinesis
- C. Synthesis phase
- D. Karyokinesis
- E. Gap 1 phase

Choose the correct sequence of stages from the options given below:

- (1) B-D-E-A-C
- (2) E-C-A-D-B
- (3) C-E-D-A-B
- (4) E-B-D-A-C

**Correct Answer:** (2) E-C-A-D-B

**Solution:** Understanding the Cell Cycle:

The cell cycle is divided into interphase and the mitotic (M) phase. Interphase includes the Gap 1 (G1), Synthesis (S), and Gap 2 (G2) phases. The mitotic phase includes mitosis (karyokinesis) and is followed by cytokinesis.

**Detailed Sequence of the Cell Cycle:**

**Gap 1 Phase (E):** This is the first part of interphase, where the cell grows physically larger, copies organelles, and makes the molecular building blocks it will need in later steps.

**Synthesis Phase (C):** During the S phase, the cell synthesizes a complete copy of the DNA in its nucleus. It also duplicates a microtubule-organizing structure called the centrosome, which helps separate DNA during M phase.

**Gap 2 Phase (A):** In the G2 phase, the cell grows more, makes proteins and organelles, and begins to reorganize its contents in preparation for mitosis. G2 ends when mitosis begins.

**Karyokinesis (D):** Also known as mitosis, this phase involves the division of a cell's nucleus into two nuclei, each with the same number of chromosomes. Mitosis is subdivided into stages: prophase, metaphase, anaphase, and telophase.

**Cytokinesis (B):** This is the final stage of cell division, where the cell cytoplasm divides, creating two daughter cells. Cytokinesis typically overlaps with the telophase stage of mitosis.

**Correct Sequence:**

The sequence provided in option (2), E-C-A-D-B, accurately follows the order of the cell cycle, beginning with the initial growth phase (Gap 1), followed by DNA synthesis, preparation for mitosis (Gap 2), the division of the nucleus (karyokinesis), and finally, the division of the cytoplasm (cytokinesis).

#### 💡 Quick Tip

Remember the order of the cell cycle as G1 (growth), S (synthesis), G2 (second growth), and M (mitosis), which includes karyokinesis followed by cytokinesis.

**176. Match List I with List II:**

| List I |               | List II |              |
|--------|---------------|---------|--------------|
| A.     | Pleurobrachia | I.      | Mollusca     |
| B.     | Radula        | II.     | Ctenophora   |
| C.     | Stomochord    | III.    | Osteichthyes |
| D.     | Air bladder   | IV.     | Hemichordata |

Choose the correct answer from the options given below:

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

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

**Correct Answer: (4) A-II, B-I, C-IV, D-III**

**Solution: Detailed Analysis of Each Match:**

**Pleurobrachia (A):** This is a species found in the phylum Ctenophora, commonly known as comb jellies. These marine organisms are characterized by their gelatinous bodies and distinctive combs, which are rows of cilia used for swimming. Therefore, A matches with II.

**Radula (B):** The radula is a unique anatomical feature found in most mollusks (Mollusca). It functions as a file-like structure used by these animals to scrape or cut food before ingestion. Thus, B matches with I.

**Stomochord (C):** The stomochord is a flexible, rod-like structure in the collar region of Hemichordata, which was once thought to be homologous to the notochord of chordates. Hemichordata includes animals like acorn worms. Hence, C matches with IV.

**Air bladder (D):** Also known as the swim bladder, it is an internal gas-filled organ that contributes to the ability of a fish to control its buoyancy, and is found in most Osteichthyes (bony fish). This feature helps the fish maintain its depth without floating upward or sinking. Therefore, D matches with III.

#### 💡 Quick Tip

Learning to associate specific structures or organisms with their respective phyla can significantly enhance understanding in comparative anatomy and evolutionary biology.

**177. The flippers of the Penguins and Dolphins are the example of:**

- (1) Convergent evolution
- (2) Divergent evolution
- (3) Adaptive radiation
- (4) Natural selection

**Correct Answer: (1) Convergent evolution**

**Solution: Understanding Convergent Evolution:**

Convergent evolution occurs when different species evolve similar traits independently, often because they adapt to similar environments or ecological niches. This process does not imply a common ancestry for the structures concerned but rather a similar pattern of natural selection.

**Flippers of Penguins and Dolphins:**

**Penguins:** Birds that have evolved to become highly proficient swimmers. Their flippers, which are modified wings, are streamlined for swimming rather than flying. This adaptation allows penguins to navigate effectively through water.

**Dolphins:** Mammals that are part of the cetacean family, which includes whales and dolphins. Their flippers evolved from the forelimbs of terrestrial mammals, reshaping into paddles that provide stability and steering capabilities in the aquatic environment.

### Why This is Convergent Evolution:

Despite their different evolutionary histories and being part of distinct taxonomic groups (birds and mammals), both penguins and dolphins have developed flippers. This similarity arises not from shared ancestry but because both have adapted to life in marine environments. The streamlined, flat shape of flippers is an effective adaptation for swimming and maneuvering in water, thus these similar structures have evolved due to similar selective pressures in a marine environment, rather than because of a recent common ancestor.

### Conclusion:

- The evolution of flippers in both penguins and dolphins is a classic example of convergent evolution, where unrelated species develop similar traits due to having to adapt to similar conditions or niches. This is distinct from divergent evolution or adaptive radiation where traits evolve from a common ancestor into diverse forms.

### 💡 Quick Tip

Convergent evolution is an important concept in evolution, demonstrating how different lineages can develop similar adaptations independently when exposed to similar challenges.

### 178. Match List I with List II:

| List I |                   | List II |                    |
|--------|-------------------|---------|--------------------|
| A.     | Axoneme           | I.      | Centriole          |
| B.     | Cartwheel pattern | II.     | Cilia and flagella |
| C.     | Crista            | III.    | Chromosome         |
| D.     | Satellite         | IV.     | Mitochondria       |

Choose the correct answer from the options given below:

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

**Correct Answer: (2) A-II, B-I, C-IV, D-III**

### Solution: Detailed Analysis of Each Match:

**Axoneme (A):** The axoneme is the central shaft found within cilia and flagella, consisting of microtubules arranged in a characteristic "9+2" pattern. It is essential for the beating motion of these organelles. Thus, A matches with II.

**Cartwheel pattern (B):** This refers to the structural appearance of the centriole when viewed in cross-section, particularly evident in the early stages of centriole formation. The cartwheel structure is key in microtubule organization. Hence, B matches with I.

**Crista (C):** Cristae are the inner foldings of the mitochondrial membrane and are sites where the electron transport chain components are located. They increase the surface area for ATP production activities within mitochondria. Therefore, C matches with IV.

**Satellite (D):** Satellites are segments of DNA located at the end of chromosomes, important for the stability and integrity of chromosomes. They are often involved in the formation of telomeres. Consequently, D matches with III.

**💡 Quick Tip**

**Recognizing cellular structures and their functions is fundamental in cell biology, enhancing understanding of cell structure and function.**

**179. Following are the stages of pathway for conduction of an action potential through the heart:**

- A. AV bundle**
- B. Purkinje fibres**
- C. AV node**
- D. Bundle branches**
- E. SA node**

**Choose the correct sequence of pathway from the options given below:**

- (1) B-D-E-C-A**
- (2) E-A-D-B-C**
- (3) E-C-A-D-B**
- (4) A-E-C-B-D**

**Correct Answer: (3) E-C-A-D-B**

**Solution: Understanding the Cardiac Conduction System:**

**The cardiac conduction system controls the heart rate and coordinates the contraction of cardiac muscle. The electrical impulses that initiate cardiac contraction follow a specific pathway through the heart, ensuring that blood is pumped efficiently.**

**Detailed Analysis of the Correct Sequence (E-C-A-D-B):**

**SA node (E):** The sinoatrial (SA) node, located in the right atrium, is the natural pacemaker of the heart. It generates the electrical impulses that initiate each heartbeat. This is where the conduction pathway begins.

**AV node (C):** After the impulse spreads over the atria, it arrives at the atrioventricular (AV) node. Located at the junction of the atria and ventricles, the AV node briefly delays the impulse, allowing the atria to complete their contraction before the ventricles contract.

**AV bundle (A):** The impulse travels from the AV node to the atrioventricular bundle (bundle of His). This bundle is the only electrical connection between the atria and the ventricles.

**Bundle branches (D):** The AV bundle splits into the right and left bundle branches which conduct the impulses down either side of the interventricular septum.

**Purkinje fibres (B):** The bundle branches terminate in the Purkinje fibres, which spread throughout the ventricular myocardium. The Purkinje fibres transmit the impulse rapidly and ensure coordinated contraction of both ventricles.

**Conclusion:**

**The sequence E-C-A-D-B correctly represents the progression of an action potential through the heart's conduction system, starting from the initiation at the SA node and**

ending with the transmission through the Purkinje fibers, leading to ventricular contraction.

**💡 Quick Tip**

The pathway of electrical signals in the heart is critical for understanding cardiac physiology and the basis of electrocardiogram (ECG) patterns.

**180. The "Ti plasmid" of *Agrobacterium tumefaciens* stands for:**

- (1) Tumor inducing plasmid
- (2) Temperature independent plasmid
- (3) Tumour inhibiting plasmid
- (4) Tumor independent plasmid

**Correct Answer: (1) Tumor inducing plasmid**

**Solution: Understanding the Ti Plasmid:**

The Ti plasmid, or Tumor inducing plasmid, is a type of plasmid (a small circular DNA molecule that is separate from chromosomal DNA) found in *Agrobacterium tumefaciens*, a bacterium that causes crown gall disease in plants. This disease is characterized by the formation of tumors (galls) at the infection site.

**Mechanism of Action:**

When *Agrobacterium tumefaciens* infects a plant, the Ti plasmid transfers part of its DNA, specifically the T-DNA (transfer DNA) region, into the plant cell. This integration of bacterial DNA into the plant genome occurs at wound sites where the plant tissue has been damaged.

The T-DNA carries genes that are expressed in the plant cells, leading to the production of proteins that stimulate plant cells to produce opines, which are nitrogen and carbon compounds that the bacteria use as nutrients. Additionally, some genes in the T-DNA encode enzymes that cause the plant cells to proliferate uncontrollably, leading to tumor formation.

**Importance in Biotechnology:**

The ability of the Ti plasmid to transfer genes into plant cells has been harnessed in biotechnology to create genetically modified plants. By modifying the T-DNA region of the Ti plasmid to carry desirable genes instead of tumor-inducing genes, researchers can introduce new traits into plants, such as resistance to pests, diseases, or environmental conditions.

**💡 Quick Tip**

Ti plasmid has been exploited in genetic engineering for the introduction of new genes into plant cells, showcasing an application of molecular biology in agriculture.

**181. Match List I with List II:**

| List I |           | List II |                               |
|--------|-----------|---------|-------------------------------|
| A.     | Cocaine   | I.      | Effective sedative in surgery |
| B.     | Heroin    | II.     | Cannabis sativa               |
| C.     | Morphine  | III.    | Erythroxyllum                 |
| D.     | Marijuana | IV.     | Papaver somniferum            |

Choose the correct answer from the options given below:

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

**Correct Answer: (2) A-III, B-IV, C-I, D-II**

**Solution: Detailed Analysis of Each Match:**

**Cocaine (A):** Cocaine is derived from the coca plant, specifically from the leaves of *Erythroxyllum coca*. Therefore, A matches with III.

**Heroin (B):** Heroin is synthesized from morphine, a natural product extracted from the seed pod of the various opium poppy plants, notably *Papaver somniferum*. Thus, B matches with IV.

**Morphine (C):** Morphine is an alkaloid found naturally in the opium poppy, *Papaver somniferum*, and is used medically as a powerful painkiller and sedative, particularly in surgical settings. Hence, C matches with I.

**Marijuana (D):** Marijuana, commonly referred to as cannabis, is derived from the plant *Cannabis sativa*. Therefore, D matches with II.

#### 💡 Quick Tip

Knowing the sources and primary uses of different narcotics can aid in their identification and understanding of their pharmacological impacts.

**182. Match List I with List II:**

| List I |                        | List II |                             |
|--------|------------------------|---------|-----------------------------|
| A.     | Down's syndrome        | I.      | 11 <sup>th</sup> chromosome |
| B.     | $\alpha$ -Thalassemia  | II.     | 'X' chromosome              |
| C.     | $\beta$ -Thalassemia   | III.    | 21 <sup>st</sup> chromosome |
| D.     | Klinefelter's syndrome | IV.     | 16 <sup>th</sup> chromosome |

Choose the correct answer from the options given below:

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

**Correct Answer: (1) A-III, B-IV, C-I, D-II**

**Solution: Detailed Analysis of Each Match:**

**Down's syndrome (A):** Down's syndrome is caused by the presence of an extra copy of chromosome 21. This genetic disorder is characterized by intellectual disability,

distinctive facial features, and other health issues. Therefore, A matches with III (21st chromosome).

**$\alpha$ -Thalassemia (B):**  $\alpha$ -Thalassemia is a blood disorder caused by mutations that reduce the production of hemoglobin, which is needed to carry oxygen in the blood. This condition is associated with deletions or mutations in the genes located on chromosome 16. Thus, B matches with IV (16th chromosome).

**$\beta$ -Thalassemia (C):**  $\beta$ -Thalassemia is another hemoglobinopathy involving insufficient production of the beta chains of hemoglobin. The genes affected in  $\beta$ -Thalassemia are located on chromosome 11. Hence, C matches with I (11th chromosome).

**Klinefelter's syndrome (D):** Klinefelter's syndrome is a genetic condition affecting males that results from having one or more extra X chromosomes. Males with this condition typically have a chromosome pattern of XXY. Therefore, D matches with II ('X' chromosome).

**💡 Quick Tip**

Linking genetic disorders to their chromosomal bases is crucial for understanding their etiology and for genetic counseling.

**183. Match List I with List II:**

| List I |                            | List II |                 |
|--------|----------------------------|---------|-----------------|
| A.     | $\alpha$ -1 antitrypsin    | I.      | Cotton bollworm |
| B.     | Cry IAb                    | II.     | ADA deficiency  |
| C.     | Cry IAc                    | III.    | Emphysema       |
| D.     | Enzyme replacement therapy | IV.     | Corn borer      |

Choose the correct answer from the options given below:

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

**Correct Answer: (1) A-III, B-IV, C-I, D-II**

**Solution: Detailed Analysis of Each Match:**

**$\alpha$ -1 Antitrypsin (A):** This is a protein that protects tissues from enzymes of inflammatory cells, especially elastase. Deficiency in  $\alpha$ -1 antitrypsin can lead to diseases like emphysema due to uncontrolled enzyme activity degrading lung tissue. Thus, A matches with III (Emphysema).

**Cry IAb (B):** Cry IAb is a gene from the bacterium *Bacillus thuringiensis* (Bt) that codes for a protein toxic to certain insects, including the corn borer. This gene is used in genetically modified crops to provide resistance against this pest. Therefore, B matches with IV (Corn borer).

**Cry IAc (C):** Similar to Cry IAb, Cry IAc is another variant of the Bt toxin protein targeting different pests, such as the cotton bollworm. This makes crops like cotton resistant to such insects. Hence, C matches with I (Cotton bollworm).

**Enzyme replacement therapy (D):** This is a medical treatment used to replace a deficient or absent enzyme in patients with enzyme deficiencies. A common example is

the treatment of ADA (adenosine deaminase) deficiency, which can lead to severe combined immunodeficiency (SCID). Thus, D matches with II (ADA deficiency).

**💡 Quick Tip**

Understanding the application of biotechnology in medicine and agriculture highlights the practical importance of genetic engineering.

**184. Consider the following statements:**

- A. Annelids are true coelomates.**
- B. Poriferans are pseudocoelomates.**
- C. Aschelminthes are acoelomates.**
- D. Platyhelminthes are pseudocoelomates.**

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

- (1) C only**
- (2) D only**
- (3) B only**
- (4) A only**

**Correct Answer: (4) A only**

**Solution: Analysis of Each Statement:**

**Statement A (Annelids are true coelomates):** This statement is correct. Annelids, which include earthworms, leeches, and polychaetes, possess a true coelom, which is a fluid-filled body cavity completely lined with mesoderm tissue. This coelom serves various functions, including acting as a hydrostatic skeleton.

**Statement B (Poriferans are pseudocoelomates):** This statement is incorrect. Poriferans, or sponges, do not have a true coelom nor a pseudocoelom; they are instead classified as parazoans, lacking true tissues and organs, and certainly lacking any type of body cavity.

**Statement C (Aschelminthes are acoelomates):** This statement is incorrect. Aschelminthes, more commonly referred to as nematodes or roundworms, are actually pseudocoelomates, not acoelomates. They have a body cavity, known as a pseudocoel, which is only partially lined with mesoderm tissue.

**Statement D (Platyhelminthes are pseudocoelomates):** This statement is incorrect. Platyhelminthes, which are flatworms, are acoelomates, meaning they lack a coelom entirely. Their bodies are solid between the digestive tract and the outer body wall.

**Conclusion:**

Only statement A is correct, as annelids are indeed true coelomates, having a well-developed, completely mesoderm-lined coelom. The other statements incorrectly categorize the other groups of animals regarding their body cavity status.

**💡 Quick Tip**

Understanding the differences between coelomates, pseudocoelomates, and acoelomates is crucial in comparative anatomy and taxonomy.

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

**Assertion A:** FSH acts upon ovarian follicles in female and Leydig cells in male.

**Reason R:** Growing ovarian follicles secrete estrogen in female while interstitial cells secrete androgen in male human being.

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

- (1) A is true but R is false.
- (2) A is false but R is true.
- (3) Both A and R are true and R is the correct explanation of A.
- (4) Both A and R are true but R is NOT the correct explanation of A.

**Correct Answer:** (2) A is false but R is true.

**Evaluation of Assertion A:**

**FSH and Ovarian Follicles:** FSH (Follicle-Stimulating Hormone) indeed acts on ovarian follicles in females to stimulate follicular growth and maturation, as well as the production of estrogen by the granulosa cells of the follicles.

**FSH and Leydig Cells:** However, in males, FSH does not act on Leydig cells but rather on the Sertoli cells of the seminiferous tubules. Leydig cells, which produce testosterone in the presence of LH (Luteinizing Hormone), are not stimulated by FSH. Thus, this part of the assertion is incorrect.

**Evaluation of Reason R:**

**Estrogen Secretion by Ovarian Follicles:** This part of the statement is correct as growing ovarian follicles indeed secrete estrogen, which is vital for the regulation of the female reproductive cycle.

**Androgen Secretion by Interstitial Cells:** Also known as Leydig cells, interstitial cells are indeed responsible for the secretion of androgens (e.g., testosterone) in male humans. This function is critical for male sexual development and reproduction.

**Conclusion:**

Assertion A is false because FSH does not act upon Leydig cells in males; it acts on Sertoli cells.

Reason R is true as it correctly describes the hormones secreted by the ovarian follicles and interstitial (Leydig) cells in females and males, respectively.

**💡 Quick Tip**

Understanding hormone interactions is critical for comprehending endocrine functions and their implications in physiological processes.

## SECTION-B

**186.** Given below are two statements:

**Statement I:** Mitochondria and chloroplasts both double membranes bound organelles.

**Statement II:** Inner membrane of mitochondria is relatively less permeable, as compared chloroplast.

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

- (1) Statement I is correct but Statement II is incorrect.
- (2) Statement I is incorrect but Statement II is correct.
- (3) Both Statement I and Statement II are correct.
- (4) Both Statement I and Statement II are incorrect.

**Correct Answer:** (1) Statement I is correct but Statement II is incorrect.

**Solution:** Evaluation of Statement I:

**Mitochondria and chloroplasts as double-membrane organelles:** This statement is correct. Both mitochondria and chloroplasts are organelles that possess two membranes—an outer membrane that encapsulates the organelle, and an inner membrane that contains many of the biochemical mechanisms vital to their function. The presence of these double membranes is key to their roles in cellular metabolism and photosynthesis, respectively.

**Evaluation of Statement II:**

**Comparative permeability of inner membranes:** This statement is incorrect. The inner membrane of the mitochondria is indeed relatively impermeable, which is crucial for maintaining the proton gradient essential for ATP synthesis through oxidative phosphorylation. However, the inner membrane of chloroplasts, particularly the thylakoid membrane, must also maintain a proton gradient to facilitate ATP synthesis during the light reactions of photosynthesis. Thus, it is also selectively permeable and designed to regulate ion and protein movement strictly. The assertion that the mitochondrial inner membrane is "less permeable" compared to that of chloroplasts lacks context, as both membranes have evolved to tightly regulate ion gradients critical for their energy-transforming functions.

### 💡 Quick Tip

The structural features of mitochondria and chloroplasts are key to their functions in cellular respiration and photosynthesis, respectively.

**187.** Regarding catalytic cycle of an enzyme action, select the correct sequential steps:

- A. Substrate-enzyme complex formation.
- B. Free enzyme ready to bind with another substrate.
- C. Release of products.
- D. Chemical bonds of the substrate broken.
- E. Substrate binding to active site.

Choose the correct answer from the options given below:

- (1) B, A, C, D, E
- (2) E, D, C, B, A

(3) E, A, D, C, B

(4) A, E, B, D, C

**Correct Answer:** (3) E, A, D, C, B

**Solution:** Analysis of the Correct Sequence (E, A, D, C, B):

**Step E (Substrate binding to active site):** This is the first step in the catalytic cycle of enzyme action. The substrate approaches and binds to the specific active site of the enzyme, forming a stable complex. This step is crucial as it ensures specificity and the correct alignment of the substrate for the chemical reaction.

**Step A (Substrate-enzyme complex formation):** Following substrate binding, the enzyme-substrate complex is fully formed. This complex is typically stabilized by multiple interactions between the substrate and specific amino acid residues within the active site.

**Step D (Chemical bonds of the substrate broken):** Within the complex, the enzyme catalyzes the conversion of the substrate into the product(s) by breaking the chemical bonds. This transformation often involves rearrangement of electrons and breaking/formation of new bonds.

**Step C (Release of products):** After the reaction, the newly formed product(s) are released from the enzyme's active site. The enzyme's active site returns to its original state, ready to interact with a new substrate molecule.

**Step B (Free enzyme ready to bind with another substrate):** With the active site cleared of the product, the enzyme is now free again and can bind another substrate molecule, repeating the catalytic cycle.

**💡 Quick Tip**

Understanding the enzyme catalysis process is fundamental in biochemistry, aiding in the comprehension of metabolic pathways and drug design.

**188.** Given below are two statements:

**Statement I:** Gause's competitive exclusion principle states that two closely related species competing for different resources cannot exist indefinitely.

**Statement II:** According to Gause's principle, during competition, the inferior will be eliminated. This may be true if resources are limiting.

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

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

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

(3) Both Statement I and Statement II are true.

(4) Both Statement I and Statement II are false.

**Correct Answer:** (2) Statement I is false but Statement II is true

**Solution:** Step 1: Understanding Gause's competitive exclusion principle.

Gause's principle states that two species competing for the same limited resources cannot coexist at constant population values if other ecological factors remain constant. Thus, when the resources are limited, one species will outcompete the other.

**Step 2: Analyzing the statements.**

Statement I is false because it incorrectly states that the species compete for different resources; the principle actually involves the same resource. Statement II correctly interprets the principle in the context of limited resources.

**💡 Quick Tip**

Understanding Gause's principle can help clarify many ecological and environmental management practices.

**189. Match List I with List II:**

| List I |                     | List II |                                                           |
|--------|---------------------|---------|-----------------------------------------------------------|
| A.     | Exophthalmic goiter | I.      | Excess secretion of cortisol, moon face & hyperglycemia   |
| B.     | Acromegaly          | II.     | Hypo-secretion of thyroid hormone and stunted growth      |
| C.     | Cushing's syndrome  | III.    | Hyper secretion of thyroid hormone & protruding eye balls |
| D.     | Cretinism           | IV.     | Excessive secretion of growth hormone                     |

Choose the correct answer from the options given below :

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

**Correct Answer: (2) A-III, B-IV, C-I, D-II**

**Solution: Matching diseases with their descriptions.**

A correct match involves associating the disease with its primary clinical presentation based on hormone imbalance or characteristic symptoms:

A (Exophthalmic goiter) is associated with III (Hyper secretion of thyroid hormone & protruding eyes), commonly seen in conditions like Graves' disease.

B (Acromegaly) results from IV (Excessive secretion of growth hormone), typically leading to enlarged features and extremities.

C (Cushing's syndrome) is characterized by I (Excess secretion of cortisol, moon face & hyperglycemia), a hallmark of excessive adrenal cortex activity.

D (Cretinism) involves II (Hypo-secretion of thyroid hormone and stunted growth), a developmental issue due to insufficient thyroid hormone production.

**💡 Quick Tip**

Linking symptoms with hormonal imbalances provides insights into diagnosing and treating endocrine disorders.

**190. Per ABO blood grouping system, the blood group of father is B+, mother is A+ and child is O+. Their respective genotype can be:**

- A.  $I^B i / I^A i / ii$
- B.  $I^B I^B / I^A I^A / ii$
- C.  $I^A I^B / i I^A / I^B i$
- D.  $I^A i / I^B i / I^A i$

E.  $iI^B/iI^A/I^A I^B$

Choose the most appropriate answer from the options given below:

- (1) C & B only
- (2) D & E only
- (3) A only
- (4) B only

**Correct Answer: (3) A only**

**Solution: Analysis of Blood Groups and Genotypes:**

- The ABO blood group system is determined by a single gene with three alleles:  $I^A$ ,  $I^B$ , and  $i$ .  $I^A$  and  $I^B$  are codominant, and  $i$  is recessive.

**Father (Blood Group B+):**

- To have a B blood type, the father can be either  $I^B I^B$  or  $I^B i$ .

**Mother (Blood Group A+):**

- To have an A blood type, the mother can be either  $I^A I^A$  or  $I^A i$ .

**Child (Blood Group O+):**

- To have an O blood type, the child must be  $ii$ . This means each parent must contribute an  $i$  allele.

**Evaluating Options:**

**Option A ( $I^B i/I^A i/ii$ ):** This is the only scenario that can produce a child with blood type O ( $ii$ ) from parents with blood types B ( $I^B i$ ) and A ( $I^A i$ ). Both parents possess one  $i$  allele, which they can pass to their child, resulting in the child having  $ii$  genotype. **Other Options:** They either lack the necessary  $i$  alleles or specify impossible combinations for the given blood types (e.g., parents with both dominant alleles cannot produce a child with an O blood type).

**💡 Quick Tip**

Remember, the presence of  $I^A$  or  $I^B$  alone does not determine phenotype without considering the second allele because of the recessive nature of  $i$ .

**191. The following are the statements about non-chordates:**

- A. Pharynx is perforated by gill slits.
- B. Notochord is absent.
- C. Central nervous system is dorsal.
- D. Heart is dorsal if present.
- E. Post anal tail is absent.

Choose the most appropriate answer from the options given below:

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

**Correct Answer: (1) B, D & E only**

**Solution: Evaluation of Each Statement:**

**Statement A (Pharynx is perforated by gill slits):** This is incorrect for non-chordates. Pharyngeal gill slits are a characteristic of chordates, specifically seen in some stages of development or certain adult forms.

**Statement B (Notochord is absent):** This is correct. Non-chordates do not possess a notochord at any stage of their development, distinguishing them from chordates.

**Statement C (Central nervous system is dorsal):** This statement is generally incorrect for non-chordates. Most non-chordates have a ventral nerve cord rather than a dorsal one, which is characteristic of chordates.

**Statement D (Heart is dorsal if present):** This is correct. In the few non-chordates where a heart-like structure is present, it tends to be located dorsally. This contrasts with chordates, where the heart is typically ventral.

**Statement E (Post anal tail is absent):** This is correct for non-chordates. A post-anal tail, another characteristic of chordates, is absent in non-chordates.

**Correct Combination Based on Evaluation:**

The correct statements for non-chordates are B (Notochord is absent), D (Heart is dorsal if present), and E (Post anal tail is absent), matching with option (1).

**💡 Quick Tip**

Recognize that notochords and post-anal tails are distinctive characteristics of chordates, helping differentiate them from non-chordates in classification.

**192. Match List I with List II related to digestive system of cockroach:**

| List I |                                                                                  | List II |                    |
|--------|----------------------------------------------------------------------------------|---------|--------------------|
| A.     | The structures used for storing of food                                          | I.      | Gizzard            |
| B.     | Ring of 6-8 blind tubules at junction of foregut and midgut                      | II.     | Gastric Caeca      |
| C.     | Ring of 100-150 yellow coloured thin filaments at junction of midgut and hindgut | III.    | Malpighian tubules |
| D.     | The structures used for grinding the food                                        | IV.     | Crop               |

Choose the correct answer from the options given below:

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

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

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

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

**Correct Answer: (3) A-IV, B-II, C-III, D-I**

**Solution: Step 1: Matching anatomical structures with their functions.**

**A (The structures used for storing of food) matches with IV (Crop), used for storage.**

**B (Ring of 6-8 blind tubules at junction of foregut and midgut) matches with II (Gastric Caeca), involved in enzymatic secretion.**

**C (Ring of 100-150 yellow coloured thin filaments at junction of midgut and hindgut) matches with III (Malpighian tubules), part of the excretory system.**

D (The structures used for grinding the food) matches with I (Gizzard), which mechanically breaks down food.

**💡 Quick Tip**

Understanding the specialized structures of a cockroach's digestive system can provide insights into their survival strategies and dietary habits.

**193. Choose the correct statement given below regarding juxta medullary nephron:**

- (1) Loop of Henle of juxta medullary nephron runs deep into medulla.
- (2) Juxta medullary nephrons outnumber the cortical nephrons.
- (3) Juxta medullary nephrons are located in the columns of Bertini.
- (4) Renal corpuscle of juxta medullary nephron lies in the outer portion of the renal medulla.

**Correct Answer: (1) Loop of Henle of juxta medullary nephron runs deep into medulla**

**Solution: Analysis of Each Statement:**

**Statement 1:** This statement is correct. Juxta medullary nephrons have their renal corpuscles located near the medulla, and their loops of Henle extend deeply into the renal medulla. This deep extension is crucial for the process of concentrating urine, as it allows for the creation of a significant osmotic gradient along the loop, facilitating efficient water and solute reabsorption.

**Statement 2:** This statement is incorrect. Juxta medullary nephrons do not outnumber cortical nephrons. In fact, cortical nephrons make up the majority of nephrons in the kidney.

**Statement 3:** This statement is incorrect. Juxta medullary nephrons are not located in the columns of Bertini, but their renal corpuscles are located at the boundary of the cortex and the medulla, hence the name "juxta medullary."

**Statement 4:** This statement is incorrect. The renal corpuscle of the juxta medullary nephron is located at the cortex-medulla junction, not in the outer portion of the renal medulla.

**Significance of Juxta Medullary Nephrons:**

Juxta medullary nephrons play a critical role in the kidney's ability to produce concentrated urine, which is essential for water conservation in the body. Their deep loops of Henle and the associated vasa recta create and maintain a high osmolarity in the surrounding interstitial fluid, enabling effective water reabsorption from the collecting ducts.

**💡 Quick Tip**

The deep penetration of the loop of Henle in juxta medullary nephrons is key to their role in producing concentrated urine, a vital adaptation in land animals for water conservation.

**194. Match List I with List II:**

| List I |             | List II |                                        |
|--------|-------------|---------|----------------------------------------|
| A.     | P wave      | I.      | Heart muscles are electrically silent. |
| B.     | QRS complex | II.     | Depolarisation of ventricles.          |
| C.     | T wave      | III.    | Depolarisation of atria.               |
| D.     | T-P gap     | IV.     | Repolarisation of ventricles.          |

Choose the correct answer from the options given below :

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

**Correct Answer: (4) A-III, B-II, C-IV, D-I**

**Solution: Detailed Analysis of Each Match:**

**P wave (A):** The P wave represents the depolarization of the atria in response to the SA node triggering. It precedes the atrial contraction. Therefore, A matches with III (Depolarisation of atria).

**QRS complex (B):** The QRS complex represents the rapid depolarization of the right and left ventricles. Since the ventricles are much larger than the atria, the QRS complex is much larger in amplitude than the P wave. Thus, B matches with II (Depolarisation of ventricles).

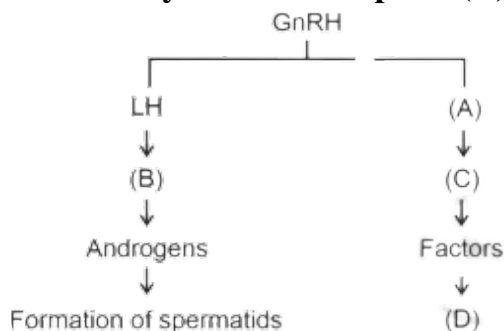
**T wave (C):** The T wave represents the repolarization (recovery) of the ventricles. The ventricles begin to relax after the contraction, coinciding with the start of the ventricular repolarization. Hence, C matches with IV (Repolarisation of ventricles).

**T-P gap (D):** The T-P segment (gap) reflects the period when the heart muscle is electrically silent between heartbeats. It occurs when the ventricles are completely depolarized and are preparing for the next cycle. This phase is crucial for the heart to fill with blood and prepare for the next contraction. Therefore, D matches with I (Heart muscles are electrically silent).

#### 💡 Quick Tip

ECG components like P wave, QRS complex, and T wave are crucial for diagnosing heart rhythms and conditions, reflecting different phases of cardiac electrical activity.

**195. Identify the correct option (A), (B), (C), (D) with respect to spermatogenesis:**



- (1) FSH, Sertoli cells, Leydig cells, spermatogenesis.

- (2) ICSH, Leydig cells, Sertoli cells, spermatogenesis.  
 (3) FSH, Leydig cells, Sertoli cells, spermiogenesis.  
 (4) ICSH, Interstitial cells, Leydig cells, spermiogenesis.

**Correct Answer:** (3) FSH, Leydig cells, Sertoli cells, spermiogenesis

**Solution: Detailed Analysis of the Correct Match:**

**FSH (A):** Follicle Stimulating Hormone influences Sertoli cells which are crucial for nourishing developing sperm cells and are instrumental in the process termed spermatogenesis.

**Leydig cells (B):** Stimulated by LH, Leydig cells are responsible for producing testosterone (Androgens), which is essential for the development of male secondary sexual characteristics and influencing spermatogenesis.

**Sertoli cells (C):** Act under the influence of FSH and testosterone to support the maturation of sperm cells, particularly during the phase called spermiogenesis, where spermatids are transformed into mature spermatozoa.

**Spermiogenesis (D):** This is the final stage of spermatogenesis where spermatids are converted into spermatozoa (mature sperm cells). This step involves significant morphological changes which are supported by Sertoli cells.

**Conclusion:** The diagram and associated hormonal pathways correctly identify the process involving FSH affecting Sertoli cells, Leydig cells producing androgens under the influence of LH, and the involvement of Sertoli cells in the final transformation during spermiogenesis. Option (3) accurately captures these interactions and the respective roles.

**💡 Quick Tip**

The hormonal control of spermatogenesis involves a finely tuned interaction between GnRH, LH, FSH, androgens, and Sertoli cells, highlighting the complexity of reproductive physiology.

**196. Match List I with List II:**

| List I |                                    | List II |                                  |
|--------|------------------------------------|---------|----------------------------------|
| A.     | Unicellular glandular epithelium   | I.      | Salivary glands                  |
| B.     | Compound epithelium                | II.     | Pancreas                         |
| C.     | Multicellular glandular epithelium | III.    | Goblet cells of alimentary canal |
| D.     | Endocrine glandular epithelium     | IV.     | Moist surface of buccal cavity   |

Choose the correct answer from the options given below:

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

**Correct Answer:** (1) A-III, B-IV, C-I, D-II

**Solution: Expanded Analysis of Each Match:**

**A. Unicellular glandular epithelium (III):** Goblet cells are a prime example of unicellular glandular epithelium. Located throughout the respiratory and

gastrointestinal tracts, these cells secrete mucus that lubricates and protects the lining surfaces. Their widespread presence in the alimentary canal aids in facilitating the smooth passage of food while protecting the mucosal layer.

**B. Compound epithelium (IV):** Compound epithelium is structured in multiple layers to protect against chemical and mechanical stresses. In the buccal cavity, this type of epithelium provides a barrier against pathogens, mechanical injury due to food particles, and the corrosive effects of enzymes and acidic food substances.

**C. Multicellular glandular epithelium (I):** The salivary glands are composed of multicellular glandular epithelium and play a crucial role in the digestion process. They produce and secrete saliva that begins the digestion of starches. Moreover, saliva contains antibacterial compounds that help maintain oral hygiene.

**D. Endocrine glandular epithelium (II):** The pancreas functions as both an endocrine and exocrine gland. The endocrine part, through the Islets of Langerhans, secretes important hormones such as insulin and glucagon directly into the bloodstream, regulating blood glucose levels. This glandular structure is vital for metabolic homeostasis.

#### Quick Tip

Differentiating between unicellular and multicellular glandular structures is key to understanding their specific functions in secretion and absorption in various body systems.

197. Given below are two statements:

**Statement I:** The cerebral hemispheres are connected by nerve tract known as corpus callosum.

**Statement II:** The brain stem consists of the medulla oblongata, pons and cerebrum.

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

- (1) Statement I is correct but Statement II is incorrect.
- (2) Statement I is incorrect but Statement II is correct.
- (3) Both Statement I and Statement II are true.
- (4) Both Statement I and Statement II are incorrect.

**Correct Answer:** (1) Statement I is correct but Statement II is incorrect.

**Solution:** Step 1: Verifying Statement I.

The corpus callosum is indeed the nerve tract that connects the two cerebral hemispheres, making Statement I correct.

Step 2: Verifying Statement II.

The brain stem is composed of the medulla oblongata, pons, and midbrain, not the cerebrum, making Statement II incorrect.

#### Quick Tip

The corpus callosum plays a critical role in enabling communication between the left and right hemispheres of the brain.

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**198. Match List I with List II:**

| List I |                 | List II |                     |
|--------|-----------------|---------|---------------------|
| A.     | Mesozoic Era    | I.      | Lower invertebrates |
| B.     | Proterozoic Era | II.     | Fish & Amphibia     |
| C.     | Cenozoic Era    | III.    | Birds & Reptiles    |
| D.     | Paleozoic Era   | IV.     | Mammals             |

Choose the correct answer from the options given below :

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

**Correct Answer: (2) A-III, B-I, C-IV, D-II**

**Solution: Detailed Analysis of Each Match:**

**A. Mesozoic Era (III):** The Mesozoic Era, often referred to as the "Age of Reptiles," is notable for the dominance and diversification of reptiles, including the dinosaurs, as well as the early evolution of birds. Hence, A matches with III (Birds & Reptiles).

**B. Proterozoic Era (I):** The Proterozoic Era spans from 2.5 billion to 540 million years ago and is characterized by the emergence of the first complex life forms, including the first multicellular organisms, which were predominantly lower invertebrates. Thus, B matches with I (Lower invertebrates).

**C. Cenozoic Era (IV):** Known as the "Age of Mammals," the Cenozoic Era follows the Mesozoic and features the extensive diversification and dominance of mammals following the extinction of the non-avian dinosaurs. Therefore, C matches with IV (Mammals).

**D. Paleozoic Era (II):** The Paleozoic Era is known for the "Cambrian Explosion," leading to the appearance and evolution of a wide variety of life forms, including the first fish and later amphibians. Hence, D is correctly paired with II (Fish & Amphibia).

**💡 Quick Tip**

Each geological era is characterized by the dominance of certain life forms which can be used as a timeline to understand evolutionary history.

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**199. Match List I with List II:**

| List I |                              | List II |              |
|--------|------------------------------|---------|--------------|
| A.     | RNA polymerase III           | I.      | snRNPs       |
| B.     | Termination of transcription | II.     | Promotor     |
| C.     | Splicing of Exons            | III.    | Rho factor   |
| D.     | TATA box                     | IV.     | SnRNAs, tRNA |

Choose the correct answer from the options given below :

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

**Correct Answer: (2) A-IV, B-III, C-I, D-II**

**Solution: Detailed Analysis of Each Match:**

**A. RNA polymerase III (IV):** RNA polymerase III is responsible for transcribing DNA to synthesize ribosomal 5S rRNA, tRNA, and other small RNAs. The correct match here is IV (SnRNAs, tRNA), as it includes tRNA which is a primary product of RNA polymerase III.

**B. Termination of transcription (III):** Termination of transcription in prokaryotes often involves the rho factor, a protein that facilitates the termination of RNA synthesis by RNA polymerase at specific sites. This makes B correctly paired with III (Rho factor).

**C. Splicing of Exons (I):** Splicing of exons during mRNA processing involves snRNPs (small nuclear ribonucleoproteins), which play a crucial role in recognizing and excising introns, making C correctly matched with I (snRNPs).

**D. TATA box (II):** The TATA box is a DNA sequence that indicates where a genetic sequence can be read and decoded. It is a component of the promotor region of genes, typically found in the core promoter area and is crucial for forming the transcription initiation complex. Thus, D is accurately matched with II (Promotor).

**💡 Quick Tip**

The TATA box is a crucial promoter element in many eukaryotic genes, playing a key role in the initiation of transcription.

**200. Given below are two statements:**

**Statement I:** Bone marrow is the main lymphoid organ where all blood cells including lymphocytes are produced.

**Statement II:** Both bone marrow and thymus provide micro environments for the development and maturation of T-lymphocytes.

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

- (1) Statement I is correct but Statement II is incorrect.
- (2) Statement I is incorrect but Statement II is correct.
- (3) Both Statement I and Statement II are correct.
- (4) Both Statement I and Statement II are incorrect.

**Correct Answer: (3) Both Statement I and Statement II are correct.**

**Solution: Step 1: Verifying Statement I.**

Bone marrow is indeed the primary site for the production of all types of blood cells, including lymphocytes, making Statement I correct.

**Step 2: Verifying Statement II.**

Both bone marrow and thymus are critical for the development and maturation of T-lymphocytes, with bone marrow producing the cells and the thymus providing the environment for their maturation, making Statement II correct.

**💡 Quick Tip**

**Understanding the roles of bone marrow and thymus in immune system development is crucial for comprehending how adaptive immunity is structured and functions.**