

## Re-Examination of NEET (UG)-2024

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|--------------------------------------------|------------------------|--------------------------|----------------------|
| Total Time Allowed<br>: 3 Hours 20 Minutes | Maximum Marks :<br>720 | Total Questions :<br>200 | Date : June 23, 2024 |
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## Physics

## Section - A

**Question 1:** The magnetic potential energy, when a magnetic bar of magnetic moment  $\vec{m}$  is placed perpendicular to the magnetic field  $\vec{B}$  is ...

**Options:**

- (1)  $-\frac{mB}{2}$
- (2) Zero
- (3)  $-mB$
- (4)  $mB$

**Correct Answer:** (2) Zero

**Solution:**

**1. Magnetic Potential Energy:** The magnetic potential energy ( $U$ ) of a magnetic dipole (magnetic moment  $\vec{m}$ ) in a magnetic field  $\vec{B}$  is given by:

$$U = -\vec{m} \cdot \vec{B} = -mB \cos \theta$$

where  $\theta$  is the angle between the magnetic moment vector and the magnetic field vector.

**2. Perpendicular Orientation ( $\theta = 90^\circ$ ):** When the magnetic bar is placed perpendicular to the magnetic field, the angle  $\theta$  is  $90^\circ$ . Therefore,  $\cos \theta = \cos(90^\circ) = 0$ .

$$U = -mB(0) = 0$$

**3. Conclusion:** The magnetic potential energy is zero when the magnetic moment is perpendicular to the magnetic field.

 Quick Tip

The magnetic potential energy is minimum ( $-mB$ ) when the magnetic moment is aligned parallel to the field and maximum ( $mB$ ) when aligned antiparallel. It is zero when perpendicular.

**Question 2:** A bob is whirled in a horizontal circle by means of a string at an initial speed of 10 rpm. If the tension in the string is quadrupled while keeping the radius constant, the new speed is:

**Options:**

- (1) 20 rpm
- (2) 40 rpm
- (3) 5 rpm
- (4) 10 rpm

**Correct Answer:** (1) 20 rpm

**Solution:**

Tension ( $T$ ) provides the centripetal force:  $T = \frac{mv^2}{r}$ . With  $r$  and  $m$  constant,  $T \propto v^2$ . If  $T_2 = 4T_1$ , then  $v_2^2 = 4v_1^2$ .

Given  $v_1 = 10$  rpm, then  $v_2 = \sqrt{4 \times 10^2} = 20$  rpm.

 Quick Tip

In circular motion, the centripetal force is directly proportional to the square of the speed. When the radius is constant, an increase in tension leads to an increase in the speed of the object.

**Question 3:** A metal cube of side 5 cm is charged with  $6 \mu\text{C}$ . The surface charge density on the cube is ...

**Options:**

- (1)  $0.125 \times 10^{-3} \text{ C m}^{-2}$
- (2)  $0.25 \times 10^{-3} \text{ C m}^{-2}$
- (3)  $4 \times 10^{-3} \text{ C m}^{-2}$
- (4)  $0.4 \times 10^{-3} \text{ C m}^{-2}$

**Correct Answer:** (4)  $0.4 \times 10^{-3} \text{ C m}^{-2}$

**Solution:**

$$\text{Surface charge density } (\sigma) = \frac{\text{Charge (Q)}}{\text{Surface Area (A)}}$$

$$\text{Side} = 5 \text{ cm} = 0.05 \text{ m.}$$

$$A = 6 \times \text{side}^2 = 6 \times (0.05)^2 = 0.015 \text{ m}^2 \quad Q = 6 \mu\text{C} = 6 \times 10^{-6} \text{ C}$$

$$\sigma = \frac{6 \times 10^{-6} \text{ C}}{0.015 \text{ m}^2} = 0.4 \times 10^{-3} \text{ C m}^{-2}$$

 Quick Tip

Surface charge density is charge per unit area. A cube has six faces. Make sure to convert units to meters.

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**Question 4:** The incorrect relation for a diamagnetic material (all the symbols carry their usual meaning and  $\epsilon$  is a small positive number) is:

**Options:**

- (1)  $\mu < \mu_0$
- (2)  $0 \leq \mu_r < 1$
- (3)  $-1 \leq \chi < 0$
- (4)  $1 < \mu_r < 1 + \epsilon$

**Correct Answer:** (4)  $1 < \mu_r < 1 + \epsilon$

**Solution:**

**1. Diamagnetic Materials:** Diamagnetic materials are weakly repelled by a magnetic field. They have a negative magnetic susceptibility ( $\chi$ ) and a relative permeability ( $\mu_r$ ) slightly less than 1.

**2. Relationship between  $\mu$ ,  $\mu_0$ , and  $\mu_r$ :**  $\mu$  is the magnetic permeability of the material,  $\mu_0$  is the permeability of free space, and  $\mu_r$  is the relative permeability. They are related by:

$$\mu_r = \frac{\mu}{\mu_0}$$

**3. Relationship between  $\mu_r$  and  $\chi$ :** The relative permeability and magnetic susceptibility are related by:

$$\mu_r = 1 + \chi$$

**4. Analyze the Options:**

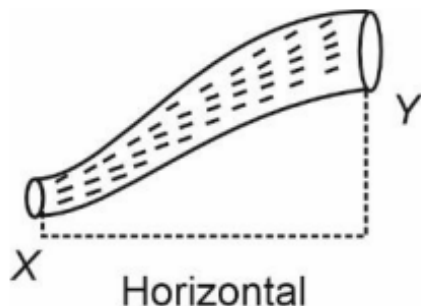
- (1)  $\mu < \mu_0$ : This is equivalent to  $\frac{\mu}{\mu_0} = \mu_r < 1$ , which is true for diamagnetic materials.
- (2)  $0 \leq \mu_r < 1$ : This is true for diamagnetic materials. The relative permeability is slightly less than 1.
- (3)  $-1 \leq \chi < 0$ : This is also true. Diamagnetic materials have a small negative susceptibility. Since  $\mu_r > 0$ ,  $\chi > -1$ .
- (4)  $1 < \mu_r < 1 + \epsilon$ : This is *incorrect*. For diamagnetic materials,  $\mu_r$  is less than 1, not greater. This would imply a positive susceptibility, which is characteristic of paramagnetic materials.

**5. Conclusion:** The incorrect relation is (4).

**💡 Quick Tip**

Diamagnetic materials have a small negative magnetic susceptibility and a relative permeability slightly less than one. They are weakly repelled by external magnetic fields.

**Question 5:** An ideal fluid is flowing in a non-uniform cross-sectional tube XY (as shown in the figure) from end X to end Y. If  $K_1$  and  $K_2$  are the kinetic energy per unit volume of the fluid at X and Y respectively, then the correct option is:



**Options:**

- (1)  $K_1 = K_2$
- (2)  $2K_1 = K_2$
- (3)  $K_1 > K_2$
- (4)  $K_1 < K_2$

**Correct Answer:** (3)  $K_1 > K_2$

**Solution:**

Kinetic energy per unit volume is  $\frac{1}{2}\rho v^2$ , where  $\rho$  is the density and  $v$  is the velocity.  
By the equation of continuity (for an incompressible fluid),  $A_1v_1 = A_2v_2$ , where A is the cross-sectional area.  
From X to Y, the area increases, so the velocity decreases.  
Since  $K \propto v^2$ ,  $K_1 > K_2$ .

 Quick Tip

The continuity equation states that the mass flow rate ( $\rho Av$ ) is constant in a steady flow of an incompressible fluid. Thus velocity is inversely proportional to area of cross-section.

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**Question 6:** The escape velocity for Earth is  $v$ . A planet having 9 times mass that of Earth and radius, 16 times that of Earth, has the escape velocity of:

**Options:**

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

**Correct Answer:** (3)  $\frac{3v}{4}$

**Solution:**

Escape velocity ( $v_e$ ) is given by  $v_e = \sqrt{\frac{2GM}{R}}$ , where G is the gravitational constant, M is the mass of the planet, and R is the radius.

For the new planet,  $M' = 9M$  and  $R' = 16R$ .

$$v'_e = \sqrt{\frac{2G(9M)}{16R}} = \frac{3}{4}\sqrt{\frac{2GM}{R}} = \frac{3v}{4}$$

 Quick Tip

Escape velocity is the minimum speed needed for an object to escape the gravitational pull of a planet. It depends on the planet's mass and radius.

**Question 7:** An electron and an alpha particle are accelerated by the same potential difference. Let  $\lambda_e$  and  $\lambda_\alpha$  denote the de-Broglie wavelengths of the electron and the alpha particle, respectively, then:

**Options:**

- (1)  $\lambda_e > \lambda_\alpha$
- (2)  $\lambda_e = 4\lambda_\alpha$
- (3)  $\lambda_e = \lambda_\alpha$
- (4)  $\lambda_e < \lambda_\alpha$

**Correct Answer:** (1)  $\lambda_e > \lambda_\alpha$

**Solution:**

de-Broglie wavelength:  $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$  For the same potential difference (V),  $\lambda \propto \frac{1}{\sqrt{mq}}$ .

$$\frac{\lambda_\alpha}{\lambda_e} = \sqrt{\frac{m_e q_e}{m_\alpha q_\alpha}}$$

Since  $m_\alpha \gg m_e$  and  $q_\alpha = 2q_e$ ,  $\lambda_e > \lambda_\alpha$ .

 Quick Tip

The de-Broglie wavelength is inversely proportional to the square root of the mass and charge of the particle.

**Question 8:** An object moving along the horizontal x-direction with kinetic energy 10 J is displaced through  $\vec{x} = (3\hat{i})$  m by the force  $\vec{F} = (-2\hat{i} + 3\hat{j})$  N. The kinetic energy of the object at the end of the displacement  $\vec{x}$  is ...

**Options:**

- (1) 10 J
- (2) 16 J
- (3) 4 J
- (4) 6 J

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

**Solution:**

Work done ( $W$ ) =  $\vec{F} \cdot \vec{x} = (-2\hat{i} + 3\hat{j}) \cdot (3\hat{i}) = -6 \text{ J}$ .

Work-energy theorem:  $W = \Delta KE = KE_f - KE_i$   $-6 \text{ J} = KE_f - 10 \text{ J}$   $KE_f = 4 \text{ J}$

 Quick Tip

The work-energy theorem states that the net work done on an object is equal to the change in its kinetic energy.

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**Question 9:** An object falls from a height of 10 m above the ground. After striking the ground it loses 50% of its kinetic energy. The height upto which the object can rebound from the ground is:

**Options:**

- (1) 7.5 m
- (2) 10 m
- (3) 2.5 m
- (4) 5 m

**Correct Answer: (4)**

**Solution:**

**1. Initial Potential Energy:** Initial potential energy (PE) =  $mgh$ , where  $m$  is the mass,  $g$  is acceleration due to gravity, and  $h$  is the initial height (10 m).

**2. Kinetic Energy Just Before Impact:** By conservation of energy, the potential energy is converted to kinetic energy (KE) just before the object strikes the ground:  $KE = mgh$ .

**3. Kinetic Energy After Impact:** The object loses 50% of its KE after striking the ground, so the remaining KE is  $0.5(mgh)$ .

**4. Rebound Height:** The remaining KE is converted back to potential energy as the object rebounds. Let  $h'$  be the rebound height.

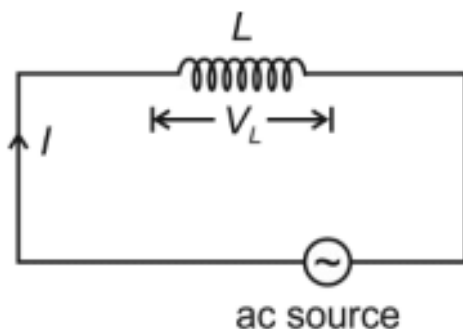
$$0.5(mgh) = mgh' \quad h' = 0.5h = 0.5(10 \text{ m}) = 5 \text{ m}$$

**5. Conclusion:** The rebound height is 5 m.

**💡 Quick Tip**

Energy is conserved in the absence of non-conservative forces. The loss of kinetic energy upon impact affects the rebound height.

**Question 10:** In the circuit shown below, the inductance  $L$  is connected to an ac source. The current flowing in the circuit is  $I = I_0 \sin \omega t$ . The voltage drop ( $V_L$ ) across  $L$  is:



**Options:**

- (1)  $\omega L I_0 \sin \omega t$
- (2)  $\frac{I_0}{\omega L} \sin \omega t$
- (3)  $\frac{I_0}{\omega L} \cos \omega t$
- (4)  $\omega L I_0 \cos \omega t$

**Correct Answer:** (4)  $\omega L I_0 \cos \omega t$

**Solution:**

The voltage across an inductor ( $V_L$ ) is given by:

$$V_L = L \frac{dI}{dt}$$

Given  $I = I_0 \sin \omega t$ :



$$\begin{aligned}\frac{dI}{dt} &= \frac{d}{dt}(I_0 \sin \omega t) \\ &= I_0 \omega \cos \omega t\end{aligned}$$

Therefore:

$$V_L = L(I_0 \omega \cos \omega t) = \omega L I_0 \cos \omega t$$

 Quick Tip

The voltage across an inductor is proportional to the rate of change of current. In an AC circuit, the voltage across an inductor leads the current by 90 degrees.

**Question 11:** A 12 pF capacitor is connected to a 50 V battery. The electrostatic energy stored in the capacitor in nJ is ...

**Options:**

- (1) 15
- (2) 7.5
- (3) 0.3
- (4) 150

**Correct Answer:** (1) 15

**Solution:**

Energy stored in a capacitor (E) =  $\frac{1}{2}CV^2$ , where C is capacitance and V is voltage.

$$C = 12 \text{ pF} = 12 \times 10^{-12} \text{ F} \quad V = 50 \text{ V}$$

$$E = \frac{1}{2}(12 \times 10^{-12} \text{ F})(50 \text{ V})^2 = 15 \times 10^{-9} \text{ J} = 15 \text{ nJ}$$

 Quick Tip

The energy stored in a capacitor is directly proportional to the capacitance and the square of the voltage.

**Question 12:** A uniform wire of diameter  $d$  carries a current of 100 mA when the mean drift velocity of electrons in the wire is  $v$ . For a wire of diameter  $\frac{d}{2}$

of the same material to carry a current of 200 mA, the mean drift velocity of electrons in the wire is ...

**Options:**

- (1)  $4v$
- (2)  $8v$
- (3)  $v$
- (4)  $2v$

**Correct Answer:** (2)  $8v$

**Solution:**

Current ( $I$ ) =  $nAv_dqe$ , where  $n$  is electron density,  $A$  is cross-sectional area,  $v_d$  is drift velocity,  $q$  is the charge of an electron, and  $e$  is the electronic charge.

Since  $A = \pi\left(\frac{D}{2}\right)^2 = \frac{\pi D^2}{4} \propto d^2$ , we have  $I \propto d^2 v_d$ .

$$\frac{100}{200} = \frac{d^2 v}{\left(\frac{d}{2}\right)^2 v'} \Rightarrow v' = 2 \times 2^2 v = 8v$$

 Quick Tip

Current is proportional to both the cross-sectional area (diameter squared) and the drift velocity.

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**Question 13:** In an electrical circuit, the voltage is measured as  $V = (200 \pm 4)$  volt and the current is measured as  $I = (20 \pm 0.2)$  A. The value of the resistance is:

**Options:**

- (1)  $(10 \pm 4.2) \Omega$
- (2)  $(10 \pm 0.3) \Omega$
- (3)  $(10 \pm 0.1) \Omega$
- (4)  $(10 \pm 0.8) \Omega$

**Correct Answer:** (2)  $(10 \pm 0.3) \Omega$

**Solution:**

$$\text{Resistance (R)} = \frac{V}{I} = \frac{200}{20} = 10 \, \Omega$$

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

$$\frac{\Delta R}{10} = \frac{4}{200} + \frac{0.2}{20} = 0.02 + 0.01 = 0.03$$

$$\Delta R = 0.3 \, \Omega$$

$$\text{Thus, } R = (10 \pm 0.3) \, \Omega$$

 Quick Tip

When calculating resistance from voltage and current measurements with uncertainties, use the formula  $\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$  to determine the uncertainty in the resistance.

**Question 14:** A step-up transformer is connected to an ac mains supply of 220 V to operate at 11000 V, 88 watt. The current in the secondary circuit, ignoring the power loss in the transformer, is:

**Options:**

- (1) 8 mA
- (2) 4 mA
- (3) 0.4 A
- (4) 4 A

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

**Solution:**

Ignoring power loss, power in primary = power in secondary. Power (P) = VI Primary voltage ( $V_p$ ) = 220 V Secondary voltage ( $V_s$ ) = 11000 V Power (P) = 88 W Secondary current ( $I_s$ ) = ?

$$88 = 11000$$

$$\Rightarrow i = \frac{88}{11 \times 10^3}$$

$$= 8 \times 10^{-3} \text{ A}$$

$$\Rightarrow i = 8 \text{ mA}$$

 Quick Tip

In an ideal transformer, the power in the primary circuit equals the power in the secondary circuit.

**Question 15:** A particle is moving along the x-axis with its position (x) varying with time (t) as  $x = \alpha t^4 + \beta t^2 + \gamma t + \delta$ . The ratio of its initial velocity to its initial acceleration, respectively, is:

**Options:**

- (1)  $2\alpha : \delta$
- (2)  $\gamma : 2\beta$
- (3)  $4\alpha : \beta$
- (4)  $\gamma : 2\beta$

**Correct Answer:** (4)  $\gamma : 2\beta$

**Solution:**

Velocity (v) =  $\frac{dx}{dt} = 4\alpha t^3 + 2\beta t + \gamma$  Initial velocity (at  $t = 0$ ) =  $\gamma$

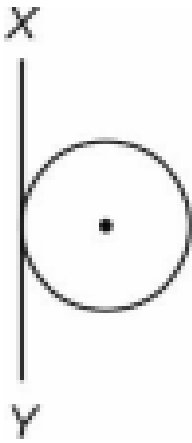
Acceleration (a) =  $\frac{dv}{dt} = 12\alpha t^2 + 2\beta$  Initial acceleration (at  $t = 0$ ) =  $2\beta$

Ratio of initial velocity to initial acceleration =  $\frac{\gamma}{2\beta}$

 Quick Tip

Remember the relationships between position, velocity, and acceleration. Initial velocity and acceleration are found by setting  $t = 0$ .

**Question 16:** The radius of gyration of a solid sphere of mass 5 kg about XY is 5 m as shown in the figure. The radius of the sphere is  $\frac{5x}{\sqrt{7}}$  m, then the value of x is:



**Options:**

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

**Correct Answer: (4)**

**Solution:**

$$I_{xy} = I_{CM} + MR^2 = \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2 = \frac{7}{5} \times 5R^2 = 7R^2 \dots (1)$$

$$I_{xy} = MK^2 = 5 \times 5^2 \dots (2)$$

$$5 \times 5^2 = 7 \times R^2 \quad [\text{From (1) and (2)}]$$

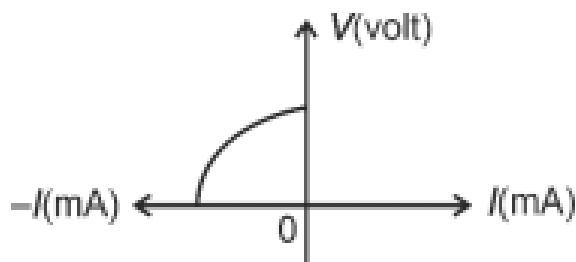
$$\Rightarrow R = \sqrt{\frac{5}{7}} \times 5 = \frac{5x}{\sqrt{7}} \quad (\text{Given})$$

$$x = \sqrt{5}$$

**💡 Quick Tip**

The radius of gyration relates the moment of inertia of a body to its mass. Use the appropriate formula for the moment of inertia of a solid sphere.

**Question 17: The I-V characteristics shown above are exhibited by a:**



**Options:**

- (1) Light emitting diode
- (2) Zener diode
- (3) Photodiode
- (4) Solar cell

**Correct Answer: (4) Solar cell**

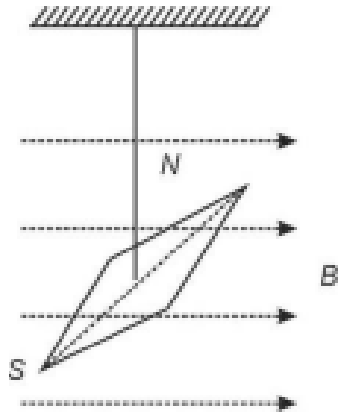
**Solution:**

The given I-V characteristic curve shows a device that produces current when exposed to light (positive current for positive voltage). This characteristic is shown by a solar cell. Solar cells convert light energy into electrical energy. The other options have different I-V characteristics.

**💡 Quick Tip**

Solar cells generate current when light is incident on them; this characteristic is represented by an I-V curve showing current generation for positive voltage.

**Question 18:** The magnetic moment and moment of inertia of a magnetic needle as shown are, respectively,  $1.0 \times 10^{-2} \text{ A m}^2$  and  $\frac{10^{-6}}{\pi^2} \text{ kg m}^2$ . If it completes 10 oscillations in 10 s, the magnitude of the magnetic field is:



**Options:**

- (1) 0.4 T
- (2) 4 T
- (3) 0.4 mT
- (4) 4 mT

**Correct Answer: (3) 0.4 mT**

**Solution:**

Time period (T) of oscillation of a magnetic needle in a magnetic field is given by:

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

where: \* I is the moment of inertia. \* m is the magnetic moment. \* B is the magnetic field.

Given:  $I = \frac{10^{-6}}{\pi^2}$  kg m<sup>2</sup>  $m = 1.0 \times 10^{-2}$  A m<sup>2</sup> Time for 10 oscillations = 10 s Time period (T) =  $\frac{10}{10} = 1$  s

$$1 = 2\pi \sqrt{\frac{10^{-6}/\pi^2}{(10^{-2})B}}$$

$$1 = 2\sqrt{\frac{10^{-4}}{B}}$$

$$B = 4 \times 10^{-4}$$

$$T = 0.4 \text{ mT}$$

 Quick Tip

The time period of oscillation of a magnetic needle in a magnetic field depends on its moment of inertia and magnetic moment.

**Question 19:** The capacitance of a capacitor with charge  $q$  and a potential difference  $V$  depends on:

**Options:**

- (1) both  $q$  and  $V$
- (2) the geometry of the capacitor
- (3)  $q$  only
- (4)  $V$  only

**Correct Answer:** (2) the geometry of the capacitor

**Solution:**

Capacitance ( $C$ ) is defined as the ratio of charge ( $q$ ) to potential difference ( $V$ ):

$$C = \frac{q}{V}$$

However, capacitance is primarily determined by the geometry of the capacitor (plate area, separation between plates, dielectric material). The charge ( $q$ ) and potential difference ( $V$ ) are related to the capacitance but do not determine it. A capacitor with a specific geometry will have a fixed capacitance.

 Quick Tip

The capacitance of a capacitor is a geometric property, determined by its physical dimensions and the dielectric material between the plates.

**Question 20:** Given below are two statements:

**Statement I:** Image formation needs regular reflection and/or refraction.

**Statement II:** The variety in colour of objects we see around us is due to the constituent colours of the light incident on them.

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



**Options:**

- (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 is correct. Image formation by lenses and mirrors relies on regular reflection and/or refraction of light.

Statement II is also correct. The color of an object is determined by the wavelengths of light that it reflects. An object appears red because it reflects red light and absorbs other wavelengths.

**💡 Quick Tip**

Image formation requires regular reflection or refraction, while object color depends on selective absorption and reflection of light.

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**Question 21:** A uniform metal wire of length  $l$  has  $10\ \Omega$  resistance. Now this wire is stretched to a length  $2l$  and then bent to form a perfect circle. The equivalent resistance across any arbitrary diameter of that circle is:

**Options:**

- (1)  $10\ \Omega$
- (2)  $5\ \Omega$
- (3)  $40\ \Omega$
- (4)  $20\ \Omega$

**Correct Answer: (1)  $10\ \Omega$**

**Solution:**

Let  $R_0$  be initial resistance =  $10\ \Omega$ . When stretched to length  $2l$ , the resistance becomes  $R_1 = \frac{2l}{l}R_0 = 20\ \Omega$ . When bent into a circle, the total resistance remains  $20\ \Omega$ . The resistance of the semi-circle along any diameter is given by  $20/2=10\ \Omega$

 Quick Tip

Resistance is directly proportional to length and inversely proportional to the cross-sectional area. When a wire is stretched, its length increases, and its cross-sectional area decreases. In parallel combination  $R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$ .

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**Question 22:** The spectral series which corresponds to the electronic transition from the levels  $n_2 = 5, 6, \dots$  to the level  $n_1 = 4$  is:

**Options:**

- (1) Pfund series
- (2) Brackett series
- (3) Lyman series
- (4) Balmer series

**Correct Answer:** (2) Brackett series

**Solution:**

The Brackett series corresponds to electronic transitions from higher energy levels ( $n_2 = 5, 6, 7, \dots$ ) to the  $n_1 = 4$  level.

 Quick Tip

Remember the spectral series in hydrogen-like atoms (Lyman, Balmer, Paschen, Brackett, Pfund) and the energy levels involved in each transition.

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

**Assertion A:** Houses made of concrete roofs overlaid with foam keep the room hotter during summer.

**Reason R:** The layer of foam insulation prohibits heat transfer, as it contains air pockets.

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

**Options:**

- (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.**

**Solution:**

Reason R is true: Foam insulation reduces heat transfer due to the presence of air pockets which are poor conductors of heat. However, Assertion A is false. Foam insulation is used to keep the room \*cooler\* during summer and warmer during winter by acting as a heat insulator.

 **Quick Tip**

Foam insulation works by trapping air, which is a poor conductor of heat. Thus the foam layer acts as an insulator, reducing heat transfer.

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**Question 24: A particle executing simple harmonic motion with amplitude A has the same potential and kinetic energies at the displacement:**

**Options:**

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

**Correct Answer: (3)  $\frac{A}{\sqrt{2}}$**

**Solution:**

In simple harmonic motion (SHM), the total energy (E) is constant and given by  $E = PE + KE$  where, PE is potential energy and KE is kinetic energy. At any displacement (x) from the equilibrium position:

$$PE = \frac{1}{2}kx^2$$

$$KE = \frac{1}{2}k(A^2 - x^2)$$

When PE = KE:  $\frac{1}{2}kx^2 = \frac{1}{2}k(A^2 - x^2)$

$$x^2 = A^2 - x^2$$

$$2x^2 = A^2$$

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

#### 💡 Quick Tip

In SHM, the total energy is the sum of potential and kinetic energies and remains constant. Potential energy and kinetic energies are equal when the displacement is  $A/\sqrt{2}$ .

**Question 25:** Two slits in Young's double slit experiment are 1.5 mm apart and the screen is placed at a distance of 1 m from the slits. If the wavelength of light used is  $600 \times 10^{-9}$  m, then the fringe separation is:

**Options:**

- (1)  $4 \times 10^{-5}$  m
- (2)  $9 \times 10^{-8}$  m
- (3)  $4 \times 10^{-7}$  m
- (4)  $4 \times 10^{-4}$  m

**Correct Answer:** (4)  $4 \times 10^{-4}$  m

**Solution:**

Fringe separation ( $\beta$ ) in Young's double slit experiment is given by:

$$\beta = \frac{\lambda D}{d}$$

where:

$\lambda$  is the wavelength of light.

D is the distance between the slits and the screen.

d is the distance between the slits.

Given:  $\lambda = 600 \times 10^{-9}$  m D = 1 m d = 1.5 mm =  $1.5 \times 10^{-3}$  m

$$\beta = \frac{(600 \times 10^{-9} \text{ m})(1 \text{ m})}{1.5 \times 10^{-3} \text{ m}} = 4 \times 10^{-4} \text{ m}$$

**💡 Quick Tip**

Fringe separation in Young's double slit experiment is directly proportional to the wavelength and the distance to the screen and inversely proportional to the slit separation.

---

**Question 26:** Water is used as a coolant in a nuclear reactor because of its:

**Options:**

- (1) High thermal expansion coefficient
- (2) High specific heat capacity
- (3) Low density
- (4) Low boiling point

**Correct Answer:** (2) High specific heat capacity

**Solution:**

Water's high specific heat capacity allows it to absorb a large amount of heat without a significant temperature change, making it an effective coolant.

**💡 Quick Tip**

A coolant's ability to absorb heat is crucial in nuclear reactors to prevent over-heating.

---

**Question 27:** The pitch of an error-free screw gauge is 1 mm, and there are 100 divisions on the circular scale. While measuring the diameter of a thick wire, the pitch scale reads 1 mm, and the 63<sup>rd</sup> division on the circular scale coincides with the reference line. The diameter of the wire is:

**Options:**

- (1) 1.63 cm
- (2) 0.163 cm
- (3) 0.163 m

(4) 1.63 m

**Correct Answer: (2) 0.163 cm**

**Solution:**

$$\text{Least count (LC) of screw gauge} = \frac{\text{Pitch}}{\text{Number of divisions on circular scale}} = \frac{1 \text{ mm}}{100} = 0.01 \text{ mm}$$

$$\text{Main scale reading (MSR)} = 1 \text{ mm}$$

$$\text{Circular scale reading (CSR)} = 63 \text{ divisions}$$

$$\text{Final reading} = \text{MSR} + \text{CSR} \times \text{LC} = 1 \text{ mm} + 63(0.01 \text{ mm}) = 1.63 \text{ mm} = 0.163 \text{ cm}$$

 Quick Tip

The least count of a screw gauge is the smallest length that can be measured accurately. The final reading is the sum of the main scale reading and the circular scale reading multiplied by the least count.

---

**Question 28:** Let us consider two solenoids A and B, made from the same magnetic material of relative permeability  $\mu$ , and equal area of cross-section. Length of A is twice that of B, and the number of turns per unit length in A is half that of B. The ratio of self-inductances of the two solenoids,  $L_A : L_B$  is:

**Options:**

- (1) 1:2
- (2) 2:1
- (3) 8:1
- (4) 1:8

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

**Solution:**

Self-inductance ( $L$ ) of a solenoid is proportional to  $n^2l$ , where  $n$  is the number of turns per unit length and  $l$  is the length.

Given:  $L_A = 2L_B$   $n_A = \frac{1}{2}n_B$  Let  $L_A$  and  $L_B$  be the self-inductances of solenoids A and B respectively.

Then,  $L_A \propto n_A^2 l_A$  and  $L_B \propto n_B^2 l_B$ .

Since  $l_A = 2l_B$  and  $n_A = n_B/2$ ,  $\frac{L_A}{L_B} = \frac{n_A^2 l_A}{n_B^2 l_B} = \frac{(n_B/2)^2 (2l_B)}{n_B^2 l_B} = \frac{1}{2}$

Thus,  $L_A : L_B = 1 : 2$

#### 💡 Quick Tip

Self-inductance of a solenoid depends on its geometry (length and number of turns) and the magnetic properties of the material.

**Question 29:** When the output of an OR gate is applied as input to a NOT gate, then the combination acts as a:

**Options:**

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

**Correct Answer:** (2) NOR gate

**Solution:**

This combination is equivalent to a NOR gate.

#### 💡 Quick Tip

Understanding the logic gates (AND, OR, NOT, NAND, NOR) and their truth tables is essential in digital electronics.

**Question 30:** Interference pattern can be observed due to superposition of

the following waves:

- A.  $y = a \sin \omega t$       B.  $y = a \sin 2\omega t$       C.  $y = a \sin(\omega t - \phi)$       D.  $y = a \sin 3\omega t$

Choose the correct answer from the options given below.

Options:

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

Correct Answer: (3) A and C

Solution:

For an interference pattern to be observed, the sources must be coherent (i.e., have a constant phase difference). Waves A and C satisfy this condition because they have the same frequency and a constant phase difference  $\phi$ .

 Quick Tip

Interference requires coherent sources; they must have the same frequency and a constant phase difference.

---

**Question 31:** If  $\phi$  is the work function of photosensitive material in eV and light of wavelength of numerical value  $\lambda = \frac{hc}{e}$  metre, is incident on it with energy above its threshold value at an instant, then the maximum kinetic energy of the photo-electron ejected by it at that instant (Take h-Plank's constant, c-velocity of light in free space) is (in SI units):

Options:

- (1)  $e + 2\phi$
- (2)  $2e - \phi$
- (3)  $e - \phi$
- (4)  $e + \phi$

Correct Answer: (3)  $e - \phi$

Solution:



Using Einstein's photoelectric equation:

$(K.E.)_{\max} = e - \phi$  where,  $e$  is the energy of incident photon in eV, and  $\phi$  is work function.

Given  $\lambda = hc/e$ .

Thus,  $e = hc/\lambda$ .

$(K.E.)_{\max} = e - \phi$

 Quick Tip

In the photoelectric effect, the maximum kinetic energy of emitted electrons is the difference between the incident photon's energy and the work function.

---

**Question 32:** The electromagnetic radiation which has the smallest wavelength are:

**Options:**

- (1) Ultraviolet rays
- (2) Gamma rays
- (3) X-rays
- (4) Microwaves

**Correct Answer: (2)**

**Solution:**

Gamma rays have the shortest wavelength among the given options.

 Quick Tip

Electromagnetic radiation spans a wide range of wavelengths, from long radio waves to short gamma rays.

---

**Question 33:** The equilibrium state of a thermodynamic system is described by:

- A. Pressure      B. Total heat      C. Temperature      D. Volume      E. Work done

Choose the most appropriate answer from the options given below.

**Options:**

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

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

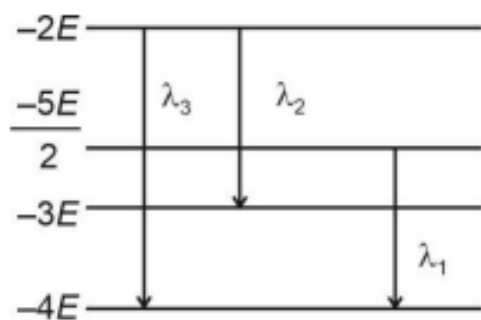
**Solution:**

The equilibrium state of a thermodynamic system is characterized by constant pressure, temperature, and volume.

💡 Quick Tip

At equilibrium, a thermodynamic system's macroscopic properties (pressure, temperature, volume) are constant.

**Question 34:** Some energy levels of a molecule are shown in the figure with their wavelengths of transitions. Then:



**Options:**

- (1)  $\lambda_3 > \lambda_2$ ,  $\lambda_1 = 2\lambda_2$
- (2)  $\lambda_3 > \lambda_2$ ,  $\lambda_1 = 4\lambda_2$
- (3)  $\lambda_1 > \lambda_2$ ,  $\lambda_2 = 2\lambda_3$
- (4)  $\lambda_2 > \lambda_1$ ,  $\lambda_2 = 2\lambda_3$

**Correct Answer:** (4)  $\lambda_2 > \lambda_1$ ,  $\lambda_2 = 2\lambda_3$

**Solution:**

The energy of a photon is given by  $E = \frac{hc}{\lambda}$ . Therefore,  $\lambda \propto \frac{1}{E}$ .

From the diagram:  $\lambda_1$  corresponds to energy difference  $E$

$\lambda_2$  corresponds to energy difference  $\frac{E}{2}$

$\lambda_3$  corresponds to energy difference  $\frac{E}{2}$

Thus  $\lambda_2 = 2\lambda_3$  and  $\lambda_2 > \lambda_1$ .

**💡 Quick Tip**

Wavelength is inversely proportional to energy difference between energy levels.

---

**Question 35:** A box of mass 5 kg is pulled by a cord, up along a frictionless plane inclined at  $30^\circ$  with the horizontal. The tension in the cord is 30 N. The acceleration of the box is (Take  $g = 10 \text{ m s}^{-2}$ )

**Options:**

- (1)  $2 \text{ m s}^{-2}$
- (2) Zero
- (3)  $0.1 \text{ m s}^{-2}$
- (4)  $1 \text{ m s}^{-2}$

**Correct Answer:** (4)  $1 \text{ m s}^{-2}$

**Solution:**

Let's analyze the forces acting on the box:

- Tension (T) = 30 N (up the incline)
- Weight (mg) =  $5 \text{ kg} \times 10 \text{ m/s}^2 = 50 \text{ N}$  (vertically downwards)

The component of weight parallel to the incline is  $mg \sin 30^\circ = 50 \times \frac{1}{2} = 25 \text{ N}$  (down the incline).

Applying Newton's second law along the incline (upward direction as positive):

$$T - mg \sin 30^\circ = ma$$

$$30 \text{ N} - 25 \text{ N} = 5 \text{ kg} \times a$$

$$a = \frac{5}{5} = 1 \text{ m s}^{-2}$$

 Quick Tip

Resolve the weight vector into components parallel and perpendicular to the incline. Apply Newton's second law along the incline.

## Section - B

**Question 36:** If the ratio of relative permeability and relative permittivity of a uniform medium is 1:4. The ratio of the magnitudes of electric field intensity (E) to the magnetic field intensity (H) of an EM wave propagating in that medium is ...

[Given that  $\sqrt{\frac{\mu_0}{\epsilon_0}} = 120\pi$ ]

**Options:**

- (1)  $30\pi : 1$
- (2)  $1 : 120\pi$
- (3)  $60\pi : 1$
- (4)  $120\pi : 1$

**Correct Answer:** (3)  $60\pi : 1$

**Solution:**

In an electromagnetic wave, the ratio of electric field intensity (E) to magnetic field intensity (H) in a medium is given by:

$$\frac{E}{H} = \sqrt{\frac{\mu}{\epsilon}} = \sqrt{\frac{\mu_r \mu_0}{\epsilon_r \epsilon_0}} = \sqrt{\frac{\mu_0}{\epsilon_0}} \sqrt{\frac{\mu_r}{\epsilon_r}}$$

Given that  $\sqrt{\frac{\mu_0}{\epsilon_0}} = 120\pi$  and  $\frac{\mu_r}{\epsilon_r} = \frac{1}{4}$ .

$$\frac{E}{H} = 120\pi \sqrt{\frac{1}{4}} = 60\pi$$

Thus, the ratio of E to H is  $60\pi : 1$ .

## 💡 Quick Tip

In an electromagnetic wave, the ratio of electric field intensity to magnetic field intensity in a medium is determined by the medium's permeability and permittivity.

**Question 37:** The value of electric potential at a distance of 9 cm from the point charge  $4 \times 10^{-7}$  C is ...

$$\left[ \text{Given } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2\text{C}^{-2} \right]$$

**Options:**

- (1)  $4 \times 10^2$  V
- (2) 44.4 V
- (3)  $4.4 \times 10^5$  V
- (4)  $4 \times 10^4$  V

**Correct Answer:** (4)  $4 \times 10^4$  V

**Solution:**

Electric potential (V) due to a point charge (q) at a distance (r) is given by:

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

Given:  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{C}^{-2}$   $q = 4 \times 10^{-7} \text{ C}$   $r = 9 \text{ cm} = 0.09 \text{ m}$

$$V = (9 \times 10^9 \text{ N m}^2\text{C}^{-2}) \frac{(4 \times 10^{-7} \text{ C})}{0.09 \text{ m}} = 4 \times 10^4 \text{ V}$$

## 💡 Quick Tip

Electric potential due to a point charge is inversely proportional to the distance from the charge.

**Question 38:** The displacement of a travelling wave is  $y = C \sin\left(\frac{2\pi}{\lambda}(at - x)\right)$ , where t is time, x is distance, and  $\lambda$  is the wavelength, all in S.I. units. Then the frequency of the wave is:

**Options:**

- (1)  $\frac{2\pi\lambda}{a}$
- (2)  $\frac{2\pi a}{\lambda}$
- (3)  $\frac{\lambda}{a}$
- (4)  $\frac{a}{\lambda}$

**Correct Answer:** (4)  $\frac{a}{\lambda}$

**Solution:**

The general equation for a travelling wave is:

$$y = A \sin(kx - \omega t)$$

where:

A is the amplitude.

k is the wave number ( $k = \frac{2\pi}{\lambda}$ ).

$\omega$  is the angular frequency ( $\omega = 2\pi f$ ).

f is the frequency.

Comparing this with given equation:  $y = C \sin\left(\frac{2\pi}{\lambda}(at - x)\right)$ , we get  $\omega = \frac{2\pi a}{\lambda}$ .

Since  $\omega = 2\pi f$ :  $2\pi f = \frac{2\pi a}{\lambda}$

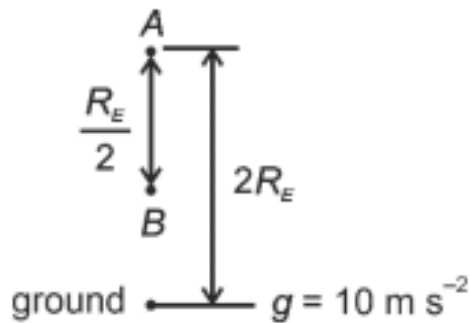
$$f = \frac{a}{\lambda}$$

 Quick Tip

The general equation for a traveling wave allows us to identify parameters like frequency and wavelength by comparing it to the given equation.

---

**Question 39:** An object of mass 100 kg falls from point A to B as shown in the figure. The change in its weight, corrected to the nearest integer is ( $R_E$  is the radius of the Earth)



**Options:**

- (1) 49 N
- (2) 89 N
- (3) 5 N
- (4) 10 N

**Correct Answer:** (1) 49 N

**Solution:**

$$Mg' = Mg \frac{R^2}{(R+h)^2}$$

$$Mg' = Mg \frac{R^2}{(R+2R)^2} = \frac{Mg}{9}$$

$$Mg' = Mg \frac{R^2}{\left(R+\frac{3R}{2}\right)^2} = \frac{Mg}{25}$$

$$Mg \frac{4}{25} - \frac{Mg}{9} = 49 \text{ N}$$

💡 Quick Tip

Weight varies inversely with the square of the distance from the Earth's center.

**Question 40:** The potential energy of a particle moving along the x-direction varies as  $V = \frac{Ax^2}{\sqrt{x+B}}$ . The dimensions of  $\frac{A^2}{B}$  are:

**Options:**

- (1)  $[M^{\frac{3}{2}}L^{\frac{1}{2}}T^{-3}]$
- (2)  $[M^{\frac{1}{2}}LT^{-3}]$
- (3)  $[M^2L^{\frac{1}{2}}T^{-4}]$
- (4)  $[ML^2T^{-4}]$

**Correct Answer: (3)**  $[M^2 L^{\frac{1}{2}} T^{-4}]$

**Solution:**

The dimensions of potential energy (V) are  $[ML^2 T^{-2}]$ .

The dimensions of x are  $[L]$ .

In the equation  $V = \frac{Ax^2}{\sqrt{x+B}}$ , the term  $\sqrt{x+B}$  must have the same dimensions as  $\sqrt{x}$  because B is added to it.

Thus,

$$[V] = \frac{[A][x]^2}{[x]^{1/2}}$$

$$[ML^2 T^{-2}] = [A][L]^{3/2}$$

$$[A] = [ML^2 T^{-2} L^{-3/2}] = [ML^{1/2} T^{-2}]$$

Also,  $[V] = \frac{[A][L]^2}{[L]^{1/2}} = [A][L]^{3/2}$ , thus,  $[A] = [ML^{1/2} T^{-2}]$

The dimensions of B are same as  $\sqrt{x}$ , thus  $[B] = [L]^{1/2}$

Then, the dimensions of  $\frac{A^2}{B}$  are:

$$\left[ \frac{A^2}{B} \right] = \frac{[ML^{1/2} T^{-2}]^2}{[L]^{1/2}} = \frac{[M^2 L T^{-4}]}{[L]^{1/2}} = [M^2 L^{1/2} T^{-4}]$$

#### Quick Tip

In physics, it is essential to ensure dimensional consistency in equations. The dimensions of each term in an equation must match.

**Question 41:** The two-dimensional motion of a particle, described by  $\vec{r} = (\hat{i} + 2\hat{j})A \cos \omega t$  is:

**Options:**

- A. parabolic path
- B. elliptical path
- C. periodic motion
- D. simple harmonic motion

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



**Options:**

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

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

**Solution:**

Let the position vector be  $\vec{r} = x\hat{i} + y\hat{j}$ . Then:

$$x = A \cos \omega t$$

$$y = 2A \cos \omega t$$

This represents simple harmonic motion along both the x and y axes.

$$\frac{x}{A} = \cos \omega t$$

$$\frac{y}{2A} = \cos \omega t$$

Therefore:  $\frac{x}{A} = \frac{y}{2A}$

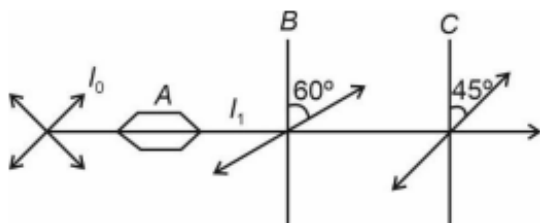
$$y = 2x$$

This is the equation of a straight line, so the path is not parabolic or elliptical. The motion is periodic and simple harmonic along the line  $y = 2x$ .

 **Quick Tip**

Analyzing the components of the position vector helps determine the nature of the motion. Simple harmonic motion is periodic.

**Question 42:** A beam of unpolarized light of intensity  $I_0$  is passed through a polaroid A, then through another polaroid B, oriented at  $60^\circ$ , and finally through another polaroid C, oriented at  $45^\circ$  relative to B as shown. The intensity of emergent light is:



**Options:**

- (1)  $\frac{I_0}{16}$
- (2)  $\frac{I_0}{4}$
- (3)  $\frac{I_0}{2}$
- (4)  $\frac{I_0}{32}$

**Correct Answer:** (1)  $\frac{I_0}{16}$

**Solution:**

After the first polarizer:  $I_1 = \frac{I_0}{2}$  After the second polarizer:  $I_2 = I_1 \cos^2 60^\circ = \frac{I_0}{2} \times \frac{1}{4} = \frac{I_0}{8}$   
After the third polarizer:  $I_3 = I_2 \cos^2 45^\circ = \frac{I_0}{8} \times \frac{1}{2} = \frac{I_0}{16}$

 Quick Tip

Malus' law states that the intensity of polarized light transmitted through a polarizer is proportional to the square of the cosine of the angle between the polarizer's axis and the polarization direction of the incident light. Unpolarized light has intensity reduced by half when passing through a polarizer.

**Question 43: Select the correct statements among the following:**

- A. Slow neutrons can cause fission in  ${}_{92}^{235}\text{U}$  than fast neutrons.
- B.  $\alpha$ -rays are Helium nuclei.
- C.  $\beta$ -rays are fast-moving electrons or positrons.
- D.  $\gamma$ -rays are electromagnetic radiations of wavelengths larger than X-rays.

**Choose the most appropriate answer from the options given below:**

**Options:**

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

**Correct Answer:** (1) A, B and C only

**Solution:**

Let's evaluate each statement:

- A. Slow neutrons are more effective in causing nuclear fission in  ${}_{92}^{235}\text{U}$  than fast neutrons

because they have a higher probability of interaction with the uranium nucleus. This statement is **correct**.

B.  $\alpha$ -rays consist of two protons and two neutrons; they are identical to Helium nuclei. This statement is **correct**.

C.  $\beta$ -rays are high-speed electrons  $^-$  or positrons  $^+$  emitted during radioactive decay. This statement is **correct**.

D.  $\gamma$ -rays are electromagnetic radiation with wavelengths shorter than X-rays. This statement is **incorrect**.

Therefore, statements A, B, and C are correct.

#### 💡 Quick Tip

Slow neutrons are better at initiating fission in  $^{235}_{92}\text{U}$  due to their longer interaction time with the nucleus. Alpha particles are Helium nuclei. Beta particles are electrons or positrons. Gamma rays have shorter wavelengths than X-rays.

**Question 44:** Let  $\omega_1, \omega_2$ , and  $\omega_3$  be the angular speed of the second hand, minute hand, and hour hand of a smoothly running analog clock, respectively. If  $x_1, x_2$ , and  $x_3$  are their respective angular distances in 1 minute, then the factor which remains constant ( $k$ ) is:

**Options:**

- (1)  $\frac{\omega_1}{x_1} = \frac{\omega_2}{x_2} = \frac{\omega_3}{x_3} = k$
- (2)  $\omega_1 x_1 = \omega_2 x_2 = \omega_3 x_3 = k$
- (3)  $\omega_1^2 x_1 = \omega_2^2 x_2 = \omega_3^2 x_3 = k$
- (4)  $\omega_1 x_1^2 = \omega_2 x_2^2 = \omega_3 x_3^2 = k$

**Correct Answer:** (1)  $\frac{\omega_1}{x_1} = \frac{\omega_2}{x_2} = \frac{\omega_3}{x_3} = k$

**Solution:**

Angular speed ( $\omega$ ) =  $\frac{\text{Angular displacement}}{\text{time}}$

For the second hand:  $\omega_1 = \frac{2\pi}{60}$  rad/s  $x_1 = \omega_1 \times 60 = 2\pi$  rad

For the minute hand:  $\omega_2 = \frac{2\pi}{3600}$  rad/s  $x_2 = \omega_2 \times 60 = \frac{2\pi}{60}$  rad

For the hour hand:

$$\omega_3 = \frac{2\pi}{3600 \times 12} \text{ rad/s}$$

$$x_3 = \omega_3 \times 60 = \frac{2\pi}{720} \text{ rad}$$

Thus,  $\frac{\omega_1}{x_1} = \frac{\omega_2}{x_2} = \frac{\omega_3}{x_3} = \frac{1}{60} = k$

 Quick Tip

Angular speed is the rate of change of angular displacement. In a clock, the angular speeds of the hands are inversely proportional to their periods.

**Question 45:** The magnetic moment of an iron bar is  $M$ . It is now bent in such a way that it forms an arc section of a circle subtending an angle of  $60^\circ$  at the centre. The magnetic moment of this arc section is:

**Options:**

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

**Correct Answer:** (1)  $\frac{3M}{\pi}$

**Solution:**

$$R\theta = L$$

$$\frac{R\pi}{3} = L$$

$$R = \frac{3L}{\pi}$$

$$M' = m(2R) \sin 30^\circ$$

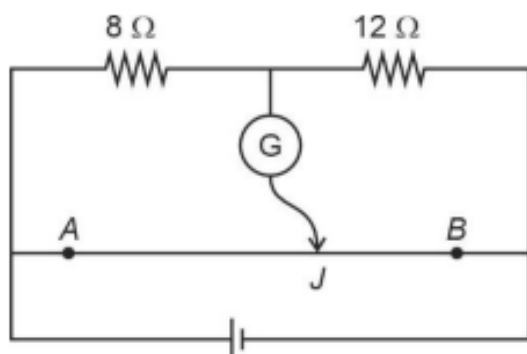
$$= m(2)\frac{3L}{\pi} \times \frac{1}{2} = \frac{3}{\pi}mL = \frac{3M}{\pi}$$

 Quick Tip

The magnetic moment is proportional to the length of the magnet. When bending the bar, only the length changes.

**Question 46:** The given circuit shows a uniform straight wire AB of 40 cm length fixed at both ends. In order to get zero reading in the galvanometer

G, the free end of J is to be placed from B at:



**Options:**

- (1) 32 cm
- (2) 8 cm
- (3) 16 cm
- (4) 24 cm

**Correct Answer: (4) 24 cm**

**Solution:**

For zero galvanometer deflection, the bridge must be balanced. This is a Wheatstone bridge arrangement. The condition for a balanced Wheatstone bridge is:

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

Where  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  represent the resistance in each arm of the Wheatstone bridge. Here,  $R_1$  and  $R_2$  are the resistances of the wire segments AJ and JB respectively, and  $R_3 = 8\ \Omega$  and  $R_4 = 12\ \Omega$ . The length of AB is 40 cm, thus,  $\frac{R_1}{R_2} = \frac{8}{12} = \frac{2}{3}$

$$\frac{R_1}{R_2} = \frac{x}{40 - x} = \frac{2}{3}$$

$$3x = 80 - 2x \quad 5x = 80 \quad x = 16\text{ cm}$$

$$\text{Distance of J from B} = 40\text{ cm} - 16\text{ cm} = 24\text{ cm}$$

**💡 Quick Tip**

The Wheatstone bridge is used to measure unknown resistances. The bridge is balanced when the ratio of resistances in opposite arms is equal.

**Question 47:** According to the law of equipartition of energy, the number of vibrational modes of a polyatomic gas of constant  $\gamma = \frac{C_p}{C_v}$  is  $C_p, C_v$  where  $C_v$  are the specific heat capacities of the gas at constant pressure and constant volume, respectively):

**Options:**

- (1)  $\frac{4+3\gamma}{\gamma-1}$
- (2)  $\frac{3+4\gamma}{\gamma-1}$
- (3)  $\frac{4-3\gamma}{\gamma-1}$
- (4)  $\frac{3-4\gamma}{\gamma-1}$

**Correct Answer:** (3)  $\frac{4-3\gamma}{\gamma-1}$

**Solution:**

For a polyatomic gas with 3 translational, 3 rotational, and  $f$  vibrational modes:

$$\text{Internal energy (U)} = \frac{3}{2}k_B T + \frac{3}{2}k_B T + f k_B T = (3 + f)k_B T$$

$$C_v = (3 + f)R$$

$$C_p = (4 + f)R$$

$$\gamma = \frac{C_p}{C_v} = \frac{4+f}{3+f}$$

$$3\gamma + f\gamma = 4 + f$$

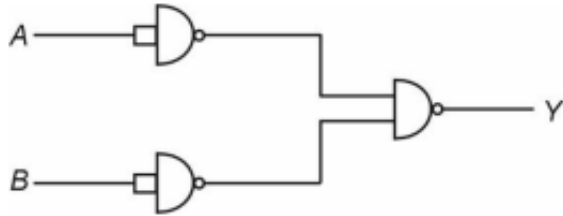
$$f(\gamma - 1) = 4 - 3\gamma$$

$$f = \frac{4 - 3\gamma}{\gamma - 1}$$

#### Quick Tip

The law of equipartition of energy relates the internal energy of a gas to its degrees of freedom. For polyatomic gases, consider translational, rotational, and vibrational degrees of freedom.

**Question 48:** The output Y for the inputs A and B of the given logic circuit is:



**Options:**

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

**Correct Answer:** (3)  $A + B$

**Solution:**

The circuit consists of two OR gates whose outputs are then applied as inputs to another OR gate. Therefore, the logic expression for the output Y is:

$$Y = (A + B)$$

**💡 Quick Tip**

The OR gate represents logical addition; the output is true (1) if either or both inputs are true.

**Question 49:** The amplitude of the charge oscillating in a circuit decreases exponentially as  $Q = Q_0 e^{-Rt/2L}$ , where  $Q_0$  is the charge at  $t = 0$  s. The time at which charge amplitude decreases to  $0.50 Q_0$  is nearly:

[Given that  $R = 1.5 \Omega$ ,  $L = 12 \text{ mH}$ ,  $\ln(2) = 0.693$ ]

**Options:**

- (1) 19.01 ms
- (2) 11.09 ms
- (3) 19.01 s
- (4) 11.09 s

**Correct Answer: (2) 11.09 ms**

**Solution:**

$$\text{Given: } Q = Q_0 e^{-Rt/2L}$$

$$\text{When } Q = 0.50Q_0:$$

$$0.50Q_0 = Q_0 e^{-Rt/2L}$$

$$0.50 = e^{-Rt/2L}$$

$$\ln(0.50) = -\frac{Rt}{2L}$$

$$\ln\left(\frac{1}{2}\right) = -\frac{Rt}{2L}$$

$$-\ln 2 = -\frac{Rt}{2L}$$

$$t = \frac{2L \ln 2}{R}$$

$$\text{Given: } R = 1.5 \, \Omega \quad L = 12 \, \text{mH} = 12 \times 10^{-3} \, \text{H} \quad \ln 2 = 0.693$$

$$t = \frac{2(12 \times 10^{-3} \, \text{H})(0.693)}{1.5 \, \Omega} \approx 11.088 \times 10^{-3} \, \text{s} \approx 11.09 \, \text{ms}$$

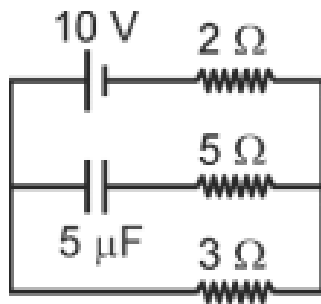
**💡 Quick Tip**

The decay of charge in an L-R circuit follows an exponential decay. The time constant is  $\frac{2L}{R}$ .

---

**Question 50:** The steady-state current in the circuit shown below is:





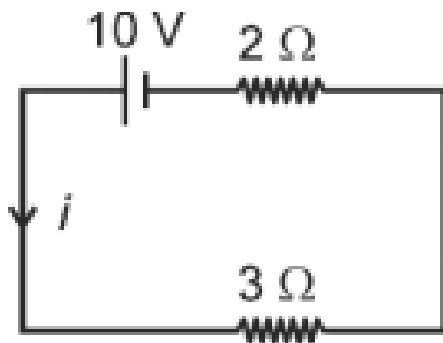
**Options:**

- (1) 0.67 A
- (2) 1.5 A
- (3) 2 A
- (4) 1 A

**Correct Answer: (3) 2 A**

**Solution:**

In steady state, the capacitor acts as an open circuit (infinite resistance). Therefore, the  $5\ \Omega$  resistor is not part of the circuit. The circuit simplifies to:



The total resistance is  $2\ \Omega + 3\ \Omega = 5\ \Omega$ . Using Ohm's law,  $I = V/R = \frac{10\text{ V}}{5\ \Omega} = 2\text{ A}$

**💡 Quick Tip**

In a DC circuit, a capacitor acts as an open circuit in steady state. Simplify the circuit accordingly before applying Ohm's law.

## Chemistry

## Section - A

**Question 51:** The correct decreasing order of atomic radii (pm) of Li, Be, B, and C is:

**Options:**

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

**Correct Answer:** (2)  $\text{Li} > \text{Be} > \text{B} > \text{C}$

**Solution:**

Li, Be, B, and C are elements of the second period. Across a period from left to right, the atomic radii generally decrease. This is because as we move across a period, the number of protons in the nucleus increases, increasing the effective nuclear charge. This stronger positive charge pulls the electrons in the outermost shell closer to the nucleus, resulting in a smaller atomic radius.

Li (Lithium) is in group 1. Be (Beryllium) is in group 2. B (Boron) is in group 13. C (Carbon) is in group 14.

Therefore, the atomic radii decrease in the order  $\text{Li} > \text{Be} > \text{B} > \text{C}$ .

 Quick Tip

Atomic radius generally decreases across a period (left to right) and increases down a group (top to bottom). Remember that there can be exceptions and nuances to these trends.

---

**Question 52:** Following data is for a reaction between reactants A and B:

| Rate<br>$\text{mol L}^{-1} \text{s}^{-1}$ | [A]   | [B]   |
|-------------------------------------------|-------|-------|
| $2 \times 10^{-3}$                        | 0.1 M | 0.1 M |
| $4 \times 10^{-3}$                        | 0.2 M | 0.1 M |
| $1.6 \times 10^{-2}$                      | 0.2 M | 0.2 M |

The order of the reaction with respect to A and B, respectively, are

**Options:**

- (1) 1, 0  
 (2) 0, 1  
 (3) 1, 2  
 (4) 2, 1

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

**Solution:**

Let the rate law be given by:  $\text{Rate} = k[A]^x[B]^y$ , where  $x$  and  $y$  are the orders of the reaction with respect to A and B respectively.

From the given data:

Comparing the first and second rows (keeping [B] constant):

$$\frac{4 \times 10^{-3}}{2 \times 10^{-3}} = \frac{k[0.2]^x[0.1]^y}{k[0.1]^x[0.1]^y}$$

$$2 = 2^x$$

$$x = 1$$

Comparing the second and third rows (keeping [A] constant):

$$\frac{1.6 \times 10^{-2}}{4 \times 10^{-3}} = \frac{k[0.2]^x[0.2]^y}{k[0.2]^x[0.1]^y}$$

$$4 = 2^y$$

$$y = 2$$

Therefore, the order of the reaction with respect to A is 1, and with respect to B is 2.

 **Quick Tip**

To determine the order of a reaction with respect to a particular reactant, compare two experiments where the concentration of only that reactant changes, while the concentrations of other reactants remain constant.

**Question 53: Given below are two statements:**

**Statement I:** Propene on treatment with diborane gives an addition product with the formula  $(\text{CH}_3)_2\text{CH}-\text{B}$ .

**Statement II:** Oxidation of  $(\text{CH}_3)_2\text{CH}-\text{B}$  with hydrogen peroxide in presence of NaOH gives propan-2-ol.

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

**Options:**

- (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: (2) Statement I is incorrect but Statement II is correct**

**Solution:**

Statement I is incorrect. Propene reacts with diborane ( $B_2H_6$ ) to form trialkylborane,  $(CH_3)_2CH-\overset{\sim}{B}$ , which is then oxidized using hydrogen peroxide in the presence of NaOH to produce propan-2-ol. The formula given in Statement I is not the correct addition product. The actual addition product is a trialkyl borane which is formed in the first step.

Statement II is correct. Oxidation of the trialkylborane by  $H_2O_2$  in NaOH gives propan-2-ol. This is the hydroboration-oxidation reaction.

**💡 Quick Tip**

Hydroboration-oxidation is a two-step reaction used to produce alcohols from alkenes. Diborane adds to the alkene, and oxidation yields an alcohol.

---

**Question 54: Baeyer's reagent is :**

**Options:**

- (1) Acidic potassium permanganate solution
- (2) Acidic potassium dichromate solution
- (3) Cold, dilute, aqueous solution of potassium permanganate
- (4) Hot, concentrated solution of potassium permanganate

**Correct Answer: (3) Cold, dilute, aqueous solution of potassium permanganate**

**Solution:**

Baeyer's reagent is a cold, dilute, alkaline solution of potassium permanganate  $KMnO_4$ . It is a powerful oxidizing agent and is used as a test for unsaturation (presence of double or triple bonds) in organic compounds. The permanganate ion  $MnO_4^-$  is a deep purple color. When it reacts with an unsaturated compound, the purple color disappears, and a brown

precipitate of manganese dioxide  $MnO_2$  forms. This decolorization of the permanganate solution is a positive test for unsaturation. It's important that the solution be cold and dilute; otherwise, the reaction may proceed too vigorously, and the permanganate may oxidize the organic compound further.

 Quick Tip

Baeyer's reagent is specifically a cold, dilute, *alkaline* solution. While the provided answer and solution mention "aqueous," it is essential to remember the alkaline nature of the reagent for a proper understanding and application of the test.

---

**Question 55:** Which of the following molecules has "NON ZERO" dipole moment value?

**Options:**

- (1)  $CCl_4$
- (2)  $HI$
- (3)  $CO_2$
- (4)  $BF_3$

**Correct Answer:** (2)  $HI$

**Solution:**

A molecule has a non-zero dipole moment when there is a separation of charge due to differences in electronegativity between the bonded atoms and the molecule's geometry does not lead to cancellation of these individual bond dipoles.

**$CCl_4$ :** Carbon tetrachloride has a tetrahedral geometry. Although the C-Cl bonds are polar, the symmetrical arrangement of the four chlorine atoms around the central carbon atom leads to the cancellation of the bond dipoles, resulting in a net zero dipole moment.

**$HI$ :** Hydrogen iodide is a diatomic molecule. Iodine is more electronegative than hydrogen, creating a polar bond and a net dipole moment pointing towards the iodine atom. Because it's diatomic, there are no other bond dipoles to cancel it out.

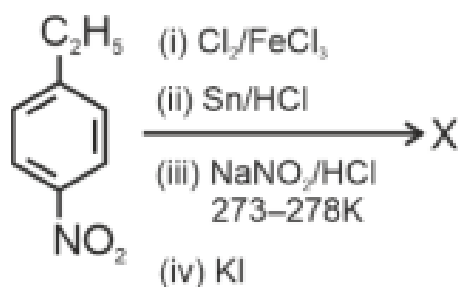
**$CO_2$ :** Carbon dioxide has a linear geometry. The C=O bonds are polar, but the molecule's symmetry results in the cancellation of the bond dipoles, leading to a zero net dipole moment.

**BF<sub>3</sub>:** Boron trifluoride has a trigonal planar geometry. The B-F bonds are polar, but their symmetrical arrangement around the central boron atom results in the cancellation of the bond dipoles, leading to a net zero dipole moment.

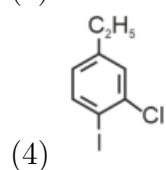
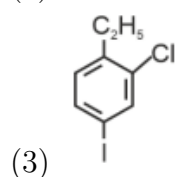
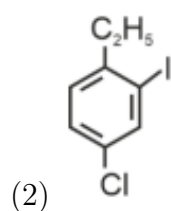
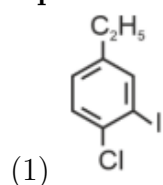
💡 Quick Tip

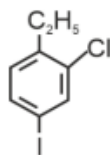
Molecular geometry plays a crucial role in determining the overall dipole moment. Even if individual bonds are polar, a symmetrical arrangement can lead to a net zero dipole moment due to the cancellation of bond dipoles.

**Question 56:** The major product X formed in the following reaction sequence is:



**Options:**





**Correct Answer: (3)**

**Solution:**

This reaction sequence involves a series of transformations:

1. Chlorination: Chlorination of the ethylbenzene ring will occur preferentially at the para position due to the activating effect of the ethyl group and the deactivating meta-directing nature of the nitro group.
2. Reduction: Reduction of the nitro group ( $-\text{NO}_2$ ) to an amino group ( $-\text{NH}_2$ ) using tin and hydrochloric acid ( $\text{Sn}/\text{HCl}$ ).
3. Diazotization: The amino group is converted into a diazonium group ( $-\text{N}_2^+$ ) using sodium nitrite and hydrochloric acid ( $\text{NaNO}_2/\text{HCl}$ ) at a low temperature (273-278 K).
4. Sandmeyer Reaction: The diazonium group is replaced by an iodide (I) using potassium iodide (KI) via a Sandmeyer reaction. This replacement occurs at the same position as the original amino group (and thus the nitro group). Thus, we have 4-iodo-1-ethyl-2-chlorobenzene.

**💡 Quick Tip**

The order of reactions is important here. Activating groups direct electrophilic aromatic substitution to ortho/para positions. The Sandmeyer reaction is a key step to obtain the final product.

---

**Question 57: Which indicator is used in the titration of sodium hydroxide against oxalic acid, and what is the colour change at the end point?**

**Options:**

- (1) Phenolphthalein, pink to yellow
- (2) Alkaline  $\text{KMnO}_4$ , colourless to pink
- (3) Phenolphthalein, colourless to pink
- (4) Methyl orange, yellow to pinkish red colour

**Correct Answer: (3) Phenolphthalein, colourless to pink**

**Solution:**

Phenolphthalein is a suitable indicator for the titration of a strong base (sodium hydroxide) against a weak acid (oxalic acid). The end point is indicated by a colour change from colourless in acidic solution to pink in basic solution.

**💡 Quick Tip**

The choice of indicator depends on the pH range at the equivalence point of the titration. Phenolphthalein is suitable for titrations involving weak acids and strong bases.

**Question 58: Match List-I with List-II :**

| <b>List-I</b><br>(Atom/Molecule) |                   | <b>List-II</b><br>(Property) |                                                      |
|----------------------------------|-------------------|------------------------------|------------------------------------------------------|
| A.                               | Nitrogen atom     | I.                           | Paramagnetic                                         |
| B.                               | Fluorine molecule | II.                          | Most reactive element in group 18                    |
| C.                               | Oxygen molecule   | III.                         | Element with highest ionisation enthalpy in group 15 |
| D.                               | Xenon atom        | IV.                          | Strongest oxidising agent                            |

Identify the correct answer from the options given below :

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

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

**Solution:**

**A. Nitrogen atom:** Nitrogen is in group 15. Nitrogen has the highest ionization enthalpy in group 15 due to its half-filled p orbitals providing extra stability. Thus, A-III.

**B. Fluorine molecule:** Fluorine is the most electronegative element and a powerful oxidizing agent.  $F_2$  is the strongest oxidizing agent among the given options. Thus, B-IV.

**C. Oxygen molecule:** Oxygen ( $O_2$ ) is paramagnetic because it has two unpaired electrons in its antibonding molecular orbitals. Thus, C-I.



**D. Xenon atom:** Xenon is a noble gas in group 18. It is the most reactive element in group 18 due to its larger size and lower ionization energy compared to other noble gases in the same group, making it more susceptible to forming compounds. Thus, D-II.

 Quick Tip

Understanding periodic trends like electronegativity, ionization enthalpy, and reactivity is crucial for predicting the chemical properties of elements and molecules. Remember that half-filled and fully filled orbitals provide extra stability.

---

**Question 59:** From the following, select the one which is not an example of corrosion.

**Options:**

- (1) Rusting of iron object
- (2) Production of hydrogen by electrolysis of water
- (3) Tarnishing of silver
- (4) Development of green coating on copper and bronze ornaments

**Correct Answer:** (2) Production of hydrogen by electrolysis of water

**Solution:**

Corrosion is the deterioration of a material due to a chemical reaction with its environment.

- Rusting of iron is a corrosion process (oxidation of iron).
- Tarnishing of silver is a type of corrosion (formation of silver sulfide).
- Development of a green coating (patina) on copper and bronze is a form of corrosion (formation of copper carbonate and other compounds).
- Production of hydrogen by electrolysis of water is not a corrosion process. It's an electrochemical process where water is decomposed into hydrogen and oxygen.

Therefore, the process which is not an example of corrosion is the production of hydrogen by electrolysis of water.

 Quick Tip

Corrosion involves a chemical or electrochemical reaction leading to the deterioration of a material. Electrolysis is a different process involving the use of electricity to drive a chemical reaction.

**Question 60:** Which of the following pairs of ions will have same spin only magnetic moment values within the pair?

- A.  $\text{Zn}^{2+}$ ,  $\text{Ti}^{2+}$
- B.  $\text{Cr}^{2+}$ ,  $\text{Fe}^{2+}$
- C.  $\text{Ti}^{3+}$ ,  $\text{Cu}^{2+}$
- D.  $\text{V}^{2+}$ ,  $\text{Cu}^{+}$

Choose the correct answer from the options given below :

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

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

**Solution:**

Spin-only magnetic moment is calculated using the formula:

$$\mu = \sqrt{n(n+2)}$$

where  $n$  is the number of unpaired electrons and  $\mu$  is the magnetic moment in Bohr magnetons.

We need to determine the number of unpaired electrons for each ion:

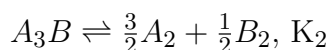
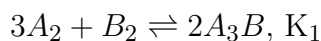
- A.  $\text{Zn}^{2+}$  ( $d^{10}$ ),  $\text{Ti}^{2+}$  ( $d^2$ ):**  $\text{Zn}^{2+}$  has 0 unpaired electrons,  $\text{Ti}^{2+}$  has 2.
- B.  $\text{Cr}^{2+}$  ( $d^4$ ),  $\text{Fe}^{2+}$  ( $d^6$ ):**  $\text{Cr}^{2+}$  has 4 unpaired electrons,  $\text{Fe}^{2+}$  has 4.
- C.  $\text{Ti}^{3+}$  ( $d^1$ ),  $\text{Cu}^{2+}$  ( $d^9$ ):**  $\text{Ti}^{3+}$  has 1 unpaired electron,  $\text{Cu}^{2+}$  has 1.
- D.  $\text{V}^{2+}$  ( $d^3$ ),  $\text{Cu}^{+}$  ( $d^{10}$ ):**  $\text{V}^{2+}$  has 3 unpaired electrons,  $\text{Cu}^{+}$  has 0.

Therefore, the pairs with the same spin-only magnetic moment are B ( $\text{Cr}^{2+}$  and  $\text{Fe}^{2+}$ ) and C ( $\text{Ti}^{3+}$  and  $\text{Cu}^{2+}$ ).

 Quick Tip

Remember to write the electronic configurations of the transition metal ions correctly, accounting for the loss of electrons from the 4s orbital before the 3d orbital in most cases. This is crucial for determining the number of unpaired electrons and calculating the magnetic moment.

**Question 61:** At a given temperature and pressure, the equilibrium constant values for the equilibria are given below:



The relation between  $K_1$  and  $K_2$  is:

**Options:**

- (1)  $K_1^2 = 2K_2$
- (2)  $K_2 = \frac{K_1}{2}$
- (3)  $K_1 = \frac{1}{\sqrt{K_2}}$
- (4)  $K_2 = \frac{1}{\sqrt{K_1}}$

**Correct Answer:** (4)  $K_2 = \frac{1}{\sqrt{K_1}}$

**Solution:**

The second equilibrium reaction is the reverse of the first reaction divided by 2.

Therefore, the relationship between the equilibrium constants is:

$$K_2 = \frac{1}{\sqrt{K_1}}$$

 Quick Tip

When manipulating equilibrium reactions (reversing, multiplying by a constant), remember how to adjust the equilibrium constant accordingly.

**Question 62:** Arrange the following compounds in increasing order of their solubilities in chloroform:

NaCl, CH<sub>3</sub>OH, cyclohexane, CH<sub>3</sub>CN

**Options:**

- (1) NaCl < CH<sub>3</sub>CN < CH<sub>3</sub>OH < Cyclohexane
- (2) CH<sub>3</sub>OH < CH<sub>3</sub>CN < NaCl < Cyclohexane
- (3) NaCl < CH<sub>3</sub>OH < CH<sub>3</sub>CN < Cyclohexane
- (4) Cyclohexane < CH<sub>3</sub>CN < CH<sub>3</sub>OH < NaCl

**Correct Answer:** (1) NaCl < CH<sub>3</sub>CN < CH<sub>3</sub>OH < Cyclohexane

**Solution:**

Chloroform (CHCl<sub>3</sub>) is a polar organic solvent. The general principle "like dissolves like" applies here. Polar substances tend to dissolve in polar solvents, and nonpolar substances tend to dissolve in nonpolar solvents.

**NaCl:** Sodium chloride is an ionic compound. Ionic compounds are generally not soluble in organic solvents like chloroform.

**CH<sub>3</sub>OH (Methanol):** Methanol is a polar molecule due to the presence of the highly electronegative oxygen atom and the polar O-H bond. It can form hydrogen bonds, but the overall polarity is less than NaCl. Methanol exhibits some solubility in chloroform.

**CH<sub>3</sub>CN (Acetonitrile):** Acetonitrile is a polar molecule due to the CN bond. It is less polar than methanol and has a smaller dipole moment. It will be more soluble in chloroform than NaCl but less soluble than methanol.

**Cyclohexane:** Cyclohexane is a nonpolar molecule. Chloroform has a dipole moment, so it's considered a polar solvent, although it's not as polar as water or methanol. Cyclohexane will be the most soluble in chloroform among the given options because chloroform's polarity is relatively low within the spectrum of polar solvents.

Therefore, the increasing order of solubility in chloroform is: NaCl < CH<sub>3</sub>CN < CH<sub>3</sub>OH < Cyclohexane.

 Quick Tip

When considering solubility, remember the principle "like dissolves like." Polar solvents dissolve polar solutes, and nonpolar solvents dissolve nonpolar solutes. The stronger the intermolecular forces between solute and solvent, the greater the solubility. Also consider hydrogen bonding capabilities.

**Question 63:** Identify the *incorrect* statement about  $\text{PCl}_5$ .

**Options:**

- (1)  $\text{PCl}_5$  possesses two different Cl – P – Cl bond angles
- (2) All five P – Cl bonds are identical in length
- (3)  $\text{PCl}_5$  exhibits  $\text{sp}^3\text{d}$  hybridisation
- (4)  $\text{PCl}_5$  consists of five P – Cl (sigma) bonds

**Correct Answer:** (2) All five P – Cl bonds are identical in length

**Solution:**

$\text{PCl}_5$  has a trigonal bipyramidal geometry. In this geometry, there are two types of P–Cl bonds:

**Axial bonds:** Two longer and weaker bonds positioned above and below the central phosphorus atom.

**Equatorial bonds:** Three shorter and stronger bonds arranged in a trigonal plane around the central phosphorus atom.

Therefore, the statement “All five P – Cl bonds are identical in length” is incorrect. The other statements are correct:  $\text{PCl}_5$  has two different bond angles ( $90^\circ$  and  $120^\circ$ ), exhibits  $\text{sp}^3\text{d}$  hybridization, and consists of five sigma bonds.

 Quick Tip

Molecules with  $\text{sp}^3\text{d}$  hybridization often have different bond lengths and angles due to their non-uniform geometries, such as trigonal bipyramidal. Visualizing the molecular geometry can be helpful.

---

**Question 64:** Choose the correct statement for the work done in the expansion and heat absorbed or released when 5 litres of an ideal gas at 10 atmospheric pressure isothermally expands into vacuum until volume is 15 litres:

**Options:**

- (1) Both the heat and work done will be greater than zero
- (2) Heat absorbed will be less than zero and work done will be positive
- (3) Work done will be zero and heat will also be zero
- (4) Work done will be greater than zero and heat will remain zero

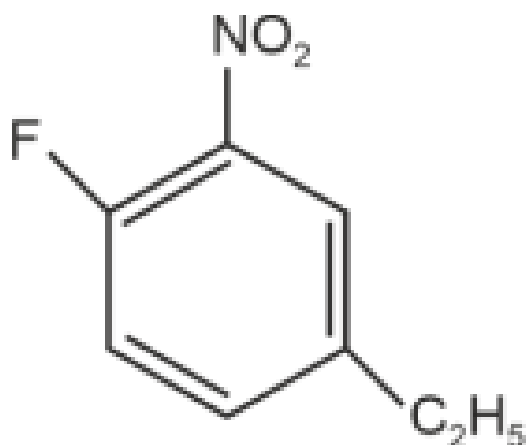
**Correct Answer:** (3) Work done will be zero and heat will also be zero

**Solution:**

This is a free expansion into a vacuum. In a free expansion, no work is done by the gas because the external pressure is zero. Since the expansion is isothermal (constant temperature), the internal energy of the ideal gas remains constant ( $\Delta U = 0$ ). From the first law of thermodynamics,  $\Delta U = q + w$ , where  $q$  is heat absorbed and  $w$  is work done. Since  $\Delta U = 0$  and  $w = 0$ , the heat absorbed ( $q$ ) is also zero.

**💡 Quick Tip**

Free expansion into a vacuum is an isothermal process where no work is done, and no heat is exchanged.

**Question 65: The correct IUPAC name of the compound**

is:

**Options:**

- (1) 4-ethyl-1-fluoro-2-nitrobenzene
- (2) 4-ethyl-1-fluoro-6-nitrobenzene
- (3) 3-ethyl-6-fluoro-1-nitrobenzene
- (4) 1-ethyl-4-fluoro-3-nitrobenzene

**Correct Answer: (1) 4-ethyl-1-fluoro-2-nitrobenzene**

**Solution:**

To name this compound according to IUPAC rules:

1. **Identify the parent chain:** The parent chain is the benzene ring.
2. **Number the substituents:** The substituents are ethyl, fluoro, and nitro. Numbering should be done to give the lowest possible numbers to the substituents. Since the nitro group has the highest priority alphabetically, we try to give it the lowest number. We can number it as 1, but then ethyl and fluoro would be 4 and 5 respectively. If we start numbering with fluoro as 1, then the nitro group becomes 2 and the ethyl group becomes 4, resulting in lower overall numbers (1, 2, 4 is better than 1, 4, 5).
3. **Arrange the substituents alphabetically:** The substituents are ethyl, fluoro, and nitro.
4. **Combine the substituents and parent chain:** The IUPAC name is 4-ethyl-1-fluoro-2-nitrobenzene.

 Quick Tip

When numbering substituents on a benzene ring, aim for the lowest possible set of numbers. If there's a tie, prioritize substituents alphabetically. Remember to consider both the position and the alphabetical order while naming benzene derivatives.

---

**Question 66:** Which of the following sets of ions act as oxidizing agents?

**Options:**

- (1)  $\text{Ce}^{4+}$  and  $\text{Tb}^{4+}$
- (2)  $\text{La}^{3+}$  and  $\text{Lu}^{3+}$
- (3)  $\text{Eu}^{2+}$  and  $\text{Yb}^{2+}$
- (4)  $\text{Eu}^{2+}$  and  $\text{Tb}^{4+}$

**Correct Answer:** (1)  $\text{Ce}^{4+}$  and  $\text{Tb}^{4+}$

**Solution:**

Oxidizing agents readily accept electrons and get reduced. Let's consider the common oxidation states of the given lanthanides:

Ce: Common oxidation states are +3 and +4.  $\text{Ce}^{4+}$  readily accepts an electron to become  $\text{Ce}^{3+}$ , acting as an oxidizing agent.

Tb: Common oxidation states are +3 and +4.  $\text{Tb}^{4+}$  can be reduced to  $\text{Tb}^{3+}$ , acting as an oxidizing agent.

La and Lu: These lanthanides predominantly exist in the +3 oxidation state and are not strong oxidizing agents.

Eu and Yb: These lanthanides exhibit +2 and +3 oxidation states.  $\text{Eu}^{2+}$  and  $\text{Yb}^{2+}$  are reducing agents (they tend to lose electrons and get oxidized).

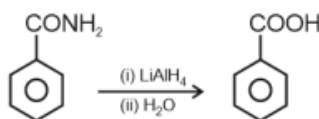
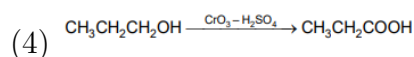
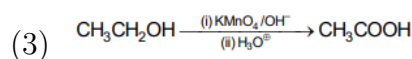
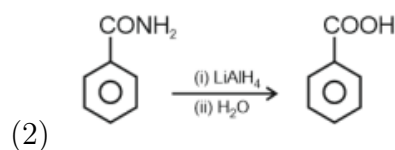
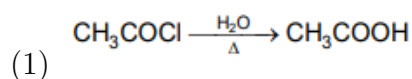
Therefore, only  $\text{Ce}^{4+}$  and  $\text{Tb}^{4+}$  from the given options are good oxidizing agents.

**💡 Quick Tip**

The oxidizing strength of a species depends on its tendency to accept electrons and get reduced. Higher oxidation states generally favor oxidizing behavior.

**Question 67:** Select the *incorrect* reaction among the following:

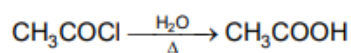
**Options:**



**Correct Answer: (2)**

**Solution:**

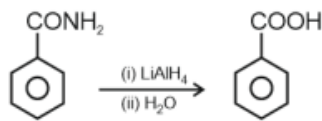
Let's analyze each reaction:



1. **Reaction (1):**

This reaction shows the hydrolysis of an acyl chloride (acetyl chloride) to a carboxylic acid (acetic acid). This is a standard reaction. Acyl chlorides readily react with water to form carboxylic acids.



**2. Reaction (2):**

This reaction depicts the attempted reduction of benzamide to benzoic acid using lithium aluminum hydride ( $\text{LiAlH}_4$ ). This is incorrect.  $\text{LiAlH}_4$  is a strong reducing agent that reduces amides to amines, not carboxylic acids. The correct product would be benzylamine.

**3. Reaction (3):**  $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow[\text{(ii) H}_3\text{O}^+]{\text{(i) KMnO}_4/\text{OH}^-} \text{CH}_3\text{COOH}$ 

This reaction shows the oxidation of ethanol to acetic acid using alkaline potassium permanganate ( $\text{KMnO}_4$ ) followed by acidification. This is a standard oxidation reaction.

**4. Reaction (4):**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{CrO}_3-\text{H}_2\text{SO}_4} \text{CH}_3\text{CH}_2\text{COOH}$ 

This reaction shows the oxidation of propanol to propanoic acid using a mixture of chromium trioxide ( $\text{CrO}_3$ ) and sulfuric acid ( $\text{H}_2\text{SO}_4$ ). This is also a standard oxidation reaction.

**💡 Quick Tip**

$\text{LiAlH}_4$  is a strong reducing agent typically used to reduce carbonyl compounds (aldehydes, ketones, esters, and carboxylic acids) and other functional groups like nitriles and amides. It's crucial to understand the specific transformations it performs and the products it yields. It reduces amides to amines.

**Question 68:** The UV-visible absorption bands in the spectra of lanthanoid ions are 'X', probably because of the excitation of electrons involving 'Y'. The 'X' and 'Y', respectively, are :

**Options:**

- (1) Broad and f orbitals
- (2) Narrow and f orbitals
- (3) Broad and d and f orbitals
- (4) Narrow and d and f orbitals

**Correct Answer:** (2) Narrow and f orbitals

**Solution:**

Lanthanides have narrow absorption bands in the UV-visible region of the spectrum. This

is because the f orbitals are shielded effectively by the outer electrons, so the electronic transitions within the f orbitals are less affected by the external environment (ligands or other ions). This shielding leads to narrow and well-defined absorption bands. The transitions responsible for these absorptions involve f orbitals.

**💡 Quick Tip**

The shielding of f orbitals in lanthanides results in narrow absorption bands in their UV-visible spectra. This shielding makes the electronic transitions within the f orbitals less sensitive to the surrounding chemical environment.

---

**Question 69: Ethylene diaminetetraacetate ion is a/an:**

**Options:**

- (1) hexadentate ligand
- (2) ambidentate ligand
- (3) monodentate ligand
- (4) bidentate ligand

**Correct Answer: (1) hexadentate ligand**

**Solution:**

Ethylenediaminetetraacetate (EDTA) is a hexadentate ligand. It has six donor atoms (two nitrogen atoms and four oxygen atoms) that can coordinate to a central metal ion.

**💡 Quick Tip**

The “dentate” number of a ligand refers to the number of donor atoms it can use to bind to a central metal ion. EDTA, with its six donor atoms, is a common example of a hexadentate ligand.

---

**Question 70: The amount of glucose required to prepare 250 mL of  $\frac{M}{20}$  aqueous solution is :** (Molar mass of glucose :  $180 \text{ g mol}^{-1}$ )

**Options:**

- (1) 2.25 g
- (2) 4.5 g
- (3) 0.44 g

(4) 1.125 g

**Correct Answer: (1) 2.25 g**

**Solution:**

Molarity (M) is defined as moles of solute per liter of solution.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution (L)}}$$

Given that the solution is  $\frac{M}{20}$ , the molarity is:

$$\text{Molarity} = \frac{1}{20}M = 0.05M$$

The volume of the solution is 250 mL, which is equal to 0.25 L. We can calculate the moles of glucose needed:

$$\text{Moles} = \text{Molarity} \times \text{Volume} = 0.05M \times 0.25L = 0.0125\text{moles}$$

Now, we can calculate the mass of glucose required:

$$\text{Mass} = \text{Moles} \times \text{Molar mass} = 0.0125\text{moles} \times 180\frac{\text{g}}{\text{mol}} = 2.25\text{g}$$

 Quick Tip

Remember to convert the volume from milliliters to liters when using the molarity formula.

---

**Question 71: Identify the *incorrect* statement from the following :**

**Options:**

- (1) The acidic strength of HX (X = F, Cl, Br and I) follows the order : HF > HCl > HBr > HI.
- (2) Fluorine exhibits -1 oxidation state whereas other halogens exhibit +1, +3, +5 and +7 oxidation states also.
- (3) The enthalpy of dissociation of F<sub>2</sub> is smaller than that of Cl<sub>2</sub>.
- (4) Fluorine is stronger oxidising agent than chlorine.

**Correct Answer: (1) The acidic strength of HX (X = F, Cl, Br and I) follows the order : HF > HCl > HBr > HI.**

**Solution:**

The acidic strength of the hydrogen halides (HX) increases down the group: HF < HCl < HBr < HI. This trend is due to the decreasing bond strength of the H-X bond as the size of the halogen atom increases. The weaker the bond, the more readily the hydrogen ion ( $\text{H}^+$ ) can dissociate, resulting in a stronger acid. Thus, statement (1) is incorrect.

The other statements are correct:

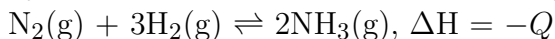
Fluorine is the most electronegative element and only exhibits a -1 oxidation state. Other halogens can exhibit multiple oxidation states (+1, +3, +5, and +7).

The bond dissociation enthalpy of  $\text{F}_2$  is smaller than that of  $\text{Cl}_2$  due to the high electron-electron repulsion between the lone pairs in the small fluorine molecule.

Fluorine is a stronger oxidizing agent than chlorine due to its higher electronegativity and smaller size.

**💡 Quick Tip**

The acidic strength of the hydrogen halides (HX) increases down Group 17 (HF < HCl < HBr < HI) due to the decreasing bond strength. Remember this trend, as it is a common exception to the general trend of electronegativity.

**Question 72: For the reaction in equilibrium**

Reaction is favoured in forward direction by:

**Options:**

- (1) use of catalyst
- (2) decreasing concentration of  $\text{N}_2$
- (3) low pressure, high temperature and high concentration of ammonia
- (4) high pressure, low temperature and higher concentration of  $\text{H}_2$

**Correct Answer:** (4) high pressure, low temperature and higher concentration of  $\text{H}_2$

**Solution:**

According to Le Chatelier's principle, if a change of condition is applied to a system in equilibrium, the system will shift in a direction that relieves the stress. For the given reaction,  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ , which is exothermic ( $\Delta H = -Q$ ):

**High Pressure:** The forward reaction produces fewer moles of gas (2 moles of  $\text{NH}_3$ ) than the reactants (4 moles of  $\text{N}_2$  and  $\text{H}_2$ ). Increasing the pressure favors the side with fewer

moles of gas, shifting the equilibrium towards the formation of ammonia.

**Low Temperature:** Since the reaction is exothermic, decreasing the temperature favors the forward reaction (heat is treated as a product).

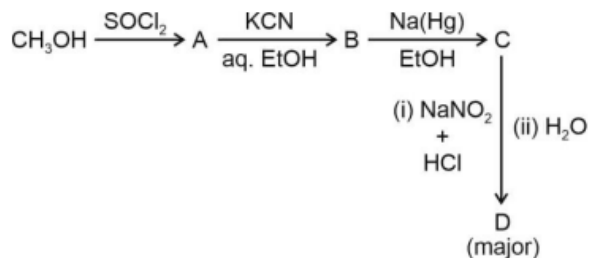
**Higher Concentration of Reactants:** Increasing the concentration of  $N_2$  or  $H_2$  shifts the equilibrium to the right to consume the added reactant.

A catalyst speeds up both the forward and reverse reactions equally but does not affect the equilibrium position.

**💡 Quick Tip**

Le Chatelier's principle predicts how changes in conditions affect equilibrium. For exothermic reactions, decreasing temperature favors product formation. Changes in pressure favor the side with fewer gas molecules if there's a difference in the number of moles of gas between reactants and products.

**Question 73:** The major product D formed in the following reaction sequence is:



**Options:**

- (1)  $\text{CH}_3\text{CHO}$
- (2)  $\text{CH}_3\text{CONH}_2$
- (3)  $\text{CH}_3\text{CH}_2\text{OH}$
- (4)  $\text{CH}_3\text{CH}_2\text{Cl}$

**Correct Answer:** (3)  $\text{CH}_3\text{CH}_2\text{OH}$

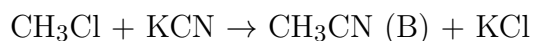
**Solution:**

Let's trace the reaction sequence:

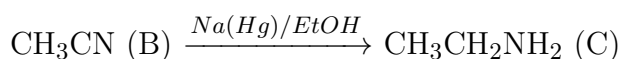
1. Step 1:  $\text{CH}_3\text{OH}$  (methanol) reacts with thionyl chloride ( $\text{SOCl}_2$ ) to form chloromethane (A):



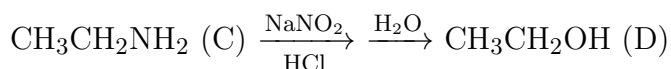
2. Step 2:  $\text{CH}_3\text{Cl}$  reacts with potassium cyanide (KCN) in aqueous ethanol to form acetonitrile (B):



3. Step 3: Acetonitrile (B) is reduced using sodium amalgam ( $\text{Na(Hg)}$ ) in ethanol to form ethylamine (C):



4. Step 4: Ethylamine (C) undergoes diazotization with sodium nitrite and hydrochloric acid ( $\text{NaNO}_2/\text{HCl}$ ), followed by hydrolysis with water ( $\text{H}_2\text{O}$ ) to produce ethanol (D) as the major product:



**Conclusion:** The major product D is ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ).

 Quick Tip

This reaction sequence involves several important organic reactions: conversion of alcohol to alkyl halide, nitrile formation, reduction of nitrile to amine, and diazotization followed by hydrolysis of amine to alcohol.

**Question 74: Match List-I with List-II:**

| List-I<br>(Block/group in periodic table) | List-II<br>(Element) |
|-------------------------------------------|----------------------|
| A. Lanthanoid                             | I. Ce                |
| B. d-block element                        | II. As               |
| C. p-block element                        | III. Cs              |
| D. s-block element                        | IV. Mn               |

Choose the correct answer from the options given below:

**Options:**

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

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

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

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

**Solution:**

Based on their positions in the periodic table:

Cerium (Ce) is a lanthanoid element. Thus A-I.

Manganese (Mn) is a d-block element. Thus B-IV.

Arsenic (As) is a p-block element. Thus C-II.

Cesium (Cs) is an s-block element. Thus D-III.

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

 Quick Tip

Review the organization of the periodic table and the location of elements within blocks (s, p, d, f) to understand their properties.

---

**Question 75: Which of the following is *not* an ambidentate ligand?**

**Options:**

(1)  $\text{C}_2\text{O}_4^{2-}$

(2)  $\text{SCN}^-$

(3)  $\text{NO}_2^-$

(4)  $\text{CN}^-$

**Correct Answer: (1)  $\text{C}_2\text{O}_4^{2-}$**

**Solution:**

An ambidentate ligand is a ligand that can bind to a central metal ion through two different donor atoms.

**$\text{C}_2\text{O}_4^{2-}$  (Oxalate):** Oxalate is a bidentate ligand, meaning it binds through two oxygen atoms. However, both oxygen atoms are equivalent, so it is not ambidentate. It always binds through its two oxygen atoms.

**SCN<sup>-</sup> (Thiocyanate):** Thiocyanate can bind through either the sulfur atom (thiocyanato-S) or the nitrogen atom (thiocyanato-N), making it ambidentate.

**NO<sub>2</sub><sup>-</sup> (Nitrite):** Nitrite can bind through either the nitrogen atom (nitro) or the oxygen atom (nitrito), making it ambidentate.

**CN<sup>-</sup> (Cyanide):** Cyanide can bind through either the carbon atom (cyano) or the nitrogen atom (isocyano), making it ambidentate. Although cyanide preferentially binds through carbon, the possibility of N-bonding makes it technically ambidentate.

 Quick Tip

Ambidentate ligands have two different potential donor atoms. While bidentate ligands bind through two atoms, if those two atoms are the same element and chemically equivalent, the ligand is not ambidentate.

**Question 76: The quantum numbers of four electrons are given below:**

- I.  $n = 4; l = 2; m_l = -2; s = -\frac{1}{2}$
- II.  $n = 3; l = 2; m_l = 1; s = +\frac{1}{2}$
- III.  $n = 4; l = 1; m_l = 0; s = +\frac{1}{2}$
- IV.  $n = 3; l = 1; m_l = -1; s = +\frac{1}{2}$

**The correct decreasing order of energy of these electrons is:**

**Options:**

- (1)  $IV > III > II > I$
- (2)  $I > III > II > IV$
- (3)  $III > I > II > IV$
- (4)  $I > II > III > IV$

**Correct Answer: (2)  $I > III > II > IV$**

**Solution:**

The energy of an electron is primarily determined by the principal quantum number ( $n$ ) and then the azimuthal quantum number ( $l$ ). Lower  $n$  and  $l$  values correspond to lower energy. For the same  $n$ , lower  $l$  has lower energy. If  $n$  and  $l$  are same, then energy depends on spin, lower energy for  $-1/2$ .

Let's analyze the electrons:



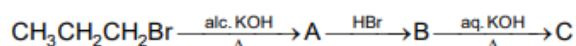
- I. (n=4, l=2)  
 II. (n=3, l=2)  
 III. (n=4, l=1)  
 IV. (n=3, l=1)

Thus, I > III and II > IV based on n and l. Also, I > II and III > IV as n is higher for I and III respectively. Thus, I>III>II>IV

 Quick Tip

Electron energy levels are determined by the quantum numbers (n, l,  $m_l$ , s), with lower values of n and l generally corresponding to lower energy. For same n and l, higher  $m_l$  values have higher energies. For same n, l,  $m_l$ , lower s value (-1/2) will have lower energy.

**Question 77:** The major product C in the below mentioned reaction is:



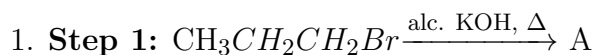
**Options:**

- (1) Propan-1-ol  
 (2) Propan-2-ol  
 (3) Propane  
 (4) Propyne

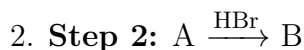
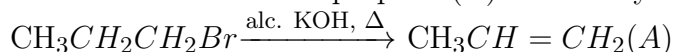
**Correct Answer:** (2) Propan-2-ol

**Solution:**

Let's analyze the reaction step-by-step:

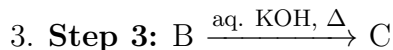


Alcoholic KOH and heat promote elimination reactions. 1-Bromopropane reacts with alcoholic KOH to form propene (A) via a dehydrohalogenation reaction.

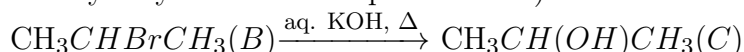


Propene (A) reacts with HBr to form 2-bromopropane (B) as the major product according to Markovnikov's rule (the hydrogen atom adds to the carbon with more hydrogen

atoms already attached).



2-Bromopropane (B) reacts with aqueous KOH and heat to form propan-2-ol (C) via a nucleophilic substitution reaction (specifically, an  $\text{S}_{\text{N}}1$  reaction is favored due to secondary alkyl halide and aqueous KOH).



Therefore, the major product C is propan-2-ol.

 Quick Tip

Alcoholic KOH favors elimination reactions, while aqueous KOH favors substitution reactions. Markovnikov's rule predicts the regioselectivity of electrophilic addition to alkenes.

**Question 78:** The compound that does not undergo Friedel-Crafts alkylation reaction but gives a positive carbylamine test is:

**Options:**

- (1) Aniline
- (2) Pyridine
- (3) N-methylaniline
- (4) Triethylamine

**Correct Answer:** (1) Aniline

**Solution:**

Friedel-Crafts alkylation requires an electrophilic aromatic substrate. Aniline does not undergo Friedel-Crafts alkylation because the amino group ( $-\text{NH}_2$ ) on the benzene ring strongly activates the ring towards electrophilic attack, leading to significant reactivity and making it difficult to control the reaction. Furthermore, the lone pair of electrons on the nitrogen atom in aniline coordinates with the Lewis acid catalyst (like  $\text{AlCl}_3$ ), deactivating the ring and preventing alkylation.

The carbylamine test is positive for primary amines. Aniline is a primary amine and will give a positive test.

 Quick Tip

Friedel-Crafts alkylation reactions are not successful with deactivated or strongly activated aromatic rings. The carbylamine test is a chemical test for primary amines.

**Question 79: For an endothermic reaction:**

- (A)  $q_p$  is negative.
- (B)  $\Delta_r H$  is positive.
- (C)  $\Delta_r H$  is negative.
- (D)  $q_p$  is positive.

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

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

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

**Solution:**

For an endothermic reaction:

$\Delta_r H$  is positive: Endothermic reactions absorb heat from the surroundings, resulting in a positive change in enthalpy ( $\Delta H$ ).

$q_p$  is positive: At constant pressure (denoted by the subscript p), the heat absorbed by the system ( $q_p$ ) is equal to the change in enthalpy ( $\Delta H$ ). Since  $\Delta H$  is positive for an endothermic reaction,  $q_p$  is also positive.

Therefore, the correct statements are B and D.

 Quick Tip

Endothermic reactions absorb heat (positive  $q$  and  $H$ ), while exothermic reactions release heat (negative  $q$  and  $H$ ). At constant pressure,  $q_p = \Delta H$ .

**Question 80: 1.0 g of  $H_2$  has the same number of molecules as in:**

**Options:**

- (1) 14 g of N<sub>2</sub>
- (2) 18 g of H<sub>2</sub>O
- (3) 16 g of CO
- (4) 28 g of N<sub>2</sub>

**Correct Answer: (1) 14 g of N<sub>2</sub>**

**Solution:**

The number of moles (n) is given by:  $n = \frac{\text{mass (g)}}{\text{molar mass (g/mol)}}$ . The number of molecules is given by  $N = nN_A$ , where  $N_A$  is Avogadro's number.

For 1.0 g of H<sub>2</sub>: Molar mass of H<sub>2</sub> = 2.016 g/mol Moles of H<sub>2</sub> =  $\frac{1.0 \text{ g}}{2.016 \text{ g/mol}} \approx 0.496 \text{ mol}$

Number of molecules =  $0.496 \times N_A$

Let's check the options:

(1) 14 g of N<sub>2</sub>: Molar mass of N<sub>2</sub> = 28 g/mol Moles of N<sub>2</sub> =  $\frac{14 \text{ g}}{28 \text{ g/mol}} = 0.5 \text{ mol}$  Number of molecules =  $0.5 \times N_A$

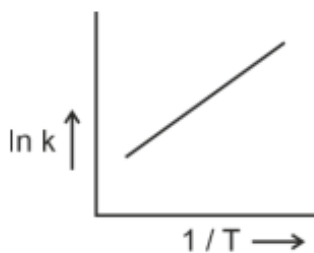
Thus, 14 g of N<sub>2</sub> has approximately the same number of molecules as 1 g of H<sub>2</sub>.

**💡 Quick Tip**

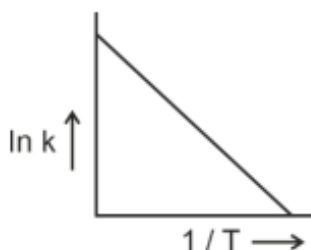
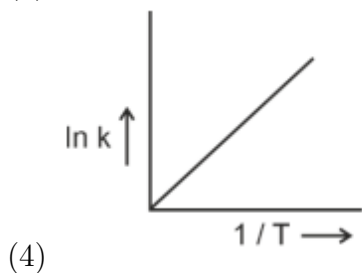
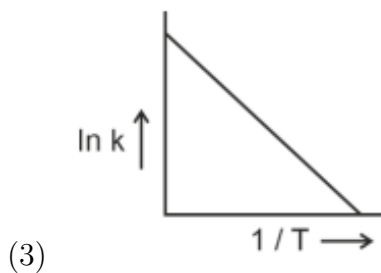
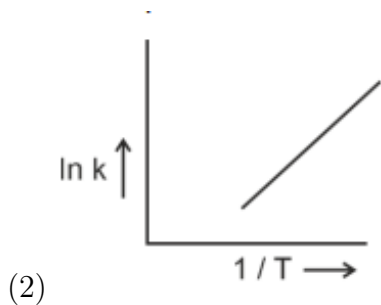
Equal number of moles of different substances contain equal numbers of molecules (Avogadro's Law).

**Question 81:** Which of the following plot represents the variation of  $\ln k$  versus  $\frac{1}{T}$  in accordance with Arrhenius equation?

**Options:**



(1)



**Correct Answer: (3)**

### Solution:

The Arrhenius equation is given by:

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

where: \*  $k$  is the rate constant \*  $A$  is the pre-exponential factor \*  $E_a$  is the activation energy \*  $R$  is the gas constant \*  $T$  is the temperature in Kelvin

Taking the natural logarithm of both sides:

$$\ln k = \ln A - \frac{E_a}{RT}$$

This equation can be rearranged into the form of a straight line equation ( $y = mx + c$ ):

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

where:

$$y = \ln k$$

$$x = 1/T$$

$$m = -E_a/R \text{ (slope)}$$

$$c = \ln A \text{ (y-intercept)}$$

Since activation energy ( $E_a$ ) and the gas constant ( $R$ ) are always positive, the slope ( $-E_a/R$ ) will always be negative. Therefore, the plot of  $\ln k$  versus  $1/T$  should be a straight line with a negative slope. This corresponds to option (3).

 Quick Tip

The Arrhenius equation shows the relationship between the rate constant of a reaction and temperature. The linearized form of the equation is helpful for determining the activation energy from experimental data. A plot of  $\ln k$  vs.  $1/T$  will have a negative slope.

**Question 82:** A steam volatile organic compound which is immiscible with water has a boiling point of  $250^\circ\text{C}$ . During steam distillation, a mixture of this organic compound and water will boil:

**Options:**

- (1) above  $100^\circ\text{C}$  but below  $250^\circ\text{C}$
- (2) above  $250^\circ\text{C}$
- (3) at  $250^\circ\text{C}$
- (4) close to but below  $100^\circ\text{C}$

**Correct Answer:** (4) close to but below  $100^\circ\text{C}$

**Solution:**

In steam distillation, a mixture of immiscible liquids boils at a temperature lower than the boiling point of either individual component. This occurs because the total vapor pressure of the mixture is the sum of the vapor pressures of the individual components. The mixture boils when the total vapor pressure equals the atmospheric pressure. Since the organic compound is steam volatile (meaning it has a significant vapor pressure even below its boiling point) and immiscible with water, it will co-distill with water at a temperature close to, but slightly below, the boiling point of water ( $100^\circ\text{C}$ ). The boiling point will be slightly below  $100^\circ\text{C}$  due to the contribution of the organic compound's vapor pressure to the total vapor pressure.

 Quick Tip

Steam distillation is used to purify and separate temperature-sensitive organic compounds that are immiscible with water. The mixture boils at a temperature lower than the boiling point of either component, preventing decomposition of the organic compound.

**Question 83: Given below are two statements :**

**Statement I :** Glycogen is similar to amylose in its structure.

**Statement II :** Glycogen is found in yeast and fungi also.

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:**

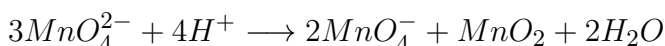
**Statement I:** Glycogen is similar to amylopectin, not amylose, in its structure. Both glycogen and amylopectin are branched polymers of glucose. Amylose, on the other hand, is a linear polymer of glucose. Thus, statement I is false.

**Statement II:** Glycogen is a storage polysaccharide found in animals, and it is also found in fungi, including yeast. Thus, statement II is true.

 Quick Tip

Glycogen is similar in structure to amylopectin, both having branched structures, while amylose is a linear polymer. Glycogen is a storage polysaccharide found in animals and fungi.

**Question 84: The oxidation states not shown by Mn in the given reaction are:**



- A. +6
- B. +2
- C. +4
- D. +7
- E. +3

Choose the most appropriate answer from the options given below:

**Options:**

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

**Correct Answer: (4) B and E only**

**Solution:**

Let's determine the oxidation states of Mn in the reactants and products:

In  $\text{MnO}_4^{2-}$ : Let x be the oxidation state of Mn.

Then  $x + 4(-2) = -2$ , so  $x = +6$ .

In  $\text{MnO}_4^-$ :  $x + 4(-2) = -1$ , so  $x = +7$ .

In  $\text{MnO}_2$ :  $x + 2(-2) = 0$ , so  $x = +4$ .

The oxidation states of Mn in the reaction are +6, +7, and +4. Therefore, the oxidation states not shown are +2 and +3.

 Quick Tip

Determine the oxidation state of Mn in each reactant and product to identify which oxidation states are not present in the reaction.

---

**Question 85: Given below are two statements:**

**Statement I:** The Balmer spectral line for H atom with lowest energy is located at  $\frac{5}{36}R_H \text{ cm}^{-1}$ . ( $R_H$  = Rydberg constant)

**Statement II:** When the temperature of blackbody increases, the maxima of the curve (intensity and wavelength) shifts to shorter wavelength.

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:** The Balmer series corresponds to electronic transitions where the electron falls to the  $n=2$  energy level. The lowest energy transition in the Balmer series is from  $n=3$  to  $n=2$ . The wavenumber ( $\bar{\nu}$ ) for this transition can be calculated using the Rydberg formula:

$$\bar{\nu} = R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

For the lowest energy Balmer transition ( $n_1=2$ ,  $n_2=3$ ):

$$\bar{\nu} = R_H \left( \frac{1}{2^2} - \frac{1}{3^2} \right) = R_H \left( \frac{1}{4} - \frac{1}{9} \right) = R_H \left( \frac{9-4}{36} \right) = \frac{5}{36} R_H$$

The wavenumber is indeed  $\frac{5}{36} R_H \text{ cm}^{-1}$ . Thus, statement I is true.

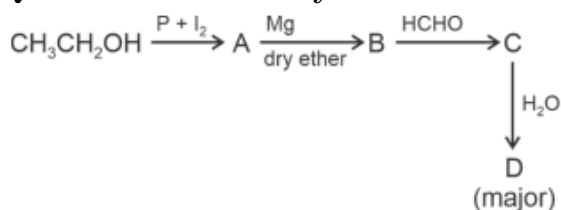
**Statement II:** Wien's displacement law states that the wavelength of maximum intensity for blackbody radiation is inversely proportional to its temperature. As the temperature increases, the wavelength of maximum intensity shifts to shorter wavelengths. Thus, statement II is true.

**💡 Quick Tip**

The Balmer series spectral lines correspond to electronic transitions to the  $n=2$  energy level in hydrogen atoms. Wien's displacement law describes the relationship between the temperature of a blackbody and the wavelength of maximum intensity.

## Section - B

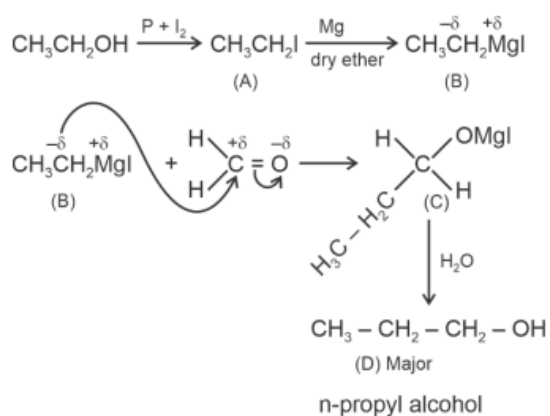
**Question 86: Identify D in the following sequence of reactions:**



**Options:**

- (1) n-propyl alcohol
- (2) isopropyl alcohol
- (3) propanal
- (4) propionic acid

**Correct Answer:** (1) n-propyl alcohol

**Solution:**

This reaction sequence involves several steps:

1. Formation of A (Grignard Reagent): Ethanol reacts with red phosphorus and iodine to form ethyl iodide which then reacts with magnesium in dry ether to form ethyl magnesium iodide (A). This is a Grignard Reagent which is very reactive.
2. Formation of B (Addition to Aldehyde): Ethylmagnesium iodide (A) reacts with formaldehyde (HCHO) to form a magnesium alkoxide intermediate (B). This addition reaction results in an increase in the carbon chain.
3. Formation of C (Acidification): Acidification of (B) leads to the protonation of the alkoxide intermediate which yields propanol (C).
4. Formation of D: No further reaction occurs as we get propan-1-ol (n-propyl alcohol).

**Conclusion:** The major product D is n-propyl alcohol.

 Quick Tip

Grignard reagents react with aldehydes to form alcohols after acidification. The reaction increases the carbon chain length.

**Question 87:** Identify the *incorrect* statement.

**Options:**

- (1)  $\text{PEt}_3$  and  $\text{AsPh}_3$  as ligands can form  $d\pi-d\pi$  bond with transition metals
- (2) The N – N single bond is as strong as the P – P single bond
- (3) Nitrogen has unique ability to form  $p\pi-p\pi$  multiple bonds with nitrogen, carbon and oxygen
- (4) Nitrogen cannot form  $d\pi-p\pi$  bond as other heavier elements of its group

**Correct Answer:** (2) The N – N single bond is as strong as the P – P single bond

**Solution:**

Let's examine each statement:

1.  $\text{PEt}_3$  and  $\text{AsPh}_3$  can form  $d\pi-d\pi$  bonds:  $\text{PEt}_3$  (triethylphosphine) and  $\text{AsPh}_3$  (triphenylarsine) are ligands that can act as  $\pi$ -acceptors. The phosphorus or arsenic atom in these ligands has empty d orbitals that can accept electron density from the filled d orbitals of transition metals, forming  $d\pi-d\pi$  backbonds. This is a correct statement.

2. N-N single bond strength: The N-N single bond is considerably weaker than the P-P single bond. This weakness is due to the lone pair repulsion between the nitrogen atoms. The lone pairs on the relatively small nitrogen atoms are close enough to experience significant repulsion, weakening the N-N single bond. Phosphorus atoms are larger, and their lone pairs are further apart, resulting in less repulsion and a stronger P-P bond. Therefore, statement (2) is *incorrect*.

3. Nitrogen's  $p\pi-p\pi$  multiple bonds: Nitrogen readily forms  $p\pi-p\pi$  multiple bonds with itself ( $\text{N}_2$ ), carbon ( $\text{C}=\text{N}$ ,  $\text{CN}$ ), and oxygen ( $\text{N}=\text{O}$ ). This is a key aspect of nitrogen chemistry and is a correct statement.

4. Nitrogen's  $d\pi-p\pi$  bonding: Nitrogen does not have accessible d orbitals in its valence shell. Therefore, it cannot form  $d\pi-p\pi$  bonds, unlike heavier elements in its group (phosphorus, arsenic, etc.) which have d orbitals available. This is a correct statement.

**💡 Quick Tip**

The weakness of the N-N single bond is a crucial factor in the reactivity of nitrogen-containing compounds. This is due to the repulsion between the lone pairs on the adjacent nitrogen atoms. In contrast, P-P single bonds are stronger.

---

**Question 88: Match List-I with List-II:**

| List-I<br>(Test/reagent)   | List-II<br>(Radical identified) |
|----------------------------|---------------------------------|
| A. Lake Test               | I. $\text{NO}_3^-$              |
| B. Nessler's Reagent       | II. $\text{Fe}^{3+}$            |
| C. Potassium sulphocyanide | III. $\text{Al}^{3+}$           |
| D. Brown Ring Test         | IV. $\text{NH}_4^+$             |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The correct matches are:

Lake test is used to identify  $\text{Al}^{3+}$  ions. Thus A-III. Nessler's reagent is used to detect  $\text{NH}_4^+$  ions. Thus B-IV.

Potassium sulphocyanide is used to identify  $\text{Fe}^{3+}$  ions. Thus C-II.

Brown ring test is used to identify  $\text{NO}_3^-$  ions. Thus D-I.

Therefore, the correct option is (4): A-III, B-IV, C-II, D-I.

 **Quick Tip**

These tests are based on specific chemical reactions that produce characteristic color changes or precipitates, allowing for the identification of particular ions or radicals.

**Question 89: Match List-I with List-II:**

| List-I<br>Molecule | List-II<br>Bond enthalpy ( $\text{kJ mol}^{-1}$ ) |
|--------------------|---------------------------------------------------|
| A. HCl             | I. 435.8                                          |
| B. $\text{N}_2$    | II. 498                                           |
| C. $\text{H}_2$    | III. 946.0                                        |
| D. $\text{O}_2$    | IV. 431.0                                         |

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

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

**Solution:**

Bond enthalpy is the energy required to break one mole of a particular bond in a gaseous substance.

A. HCl: The H-Cl bond enthalpy is approximately  $431 \text{ kJ mol}^{-1}$  (slightly lower than HBr and higher than HF due to periodic trends down the halogen group). Thus, A-IV.

B.  $\text{N}_2$ : The NN triple bond is very strong, with a bond enthalpy of approximately  $946 \text{ kJ mol}^{-1}$ . Thus, B-III.

C.  $\text{H}_2$ : The H-H single bond has a bond enthalpy of approximately  $436 \text{ kJ mol}^{-1}$ . Thus, C-I.

D.  $\text{O}_2$ : The O=O double bond has a bond enthalpy of approximately  $498 \text{ kJ mol}^{-1}$ . Thus, D-II.

Therefore, the correct matching is A-IV, B-III, C-I, D-II.

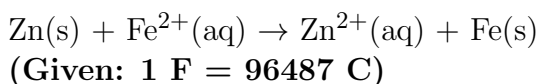
 Quick Tip

Bond enthalpy is a measure of bond strength. Triple bonds are generally stronger than double bonds, which are stronger than single bonds. Be mindful of the units ( $\text{kJ mol}^{-1}$ ).

---

**Question 90: The standard cell potential of the following cell  $\text{Zn}|\text{Zn}^{2+}(\text{aq})||\text{Fe}^{2+}(\text{aq})|\text{Fe}$  is 0.32 V.**

**Calculate the standard Gibbs energy change for the reaction:**



**Options:**

- (1)  $-61.75 \text{ kJ mol}^{-1}$   
 (2)  $+5.006 \text{ kJ mol}^{-1}$   
 (3)  $-5.006 \text{ kJ mol}^{-1}$   
 (4)  $+61.75 \text{ kJ mol}^{-1}$

**Correct Answer: (1)  $-61.75 \text{ kJ mol}^{-1}$**

**Solution:**

The standard Gibbs energy change ( $\Delta G^\circ$ ) is related to the standard cell potential ( $E^\circ$ ) by:

$$\Delta G^\circ = -nFE^\circ$$

where:

n is the number of moles of electrons transferred in the balanced redox reaction.

F is Faraday's constant ( $96487 \text{ C mol}^{-1}$ ).

$E^\circ$  is the standard cell potential.

In the given reaction,  $\text{Zn(s)}$  is oxidized to  $\text{Zn}^{2+}(\text{aq})$  and  $\text{Fe}^{2+}(\text{aq})$  is reduced to  $\text{Fe(s)}$ .  
 Thus,  $n=2$ .  $E^\circ = 0.32 \text{ V}$

$$\Delta G^\circ = -(2 \text{ mol})(96487 \text{ C mol}^{-1})(0.32 \text{ V})$$

$$\Delta G^\circ = -61751.04 \text{ J mol}^{-1} \approx -61.75 \text{ kJ mol}^{-1}$$

 **Quick Tip**

Gibbs free energy change is related to the cell potential through the equation  $\Delta G^\circ = -nFE^\circ$ . A negative  $\Delta G^\circ$  indicates a spontaneous reaction.

**Question 91: Match List-I with List-II:**

**List-I:** Solid salt treated with dil.  $\text{H}_2\text{SO}_4$

**List-II:** Anion detected

| List-I |                                 | List-II |                    |
|--------|---------------------------------|---------|--------------------|
| A.     | Effervescence of colourless gas | I.      | $\text{NO}_2^-$    |
| B.     | Gas with smell of rotten egg    | II.     | $\text{CO}_3^{2-}$ |
| C.     | Gas with pungent smell          | III.    | $\text{S}^{2-}$    |
| D.     | Brown fumes                     | IV.     | $\text{SO}_3^{2-}$ |

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

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

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

**Solution:**

This question tests your knowledge of the qualitative analysis of anions. When a solid salt is treated with dilute sulfuric acid ( $\text{H}_2\text{SO}_4$ ), different anions produce characteristic gases:

**A. Effervescence of colourless gas:** This indicates the presence of carbonate ions ( $\text{CO}_3^{2-}$ ). The reaction produces carbon dioxide ( $\text{CO}_2$ ), a colorless and odorless gas. A-II

**B. Gas with smell of rotten egg:** This characteristic smell indicates the presence of sulfide ions ( $\text{S}^{2-}$ ). The reaction produces hydrogen sulfide ( $\text{H}_2\text{S}$ ), which has a strong smell of rotten eggs. B-III

**C. Gas with pungent smell:** This indicates the presence of sulfite ions ( $\text{SO}_3^{2-}$ ). The reaction produces sulfur dioxide ( $\text{SO}_2$ ), a colorless gas with a sharp, pungent smell. C-IV

**D. Brown fumes:** This observation indicates the presence of nitrite ions ( $\text{NO}_2^-$ ). The reaction produces nitrogen dioxide ( $\text{NO}_2$ ), a brown, pungent gas. D-I

 Quick Tip

Qualitative analysis of anions relies on observing characteristic reactions, such as the gases produced when treated with dilute sulfuric acid. Knowing the specific gases and their associated smells and colors is essential for identifying the anions present in a salt.

---

**Question 92:** The ratio of solubility of  $\text{AgCl}$  in 0.1 M  $\text{KCl}$  solution to the solubility of  $\text{AgCl}$  in water is:

(Given: Solubility product of  $\text{AgCl} = 10^{-10}$ )

**Options:**

- (1)  $10^{-4}$
- (2)  $10^{-6}$
- (3)  $10^{-9}$
- (4)  $10^{-5}$

**Correct Answer:** (1)  $10^{-4}$

**Solution:**

**1. Solubility in Water:**

$\text{AgCl} \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$   $K_{sp} = [\text{Ag}^+][\text{Cl}^-] = s^2$  where  $s$  is the solubility in mol/L.

Given  $K_{sp} = 10^{-10}$   $s = \sqrt{10^{-10}} = 10^{-5}$  mol/L

**2. Solubility in 0.1 M KCl Solution:** In 0.1 M KCl solution,  $[\text{Cl}^-] = 0.1$  M (due to common ion effect).

$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = s'(0.1) = 10^{-10}$  where  $s'$  is solubility in 0.1 M KCl.  $s' = \frac{10^{-10}}{0.1} = 10^{-9}$  mol/L

**3. Calculate the Ratio:**

$$\text{Ratio} = \frac{\text{Solubility in 0.1 M KCl}}{\text{Solubility in water}} = \frac{10^{-9}}{10^{-5}} = 10^{-4}$$

 **Quick Tip**

The common ion effect reduces the solubility of a sparingly soluble salt.

---

**Question 93:** On complete combustion, 0.3 g of an organic compound gave 0.2 g of  $\text{CO}_2$  and 0.1 g of  $\text{H}_2\text{O}$ . The percentage composition of carbon and hydrogen in the compound, respectively is:

**Options:**

- (1) 4.07% and 15.02%
- (2) 18.18% and 3.70%
- (3) 15.02% and 4.07%
- (4) 3.70% and 18.18%

**Correct Answer:** (2) 18.18% and 3.70%

**Solution:**



Percentage of Carbon:

The mass of carbon in 0.2 g of  $\text{CO}_2$  can be calculated using the molar masses: Molar mass of  $\text{CO}_2 = 44 \text{ g/mol}$  Molar mass of  $\text{C} = 12 \text{ g/mol}$

$$\text{Mass of C in } 0.2 \text{ g } \text{CO}_2 = \frac{12}{44} \times 0.2 \text{ g} = 0.0545 \text{ g}$$

$$\text{Percentage of C} = \frac{\text{Mass of C}}{\text{Mass of compound}} \times 100 = \frac{0.0545}{0.3} \times 100 = 18.18\%$$

Percentage of Hydrogen:

The mass of hydrogen in 0.1 g of  $\text{H}_2\text{O}$  can be calculated using the molar masses: Molar mass of  $\text{H}_2\text{O} = 18 \text{ g/mol}$  Molar mass of  $\text{H} = 1 \text{ g/mol}$  (but there are 2 H atoms, thus, 2 g/mol)

$$\text{Mass of H in } 0.1 \text{ g } \text{H}_2\text{O} = \frac{2}{18} \times 0.1 \text{ g} = 0.0111 \text{ g}$$

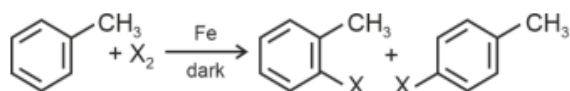
$$\text{Percentage of H} = \frac{\text{Mass of H}}{\text{Mass of compound}} \times 100 = \frac{0.0111}{0.3} \times 100 = 3.70\%$$

Therefore, the percentage composition of carbon and hydrogen is 18.18% and 3.70%, respectively.

 Quick Tip

In combustion analysis, the mass of each element in the products ( $\text{CO}_2$  and  $\text{H}_2\text{O}$ ) comes from the original organic compound. Use molar ratios to determine the mass of each element and then calculate the percentage composition.

**Question 94:** The following reaction method



is not suitable for the preparation of the corresponding haloarene products, due to high reactivity of halogen, when X is:

**Options:**

- (1) F
- (2) I
- (3) Cl
- (4) Br

**Correct Answer:** (1) F

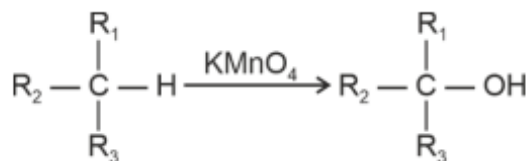
**Solution:**

The reaction shown is a free radical halogenation reaction. This method is unsuitable for the preparation of fluoroarenes because of the high reactivity of fluorine. Fluorine is so reactive that it is difficult to control the reaction, leading to multiple substitutions. In this reaction, the free radical is formed by using the metal Fe in dark conditions. For the other halogens, the reaction can be controlled to obtain the corresponding haloarenes.

**💡 Quick Tip**

Free radical halogenation is a useful method to obtain haloarenes but only if the halogen is not highly reactive. In this case, fluorine's high reactivity makes it unsuitable for this type of reaction.

**Question 95:** The alkane that can be oxidized to the corresponding alcohol by  $\text{KMnO}_4$  as per the equation



is, when:

**Options:**

- (1)  $\text{R}_1 = \text{H}$ ;  $\text{R}_2 = \text{H}$ ;  $\text{R}_3 = \text{H}$
- (2)  $\text{R}_1 = \text{CH}_3$ ;  $\text{R}_2 = \text{CH}_3$ ;  $\text{R}_3 = \text{CH}_3$
- (3)  $\text{R}_1 = \text{CH}_3$ ;  $\text{R}_2 = \text{H}$ ;  $\text{R}_3 = \text{H}$
- (4)  $\text{R}_1 = \text{CH}_3$ ;  $\text{R}_2 = \text{CH}_3$ ;  $\text{R}_3 = \text{H}$

**Correct Answer:** (2)  $\text{R}_1 = \text{CH}_3$ ;  $\text{R}_2 = \text{CH}_3$ ;  $\text{R}_3 = \text{CH}_3$

**Solution:**

Potassium permanganate ( $\text{KMnO}_4$ ) is a strong oxidizing agent. It can oxidize alkanes, but it selectively oxidizes tertiary carbons (carbons bonded to three other carbon atoms) to alcohols. In the given reaction, the carbon atom bonded to the hydrogen atom that is being replaced by the hydroxyl group ( $-\text{OH}$ ) must be a tertiary carbon for the oxidation

to occur.

Let's examine the options:

- (1) If all R groups are hydrogen atoms, the carbon is primary (bonded to only one other carbon).
- (2) If all R groups are methyl groups ( $\text{CH}_3$ ), the carbon is tertiary (bonded to three other carbons).
- (3) If  $\text{R}_1$  is a methyl group and the other R groups are hydrogen, the carbon is primary.
- (4) If  $\text{R}_1$  and  $\text{R}_2$  are methyl groups and  $\text{R}_3$  is hydrogen, the carbon is secondary (bonded to two other carbons).

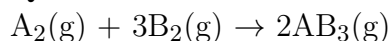
Only option (2), where all R groups are methyl groups, results in a tertiary carbon that can be oxidized by  $\text{KMnO}_4$  to the corresponding alcohol.

 Quick Tip

$\text{KMnO}_4$  selectively oxidizes tertiary carbons in alkanes to alcohols. Primary and secondary carbons are typically not oxidized by  $\text{KMnO}_4$  under mild conditions.

---

**Question 96:** For the following reaction at 300 K



the enthalpy change is +15 kJ, then the internal energy change is:

**Options:**

- (1) 19988.4 J
- (2) 200 J
- (3) 1999 J
- (4) 1.9988 kJ

**Correct Answer:** (1) 19988.4 J

**Solution:**

The relationship between enthalpy change ( $\Delta H$ ) and internal energy change ( $\Delta U$ ) is given by:

$$\Delta H = \Delta U + \Delta n_g RT$$

where:

$\Delta n_g$  is the change in the number of moles of gas.

R is the gas constant ( $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ).

T is the temperature in Kelvin.

For the given reaction:

$\Delta n_g$  = moles of gaseous products – moles of gaseous reactants

$$\Delta n_g = 2 - 4 = -2$$

$$\Delta H = +15 \text{ kJ} = 15 \times 10^3 \text{ J}$$

$$T = 300 \text{ K}$$

$$\Delta U = \Delta H - \Delta n_g RT = 15000 \text{ J} - (-2 \text{ mol})(8.314 \text{ J K}^{-1} \text{ mol}^{-1})(300 \text{ K})$$

$$\Delta U = 15000 + 4988.4 = 19988.4 \text{ J}$$

#### Quick Tip

The relationship between enthalpy change and internal energy change depends on the change in the number of moles of gaseous reactants and products. Remember to use consistent units.

**Question 97:** Rate constants of a reaction at 500 K and 700 K are  $0.04 \text{ s}^{-1}$  and  $0.14 \text{ s}^{-1}$ , respectively; then, activation energy of the reaction is:  
(Given:  $\log 3.5 = 0.5441$ ,  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

**Options:**

- (1) 182310 J
- (2) 18500 J
- (3) 18219 J
- (4) 18030 J

**Correct Answer: (3) 18219 J**

**Solution:**

We can use the Arrhenius equation to solve this problem. The two-point form of the Arrhenius equation is:

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

where:

$k_1$  and  $k_2$  are the rate constants at temperatures  $T_1$  and  $T_2$ , respectively.

$E_a$  is the activation energy.

$R$  is the ideal gas constant.

Given:  $k_1 = 0.04 \text{ s}^{-1}$

$k_2 = 0.14 \text{ s}^{-1}$

$T_1 = 500 \text{ K}$

$T_2 = 700 \text{ K}$

$R = 8.31 \text{ J K}^{-1}\text{mol}^{-1}$

$\log 3.5 = 0.5441$  which means  $\ln 3.5 = 2.303 \times 0.5441 = 1.253$

Plugging the values into the equation:

$$\ln \frac{0.14}{0.04} = \frac{E_a}{8.31} \left( \frac{1}{500} - \frac{1}{700} \right)$$

$$\ln 3.5 = \frac{E_a}{8.31} \left( \frac{700 - 500}{500 \times 700} \right)$$

$$1.253 = \frac{E_a}{8.31} \left( \frac{200}{350000} \right)$$

$$E_a = \frac{1.253 \times 8.31 \times 350000}{200}$$

$$E_a = 18219 \text{ J}$$

 Quick Tip

When given rate constants at two different temperatures, use the two-point form of the Arrhenius equation to calculate the activation energy. Make sure the units of R are consistent with the desired units for  $E_a$ .

**Question 98:** Mass of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) required to be dissolved to prepare one litre of its solution which is isotonic with  $15 \text{ g L}^{-1}$  solution of urea ( $\text{NH}_2\text{CONH}_2$ ) is (Given: Molar mass in  $\text{g mol}^{-1}$  C : 12, H : 1, O : 16, N : 14)

**Options:**

- (1) 55 g
- (2) 15 g
- (3) 30 g
- (4) 45 g

**Correct Answer:** (4) 45 g

**Solution:**

Isotonic solutions have the same osmotic pressure. The osmotic pressure ( $\pi$ ) is given by:

$$\pi = CRT$$

where C is the molar concentration, R is the gas constant, and T is the temperature.

For isotonic solutions,  $\pi_1 = \pi_2$ , so:

$$C_1RT = C_2RT$$

Since R and T are the same for both solutions, we have  $C_1 = C_2$ .

First, let's calculate the molar concentration of the urea solution:

Molar mass of urea ( $\text{NH}_2\text{CONH}_2$ ) =  $(2 \times 14) + (4 \times 1) + 12 + 16 = 60 \text{ g/mol}$

Concentration of urea ( $C_1$ ) =  $\frac{\text{mass}}{\text{molar mass} \times \text{volume}} = \frac{15 \text{ g}}{60 \text{ g/mol} \times 1 \text{ L}} = 0.25 \text{ M}$

Now, we know the molar concentration of the glucose solution must also be 0.25 M. We can use this to calculate the mass of glucose needed:

Molar mass of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) =  $(6 \times 12) + (12 \times 1) + (6 \times 16) = 180 \text{ g/mol}$

Mass of glucose (m) =  $C_2 \times \text{molar mass} \times \text{volume} = 0.25 \text{ M} \times 180 \text{ g/mol} \times 1 \text{ L} = 45 \text{ g}$

**💡 Quick Tip**

For isotonic solutions, the molar concentrations are equal. Make sure to use the correct molar masses when calculating concentrations.

---

**Question 99:**  $[\text{Mn}_2(\text{CO})_{10}]$  and  $[\text{Co}_2(\text{CO})_8]$  structures have

- A. Metal-Metal linkage
- B. Terminal CO groups
- C. Bridging CO groups
- D. Metal in zero oxidation state

Choose the correct answer from the options given below:

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

**Correct Answer:** (4) Only A, B, D

**Solution:**

$\text{Mn}_2(\text{CO})_{10}$  has a structure with a direct Mn-Mn single bond, ten terminal CO groups, and no bridging CO groups. Each Mn is in a zero oxidation state.

$\text{Co}_2(\text{CO})_8$  has a more complex structure. It can exist in different isomeric forms. The most common structure involves bridging CO groups and a Co-Co bond.

In another form, there are only terminal CO ligands and a Co-Co bond. In either isomeric form,  $\text{Co}_2(\text{CO})_8$  features a metal-metal bond, terminal CO groups, and can have bridging CO groups. Each Co atom is also in the zero oxidation state.

So, the common features are Metal-Metal linkage (A), Terminal CO groups (B), and Metal in zero oxidation state (D).

**💡 Quick Tip**

Transition metal carbonyls often feature metal-metal bonds and carbonyl ligands acting as  $\sigma$ -donors and  $\pi$ -acceptors. Drawing the structures can help visualize the bonding and determine the features present.

---

**Question 100:** Methyl group attached to a positively charged carbon atom stabilizes the carbocation due to

**Options:**

- (1) -I inductive effect
- (2) electromeric effect
- (3) hyperconjugation
- (4) mesomeric effect

**Correct Answer:** (3) hyperconjugation

**Solution:**

A methyl group attached to a carbocation stabilizes it through hyperconjugation. Hyperconjugation involves the interaction of the electrons in the C-H sigma bonds of the methyl group with the empty p-orbital of the positively charged carbon. This delocalization of electron density stabilizes the carbocation.

**💡 Quick Tip**

Hyperconjugation is a stabilizing interaction that involves the delocalization of electrons from a C-H sigma bond adjacent to a carbocation. The more alkyl groups attached to the carbocation, the greater the hyperconjugative stabilization.

---

## Botany

### Section - A

**Question 101:** The regions with a high level of species richness, high degree of endemism, and a loss of 70% of the species and habitat are identified as:

**Options:**

- (1) Natural Reserves
- (2) Sacred Groves
- (3) Biodiversity Hotspots
- (4) Biogeographical Regions

**Correct Answer: (3) Biodiversity Hotspots**

**Solution:**

Regions with high species richness, endemism, and significant habitat loss are identified as biodiversity hotspots.

**💡 Quick Tip**

Biodiversity hotspots are areas of high conservation priority due to their unique species and threatened status.

---

**Question 102:** Which of the following simple tissues are commonly found in the fruit walls of nuts and pulp of pear?

**Options:**

- (1) Sclereids
- (2) Fibres
- (3) Parenchyma



(4) Collenchyma

**Correct Answer: (1) Sclereids**

**Solution:**

Sclereids are the simple tissues commonly found in the hard parts of plants like fruit walls of nuts and the soft parts (pulp) of fruits like pears.

**💡 Quick Tip**

Sclereids provide structural support and hardness to plant parts.

---

**Question 103: In a chromosome, there is a specific DNA sequence, responsible for initiating replication. It is called as:**

**Options:**

- (1) Recognition sequence
- (2) Cloning site
- (3) Restriction site
- (4) *ori* site

**Correct Answer: (4) *ori* site**

**Solution:**

The specific DNA sequence responsible for initiating replication in a chromosome is called the *ori* site (origin of replication).

**💡 Quick Tip**

The *ori* site is crucial for DNA replication to begin.

---

**Question 104: Given below are two statements:**

**Statement I:** When many alleles of a single gene govern a character, it is called polygenic inheritance.

**Statement II:** In Polygenic inheritance, the effect of each allele is additive.

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

**Options:**

- (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:**

Polygenic inheritance is governed by multiple genes, not multiple alleles of a single gene. In polygenic inheritance, the effects of each allele are additive, contributing to the phenotype. Therefore, Statement I is incorrect, and Statement II is correct.

 **Quick Tip**

Polygenic inheritance involves multiple genes affecting a single trait, while multiple alleles refer to different versions of a single gene.

---

**Question 105: Which of the following are required for the light reaction of Photosynthesis?**

A.  $\text{CO}_2$    B.  $\text{O}_2$    C.  $\text{H}_2\text{O}$    D. Chlorophyll   E. Light

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

**Options:**

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

**Correct Answer: (2) C, D and E only**

**Solution:**

The light reaction of photosynthesis requires water ( $\text{H}_2\text{O}$ ), chlorophyll, and light.  $\text{CO}_2$  is used in the dark reaction (Calvin cycle).  $\text{O}_2$  is a product of photosynthesis.

 **Quick Tip**

The light reaction generates ATP and NADPH, which are used in the dark reaction to fix  $\text{CO}_2$  and produce glucose.

**Question 106: Match List-I with List-II:**

| List-I           | List-II                                            |
|------------------|----------------------------------------------------|
| A. Fleming       | I. Disc shaped sacs or cisternae near cell nucleus |
| B. Robert Brown  | II. Chromatin                                      |
| C. George Palade | III. Ribosomes                                     |
| D. Camillo Golgi | IV. Nucleus                                        |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The material of the nucleus stained by the basic dyes was given the name chromatin by Flemming.

Ribosomes are the granular structure first observed under the microscope as dense particle by George Palade.

Camillo Golgi first observed densely stained reticular structure near the nucleus. It consist of many disc shaped sac or cisternae.

 Quick Tip

Review the key discoveries and contributions of scientists in cell biology.

**Question 107: Match List-I with List-II:**

| List-I<br>Type of Inheritance | List-II<br>Example                      |
|-------------------------------|-----------------------------------------|
| A. Incomplete dominance       | I. Blood groups in human                |
| B. Co-dominance               | II. Flower colour in <i>Antirrhinum</i> |
| C. Pleiotropy                 | III. Skin colour in human               |
| D. Polygenic inheritance      | IV. Phenylketonuria                     |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

**A. Incomplete dominance - II. Flower colour in *Antirrhinum*:** In incomplete dominance, the heterozygote shows an intermediate phenotype (e.g., pink flowers from red and white parents).

**B. Co-dominance - I. Blood groups in human:** In co-dominance, both alleles are expressed simultaneously in the heterozygote (e.g., AB blood type).

**C. Pleiotropy - IV. Phenylketonuria:** Pleiotropy refers to a single gene affecting multiple traits. Phenylketonuria is a genetic disorder where a single gene defect leads to multiple symptoms.

**D. Polygenic inheritance - III. Skin colour in human:** Polygenic inheritance involves multiple genes contributing to a single trait. Skin color is a classic example of polygenic inheritance.

Therefore, the correct matches are A-II, B-I, C-IV, and D-III. This corresponds to option (2).

 Quick Tip

Review the different types of inheritance patterns and their characteristic examples.

---

**Question 108:** Which part of the ovule stores reserve food materials?

**Options:**

- (1) Nucellus
- (2) Integument
- (3) Placenta
- (4) Funicle

**Correct Answer:** (1) Nucellus

**Solution:**

The nucellus is the part of the ovule that stores reserve food materials.

**💡 Quick Tip**

The nucellus is the main storage tissue in the ovule providing nourishment to the developing embryo.

---

**Question 109: Which one of the following is not found in Gymnosperms?**

**Options:**

- (1) Sieve cells
- (2) Albuminous cells
- (3) Tracheids
- (4) Vessels

**Correct Answer: (4) Albuminous cells**

**Solution:**

Gymnosperms lack vessels in their xylem. They have albuminous cells instead of companion cells and sieve cells instead of sieve tubes.

**💡 Quick Tip**

Gymnosperms are characterized by the absence of vessels in their xylem and the presence of albuminous cells in place of companion cells.

---

**Question 110: Which one of the following is not included under in-situ conservation?**

**Options:**

- (1) Wild-life sanctuary
- (2) Botanical garden
- (3) Biosphere reserve
- (4) National park

**Correct Answer: (2) Botanical garden**

**Solution:**

Botanical gardens are examples of ex-situ conservation, where plants are conserved outside their natural habitat. Wild-life sanctuaries, biosphere reserves, and national parks are all examples of in-situ conservation, where species are protected in their natural environment.

**💡 Quick Tip**

In-situ conservation involves protecting species in their natural habitats, while ex-situ conservation involves protecting them outside their natural habitats (e.g., zoos, botanical gardens).

---

**Question 111: Given below are two statements:**

**Statement I:** The Indian Government has set up GEAC, which will make decisions regarding the validity of GM research.

**Statement II:** Biopiracy is the term used to refer to the use of bio-resources by native people.

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

**Options:**

- (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:**

Statement I is correct. The Genetic Engineering Appraisal Committee (GEAC) in India is responsible for assessing the validity of research involving genetically modified (GM) organisms.

Statement II is incorrect. Biopiracy refers to the use of bio-resources by others without proper authorization or compensation from the source.

 Quick Tip

GEAC is an Indian regulatory body. Biopiracy is the unauthorized appropriation of biological resources.

---

**Question 112:** Pollen grains remain preserved as fossils due to the presence of:

**Options:**

- (1) Epidermal layer
- (2) Tapetum
- (3) Exine layer
- (4) Intine layer

**Correct Answer:** (3) Exine layer

**Solution:**

Pollen grains are preserved as fossils due to the presence of the exine layer, which is made up of sporopollenin. Sporopollenin is a highly resistant polymer that protects the pollen grain from degradation.

 Quick Tip

Sporopollenin's resistance to degradation is key to the preservation of pollen grains in the fossil record.

---

**Question 113:** Identify the incorrect pair:

**Options:**

- (1) Sphenopsida – Adiantum
- (2) Pteropsida – Dryopteris
- (3) Psilotopsida – Psilotum
- (4) Lycopsida – Selaginella

**Correct Answer:** (1) Sphenopsida – Adiantum

**Solution:**

Adiantum belongs to Pteropsida, not Sphenopsida. Equisetum belongs to Sphenopsida.

 Quick Tip

Knowing the classification of different plant groups is essential.

**Question 114: Which of the following is the correct match?**

**Options:**

- (1) Gymnosperms : Cedrus, Pinus, Sequoia
- (2) Angiosperms : Wolffia, Eucalyptus, Sequoia
- (3) Bryophytes : Polytrichum, Polysiphonia, Sphagnum
- (4) Pteridophytes : Equisetum, Ginkgo, Adiantum

**Correct Answer: (1) Gymnosperms : Cedrus, Pinus, Sequoia**

**Solution:**

Cedrus, Pinus, and Sequoia are examples of Gymnosperms. Sequoia is also an Angiosperm. Wolffia and Eucalyptus are Angiosperms. Polytrichum and Sphagnum are Bryophytes. Polysiphonia is an algae. Equisetum and Adiantum are Pteridophytes. Ginkgo is a gymnosperm.

 Quick Tip

Understanding the classification of plants into different groups (Gymnosperms, Angiosperms, Bryophytes, Pteridophytes) is crucial.

**Question 115: Given below are two statements regarding RNA polymerase in prokaryotes.**

**Statement I:** In prokaryotes, RNA polymerase is capable of catalysing the process of elongation during transcription.

**Statement II:** RNA polymerase associates transiently with 'Rho' factor to initiate transcription.

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

**Options:**

- (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:**

Statement I is correct. Prokaryotic RNA polymerase is responsible for the elongation phase of transcription.

Statement II is incorrect. The Rho factor is involved in termination, not initiation of transcription. RNA polymerase interacts with sigma factor ( $\sigma$ ) for initiation and with Rho factor ( $\rho$ ) for termination.

 Quick Tip

In prokaryotes, RNA polymerase is a holoenzyme with multiple subunits. Different factors are involved in the initiation, elongation and termination of transcription.

---

**Question 116: Which of the following is a nucleotide?**

**Options:**

- (1) Uridine
- (2) Adenylic acid
- (3) Guanine
- (4) Guanosine

**Correct Answer: (2) Adenylic acid**

**Solution:**

Adenylic acid is a nucleotide; it consists of adenine base, ribose sugar, and a phosphate group.

Uridine is a nucleoside (base + sugar).

Guanine is a nitrogenous base.

Guanosine is a nucleoside (base + sugar).

 Quick Tip

A nucleotide consists of a nitrogenous base, a pentose sugar, and a phosphate group. A nucleoside consists of a nitrogenous base and a pentose sugar.

---

**Question 117: Match List-I with List-II:**

| List-I                   | List-II    |
|--------------------------|------------|
| A. Vexillary aestivation | I. Brinjal |
| B. Epipetalous stamens   | II. Peach  |
| C. Epipetalous stamens   | III. Pea   |
| D. Perigynous flower     | IV. Lily   |

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

**Options:**

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

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

**Solution:**

Here are the correct matches:

A. Vexillary aestivation - III.

Pea: Vexillary aestivation is a type of floral arrangement found in the pea family (Fabaceae), where the standard petal (vexillum) overlaps the other petals.

B. Epipetalous stamens - I. Brinjal: In epipetalous stamens, the stamens are attached to the petals. This is seen in Brinjal flowers.

C. Epipetalous stamens - IV. Lily

D. Perigynous flower - II. Peach

Therefore, the correct option is (1) although there seems to be an error in the question as C is repeated twice in List I.

 **Quick Tip**

Understanding floral morphology, including aestivation and stamen attachment, is essential for plant identification and classification.

---

**Question 118: Match List-I with List-II:**

| List-I        | List-II         |
|---------------|-----------------|
| A. China rose | I. Free central |
| B. Mustard    | II. Basal       |
| C. Primrose   | III. Axile      |
| D. Marigold   | IV. Parietal    |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The correct matches based on the type of placentation are:

**A. China rose - III. Axile:** China rose exhibits axile placentation, where the ovules are attached to the central axis of the ovary.

**B. Mustard - IV. Parietal:** Mustard displays parietal placentation; ovules develop on the inner wall of the ovary.

**C. Primrose - I. Free central:** Primrose shows free central placentation; ovules are attached to a central column in a one-chambered ovary.

**D. Marigold - II. Basal:** In marigold, the ovule is attached to the base of the ovary representing basal placentation.

Therefore, the correct option is (3): A-III, B-IV, C-I, D-II.

 **Quick Tip**

Different types of placentation (axile, parietal, free central, basal) are seen in various plants. Understanding placentation is important for plant classification and reproduction studies.

---

**Question 119: Which of the following helps in the maintenance of the pressure gradient in sieve tubes?**

**Options:**

- (1) Albuminous cells

- (2) Sieve cells
- (3) Phloem parenchyma
- (4) Companion cells

**Correct Answer: (4) Companion cells**

**Solution:**

Companion cells help maintain the pressure gradient in sieve tubes by actively loading sugars into the sieve tubes. This creates a higher solute concentration and thus a higher osmotic pressure in the sieve tubes, resulting in the movement of water into them and thus maintaining the pressure gradient for phloem transport.

 **Quick Tip**

Companion cells are metabolically active cells associated with sieve tube elements in the phloem.

---

**Question 120: Mesosome in a cell is:**

**Options:**

- (1) Membrane-bound vesicular structure
- (2) Chain of many ribosomes attached to a single mRNA
- (3) Special structure formed by the extension of the plasma membrane
- (4) Medium-sized chromosome

**Correct Answer: (3) Special structure formed by the extension of the plasma membrane**

**Solution:**

A mesosome is a specialized structure formed by an extension of the plasma membrane into the cytoplasm of prokaryotic cells. It is not found in eukaryotic cells.

 **Quick Tip**

Mesosomes are involved in various cellular processes in prokaryotes, including cell wall synthesis, respiration, and DNA replication.

**Question 121: Match List-I with List-II:**

| List-I            | List-II                                   |
|-------------------|-------------------------------------------|
| A. Absciscic acid | I. Promotes female flowers in cucumber    |
| B. Ethylene       | II. Helps seeds to withstand desiccation  |
| C. Gibberellin    | III. Helps in nutrient mobilisation       |
| D. Cytokinin      | IV. Promotes bolting in beet, cabbage etc |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The correct matches are:

Absciscic acid (ABA) is a plant hormone that is involved in various stress responses. It helps seeds to withstand desiccation (dehydration). Thus, A-II.

Ethylene is a plant hormone that promotes the development of female flowers in cucumber. Thus, B-I.

Gibberellins are plant hormones that stimulate stem elongation, germination, and flowering. They also promote bolting (early flowering) in plants such as beet and cabbage. Thus, C-IV.

Cytokinins are plant hormones that stimulate cell division and differentiation, which are crucial for growth. They are also involved in nutrient mobilization. Thus, D-III.

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

**💡 Quick Tip**

Plant hormones (phytohormones) play crucial roles in plant growth, development, and responses to environmental stimuli.

**Question 122: Match List-I with List-II:**

| List-I                                  | List-II                           |
|-----------------------------------------|-----------------------------------|
| A. Genetically engineered Human Insulin | I. Gene therapy                   |
| B. GM Cotton                            | II. <i>E. coli</i>                |
| C. ADA Deficiency                       | III. Antigen-antibody interaction |
| D. ELISA                                | IV. <i>Bacillus thuringiensis</i> |

Choose the correct answer from the options given below:

Options:

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

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

**Solution:**

The correct matches are:

Genetically engineered human insulin uses *E. coli* as a host cell. Thus, A-II.

GM cotton uses *Bacillus thuringiensis* for pest resistance. Thus, B-IV.

Gene therapy is a treatment for ADA deficiency. Thus, C-I.

ELISA (enzyme-linked immunosorbent assay) is based on antigen-antibody interactions. Thus, D-III.

Therefore, the correct option is (4): A-II, B-IV, C-I, D-III.

#### 💡 Quick Tip

Understanding the applications of biotechnology, including genetic engineering, gene therapy, and diagnostic techniques like ELISA, is crucial.

**Question 123: Match List-I with List-II:**

| List-I             | List-II                               |
|--------------------|---------------------------------------|
| A. ETS Complex I   | I. NADH Dehydrogenase                 |
| B. ETS Complex II  | II. Cytochrome <i>bc</i> <sub>1</sub> |
| C. ETS Complex III | III. Cytochrome C oxidase             |
| D. ETS Complex IV  | IV. Succinate Dehydrogenase           |

Choose the correct answer from the options given below:

Options:

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

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

**Solution:**

The correct matches for the electron transport system (ETS) complexes and their associated enzymes are:

- A. ETS Complex I - I. NADH Dehydrogenase
- B. ETS Complex II - IV. Succinate Dehydrogenase
- C. ETS Complex III - II. Cytochrome *bc*<sub>1</sub>
- D. ETS Complex IV - III. Cytochrome C oxidase

Therefore, the correct option is (2): A-I, B-IV, C-II, D-III.

 Quick Tip

The ETS complexes are integral membrane proteins involved in oxidative phosphorylation. Each complex has specific functions in electron transport and proton pumping.

---

**Question 124: Cryopreservation technique is used for:**

**Options:**

- (1) Cryoprotection of environment
- (2) Protection of Biodiversity hotspots
- (3) Preservation of gametes in viable and fertile condition for a long period
- (4) *In-situ* conservation

**Correct Answer: (3) Preservation of gametes in viable and fertile condition for a long period**

**Solution:**

Cryopreservation is an *ex-situ* conservation technique where gametes of threatened species are preserved in viable and fertile conditions for long periods.

 Quick Tip

Cryopreservation is a type of ex-situ conservation method.

**Question 125: Which of the following are correct about cellular respiration?**

- A. Cellular respiration is the breaking of C-C bonds of complex organic molecules by oxidation.
- B. The entire cellular respiration takes place in Mitochondria.
- C. Fermentation takes place under anaerobic condition in germinating seeds.
- D. The fate of pyruvate formed during glycolysis depends on the type of organism also.
- E. Water is formed during respiration as a result of  $O_2$  accepting electrons and getting reduced.

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

**Options:**

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

**Correct Answer: (1) A, C, D, E only**

**Solution:**

Cellular respiration involves the oxidation of complex organic molecules. Fermentation occurs under anaerobic conditions, and the fate of pyruvate depends on the organism. Water is formed when oxygen accepts electrons. The entire process of cellular respiration does not occur solely in mitochondria; glycolysis takes place in the cytoplasm. Statements A, C, D, and E are correct.

 Quick Tip

Cellular respiration is a complex process involving various steps and locations within the cell.

**Question 126: Given below are two statements:**

**Statement I:** In eukaryotes there are three RNA polymerases in the nucleus in addition to the RNA polymerase found in the organelles.

**Statement II:** All the three RNA polymerases in eukaryotic nucleus have different roles.

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



**Options:**

- (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:**

Eukaryotes have three nuclear RNA polymerases (I, II, and III), each with distinct roles in transcribing different types of RNA. Mitochondria and chloroplasts also have their own RNA polymerases. Thus, both statements are correct.

 **Quick Tip**

Eukaryotic RNA polymerases show functional specialization in transcribing different RNA molecules.

---

**Question 127: Match List-I with List-II:**

| List-I             | List-II                                |
|--------------------|----------------------------------------|
| A. Histones        | I. Loosely packed chromatin            |
| B. Nucleosome      | II. Densely packed chromatin           |
| C. Euchromatin     | III. Positively charged basic proteins |
| D. Heterochromatin | IV. DNA wrapped around histone octamer |

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

**Options:**

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

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

**Solution:**

The correct matches are:

**A. Histones - III. Positively charged basic proteins:** Histones are positively charged proteins that are crucial for DNA packaging in eukaryotes.

**B. Nucleosome - IV. DNA wrapped around histone octamer:** A nucleosome is the basic structural unit of chromatin, consisting of DNA wrapped around a histone octamer.

**C. Euchromatin - I. Loosely packed chromatin:** Euchromatin is the less condensed form of chromatin, which is transcriptionally active.

**D. Heterochromatin - II. Densely packed chromatin:** Heterochromatin is the highly condensed form of chromatin, which is transcriptionally inactive.

Therefore, the correct option is (4): A-III, B-IV, C-I, D-II.

 Quick Tip

Histones are key proteins in chromatin structure. Euchromatin is transcriptionally active, while heterochromatin is inactive.

---

**Question 128: Given below are two statements:**

**Statement I:** Failure of segregation of chromatids during cell cycle resulting in the gain or loss of whole set of chromosome in an organism is known as aneuploidy.

**Statement II:** Failure of cytokinesis after anaphase stage of cell division results in the gain or loss of a chromosome is called polyploidy.

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

**Options:**

- (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:**

Statement I is incorrect. Aneuploidy is the gain or loss of one or a few chromosomes, not a whole set. Polyploidy is the gain of a whole set of chromosomes.

Statement II is also incorrect. Failure of cytokinesis after anaphase leads to polyploidy (a change in the number of chromosome sets), not aneuploidy (a change in the number of individual chromosomes within a set).

 Quick Tip

Aneuploidy and polyploidy are chromosomal abnormalities resulting from errors during cell division.

**Question 129: Recombination between homologous chromosomes is completed by the end of:**

**Options:**

- (1) Diakinesis
- (2) Zygotene
- (3) Diplotene
- (4) Pachytene

**Correct Answer: (4)**

**Solution:**

Recombination between homologous chromosomes is completed by the end of the pachytene stage of meiosis I.

 Quick Tip

Pachytene is a stage in meiotic prophase I characterized by the completion of crossing over between homologous chromosomes.

**Question 130: Match List-I with List-II:**

| List-I                        | List-II                                                                                        |
|-------------------------------|------------------------------------------------------------------------------------------------|
| A. Metacentric chromosome     | I. Chromosome has a terminal centromere                                                        |
| B. Sub-metacentric chromosome | II. Middle centromere forming two equal arms of chromosome                                     |
| C. Acrocentric chromosome     | III. Centromere is slightly away from the middle of chromosome resulting into two unequal arms |
| D. Telocentric chromosome     | IV. Centromere is situated close to its end forming one extremely short and one very long arm  |

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

**Options:**

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

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

**Solution:**

The correct matches are:

- A. Metacentric chromosome - II. Middle centromere forming two equal arms of chromosome.
- B. Sub-metacentric chromosome - III. Centromere is slightly away from the middle of chromosome resulting into two unequal arms.
- C. Acrocentric chromosome - IV. Centromere is situated close to its end forming one extremely short and one very long arm.
- D. Telocentric chromosome - I. Chromosome has a terminal .

Therefore, the correct option is (4): A-II, B-III, C-IV, D-I.

 Quick Tip

The position of the centromere on a chromosome determines its morphology (metacentric, sub-metacentric, acrocentric, telocentric).

---

**Question 131:** Ligases is a class of enzymes responsible for catalysing the linking together of two compounds. Which of the following bonds is *not* catalysed by it?

**Options:**

- (1) C – C
- (2) P – O
- (3) C – O
- (4) C – N

**Correct Answer:** (1) C-C

**Solution:**

Ligases catalyze the formation of bonds between carbon and other atoms like oxygen, nitrogen, sulfur, or phosphorus (C-O, C-N, C-S, C-P). They do not directly catalyze the formation of C-C bonds. Although some ligase-catalyzed reactions might indirectly lead to C-C bond formation in subsequent steps, the direct joining of two carbon atoms isn't a primary function of ligases.

 Quick Tip

Ligases are often involved in joining two molecules together, commonly forming C-O, C-N, C-S, and C-P bonds. They typically require ATP or other energy sources for these reactions. They do not directly catalyze C-C bond formation.

**Question 132:** F. Skoog observed that callus proliferated from the internodal segments of tobacco stem when auxin was supplied with one of the following except :

**Options:**

- (1) Extract of Vascular tissues
- (2) Coconut milk
- (3) Absciscic acid
- (4) Yeast Extract

**Correct Answer:** (3) Absciscic acid

**Solution:**

F. Skoog's experiments on tobacco callus cultures showed that callus proliferation required auxin along with extracts of vascular tissues, yeast extract, or coconut milk. These extracts contain cytokinins, which, together with auxin, are essential for cell division and growth. Coconut milk is a particularly rich source of cytokinins (specifically kinetin). Absciscic acid (ABA) is a plant hormone involved in growth inhibition, dormancy, and stress responses, and it does not promote cell division and proliferation in callus cultures.

 Quick Tip

Cytokinins promote cell division and growth in plants, often working synergistically with auxins. Coconut milk is a natural source of cytokinins. Absciscic acid, on the other hand, generally inhibits growth.

**Question 133:** Given below are some statements about plant growth regulators.

- A. All GAs are acidic in nature.
- B. Auxins are antagonists to GAs.
- C. Zeatin was isolated from coconut milk.
- D. Ethylene induces flowering in Mango.
- E. Absciscic acid induces parthenocarpy.

Choose the correct set of statements from the options given below:

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

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

**Solution:**

Let's analyze each statement:

**A. All GAs are acidic:** Gibberellins (GAs) are a class of acidic plant hormones. This statement is true.

**B. Auxins are antagonists to GAs:** Auxins and gibberellins often work synergistically to promote growth, so they are not antagonists. This statement is false.

**C. Zeatin was isolated from coconut milk:** Zeatin is a type of cytokinin that was first isolated from immature corn kernels (*Zea mays*), not coconut milk. However, coconut milk does contain other cytokinins. This statement is false.

**D. Ethylene induces flowering in Mango:** Ethylene is a gaseous plant hormone that promotes flowering in some plants, including mango. This statement is true.

**E. Absciscic acid induces parthenocarpy:** Absciscic acid (ABA) generally inhibits growth and is not associated with parthenocarpy (fruit development without fertilization). Auxins and gibberellins are involved in parthenocarpy. This statement is false.

 **Quick Tip**

Plant growth regulators have diverse roles in plant development. Understanding their individual functions and interactions is crucial for understanding plant physiology.

---

**Question 134:** Identify the incorrect statement related to gel electrophoresis.

**Options:**

- (1) Separated DNA fragments can be directly seen under UV radiation

- (2) Separated DNA can be extracted from gel piece
- (3) Fragment of DNA moves toward anode
- (4) Sieving effect of agarose gel helps in separation of DNA fragments

**Correct Answer:** (1) Separated DNA fragments can be directly seen under UV radiation

**Solution:**

Statement (1) is incorrect. Separated DNA fragments are visualized after staining with a compound like ethidium bromide, followed by exposure to UV radiation. Pure DNA fragments are not directly visible under UV light without staining. The other statements are correct.

 Quick Tip

Gel electrophoresis separates DNA fragments based on size. DNA is negatively charged and moves towards the positive electrode (anode). Visualization requires staining.

---

**Question 135:** Which of the following examples show monocarpellary, unilocular ovary with many ovules?

- A. Sesbania
- B. Brinjal
- C. Indigofera
- D. Tobacco
- E. Asparagus

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

**Options:**

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

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

**Solution:**

Sesbania and Indigofera have monocarpellary, unilocular ovaries with many ovules.

**💡 Quick Tip**

Understanding the structure of gynoecium (pistil) including the number of carpels, locules, and ovules is crucial in plant morphology.

**Section - B****Question 136: Given below are two statements :**

**Statement I:** In the *lac* operon, the *z* gene codes for beta-galactosidase which is primarily responsible for the hydrolysis of lactose into galactose and glucose.

**Statement II:** In addition to lactose, glucose or galactose can also induce *lac* operon.

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:**

**Statement I:** In the *lac* operon, the *z* gene does indeed code for  $\beta$ -galactosidase, the enzyme that hydrolyzes lactose into galactose and glucose. This statement is true.

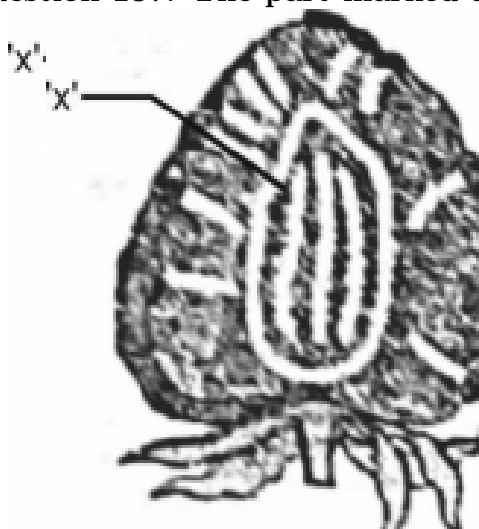
**Statement II:** The *lac* operon is induced by the presence of lactose (or allolactose, a lactose isomer). The presence of glucose actually represses the *lac* operon, even if lactose is present. This phenomenon is called catabolite repression. Galactose doesn't directly induce the *lac* operon; it's the presence of lactose that matters. Therefore, statement II is false.



**💡 Quick Tip**

The *lac* operon is a classic example of gene regulation. It's induced by lactose but repressed by glucose. Understanding the roles of the different genes (*z*, *y*, and *a*) and the regulatory mechanisms is crucial.

**Question 137:** The part marked as 'x' in the given figure is:

**Options:**

- (1) Endosperm
- (2) Thalamus
- (3) Endocarp
- (4) Mesocarp

**Correct Answer:** (2) Thalamus

**Solution:**

The figure shows a longitudinal section of a flower with a single ovule. The part labeled 'x' represents the thalamus. The thalamus is the part of the flower that forms the receptacle which supports the rest of the floral organs.

**💡 Quick Tip**

The thalamus is the part of the flower that bears the other floral organs. The other options (endosperm, endocarp, mesocarp) are parts of a fruit.

---

**Question 138: Given below are two statements:**

**Statement I:** In a dicotyledonous leaf, the adaxial epidermis generally bears more stomata than the abaxial epidermis.

**Statement II:** In a dicotyledonous leaf, the adaxially placed palisade parenchyma is made up of elongated cells, which are arranged vertically and parallel to each other.

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

**Options:**

- (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:**

Statement I is false. In most dicotyledonous leaves, the abaxial epidermis (lower surface) has more stomata than the adaxial epidermis (upper surface). This is an adaptation to reduce water loss.

Statement II is true. Palisade parenchyma cells are elongated, vertically arranged, and parallel to each other, maximizing light absorption for photosynthesis.

 **Quick Tip**

Stomatal distribution in leaves is related to water conservation. Palisade parenchyma is adapted for efficient light capture in photosynthesis.

---

**Question 139: Which of the following are *not* fatty acids?**

- A. Glutamic acid
- B. Arachidonic acid
- C. Palmitic acid
- D. Lecithin
- E. Aspartic acid

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

- (1) C, D and E only

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

**Correct Answer: (3) A, D, and E only**

**Solution:**

Fatty acids: Are long-chain carboxylic acids. Palmitic acid (C) and arachidonic acid (B) are examples of fatty acids.

Amino acids: Glutamic acid (A) and aspartic acid (E) are amino acids, the building blocks of proteins. They are not fatty acids.

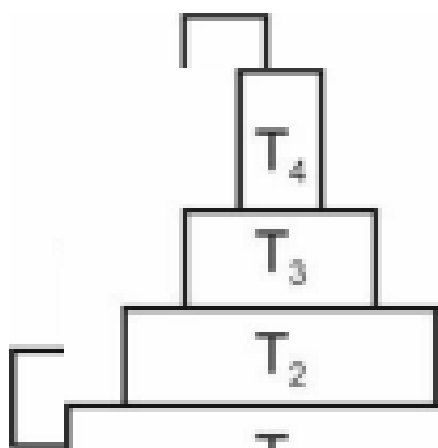
Phospholipid: Lecithin (D) is a type of phospholipid, a major component of cell membranes. While fatty acids are part of the structure of lecithin, lecithin itself is not a fatty acid.

Thus, the compounds that are not fatty acids are A, D, and E.

**💡 Quick Tip**

Fatty acids are long-chain carboxylic acids. They are different from amino acids, which are the building blocks of proteins, and phospholipids, which are important components of cell membranes.

**Question 140: Consider the pyramid of energy of an ecosystem given below:**



If  $T_4$  is equivalent to 1000 J, what is the value at  $T_1$ ?

**Options:**

- (1)  $\frac{10000}{10}$  J
- (2)  $\frac{10000}{10} \times 4$  J
- (3) 10,000 J
- (4) 10,00,000 J

**Correct Answer: (4) 10,00,000 J**

**Solution:**

The pyramid of energy represents the flow of energy through different trophic levels in an ecosystem. There is approximately a 10% energy transfer efficiency from one trophic level to the next. This means that each level above retains about 10% of the energy from the level below it.

In this pyramid,  $T_4$  represents the top trophic level, and  $T_1$  represents the producers (the base of the pyramid). If  $T_4$  has 1000 J, then:

$$T_3 = 1000 \text{ J} \times \frac{100}{10} = 10,000$$

$$J \text{ (because } T_4 \text{ is } 10T_2 = 10,000 \text{ J} \times \frac{100}{10} = 100,000 \text{ J}$$

$$T_1 = 100,000 \text{ J} \times \frac{100}{10} = 10,00,000 \text{ J}$$

 Quick Tip

In a pyramid of energy, only about 10% of the energy is transferred from one trophic level to the next. Most of the energy is lost as heat.

---

**Question 141:** Which *one* of the following products diffuses out of the chloroplast during photosynthesis?

**Options:**

- (1) ADP
- (2) NADPH
- (3)  $O_2$
- (4) ATP

**Correct Answer: (3)  $O_2$**

**Solution:**

During photosynthesis, the light-dependent reactions in the chloroplast produce ATP, NADPH, and  $O_2$ . Of these, oxygen ( $O_2$ ) diffuses out of the chloroplast as a byproduct. ATP and NADPH are used within the chloroplast to drive the light-independent reactions (Calvin cycle), which produce sugars.

**💡 Quick Tip**

Oxygen is produced during the light-dependent reactions of photosynthesis and diffuses out of the chloroplast. ATP and NADPH are used in the Calvin cycle within the chloroplast.

---

**Question 142:** Recombinant DNA molecule can be created normally by cutting the vector DNA and source DNA respectively with:

**Options:**

- (1) Hind II, Hind II
- (2) Hind II, Alu I
- (3) Hind II, EcoR I
- (4) Hind II, BamHI

**Correct Answer:** (1) Hind II, Hind II

**Solution:**

To create a recombinant DNA molecule, both the vector DNA and the source DNA need to be cut with the same restriction enzyme. This creates complementary sticky ends that can anneal (base pair) with each other, allowing the source DNA to be inserted into the vector. If different restriction enzymes are used, the sticky ends will not be complementary, and the recombinant DNA molecule cannot be formed.

**💡 Quick Tip**

Creating recombinant DNA requires cutting both the vector and source DNA with the same restriction enzyme to generate complementary sticky ends.

---

**Question 143:** Which one of the following is *not* a limitation of ecological pyramids?

**Options:**

- (1) Saprophytes are not given any place in ecological pyramids
- (2) It assumes a simple food chain, that almost never exists in nature
- (3) It accommodates a food web
- (4) It does not take into account the same species belonging to two or more trophic levels

**Correct Answer: (3)**

**Solution:**

Ecological pyramids typically represent a simplified view of energy flow or biomass within an ecosystem. The limitations of ecological pyramids include:

No place for saprophytes: Saprophytes (decomposers) play a crucial role in nutrient cycling but are often not explicitly represented in ecological pyramids.

Simplified food chains: Ecological pyramids often depict simple, linear food chains, while in reality, ecosystems have complex food webs.

Ignoring same species at multiple trophic levels: Some species can occupy multiple trophic levels (e.g., an omnivore). Ecological pyramids often don't account for this.

The statement "It accommodates a food web" is *not* a limitation; it would be an improvement if they did.

**💡 Quick Tip**

Ecological pyramids are simplified representations of ecosystems. They often don't accurately reflect the complexity of food webs and the roles of all organisms, such as saprophytes and omnivores.

---

**Question 144:** The *Bt* toxin in genetically engineered *Bt* cotton kills the pest by:

- 1. creating pores in the midgut
- 2. damaging the respiratory system
- 3. degenerating the nervous system
- 4. altering the pH of body fluids

**Correct Answer: (1) creating pores in the midgut**

**Solution:**

The Bt toxin produced by *Bacillus thuringiensis* in genetically modified Bt cotton primarily kills pests by creating pores in their midgut. This disruption of the gut lining leads to the death of the insect pest.

**💡 Quick Tip**

Bt toxin is a protein that specifically targets the digestive system of certain insect pests.

**Question 145: Match List-I with List-II:**

| List-I<br>Organisms  | List-II<br>Mode of Nutrition                                |
|----------------------|-------------------------------------------------------------|
| A. Euglenoid         | I. Parasitic                                                |
| B. Dinoflagellate    | II. Saprophytic                                             |
| C. Slime mould       | III. Photosynthetic                                         |
| D. <i>Plasmodium</i> | IV. Switching between photosynthetic and heterotrophic mode |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The correct matches are:

Euglenoids can switch between photosynthetic (autotrophic) and heterotrophic modes of nutrition. Thus, A-IV.

Dinoflagellates are mostly photosynthetic. Thus, B-III.

Slime moulds are saprophytic (feed on dead organic matter). Thus, C-II.

*Plasmodium* is parasitic, obtaining nutrients from a host. Thus, D-I.

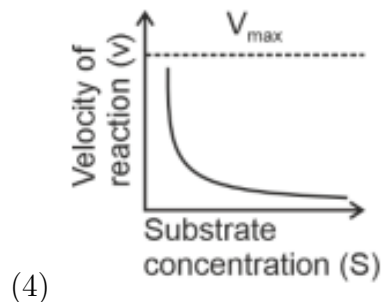
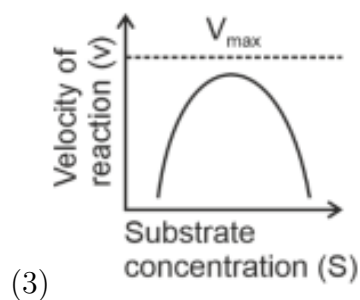
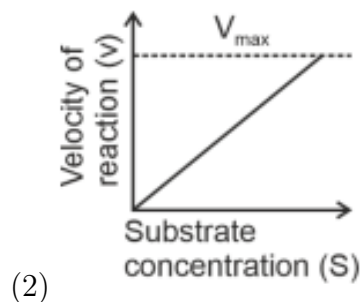
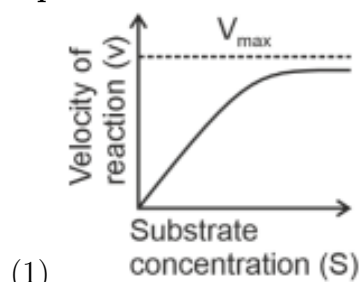
Therefore, the correct option is (3): A-IV, B-III, C-II, D-I.

**💡 Quick Tip**

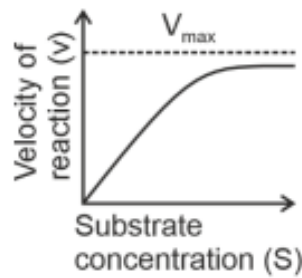
Different organisms exhibit diverse modes of nutrition, depending on their metabolic capabilities and environment. Remember the key characteristics of Euglenoids, Dinoflagellates, Slime moulds and Plasmodium.

**Question 146:** Which of the following graphs depicts the effect of substrate concentration on velocity of enzyme catalysed reaction?

**Options:**







Correct Answer: (1)

### Solution:

In an enzyme-catalyzed reaction, the velocity of the reaction increases with increasing substrate concentration until the enzyme becomes saturated. At saturation, all active sites of the enzyme are occupied by substrate molecules, and the reaction reaches its maximum velocity ( $V_{\max}$ ). Further increases in substrate concentration do not increase the velocity because there are no free active sites available.

This relationship is described by the Michaelis-Menten equation and is graphically represented by a hyperbolic curve, as shown in option (1).

#### 💡 Quick Tip

The relationship between substrate concentration and enzyme reaction velocity is typically hyperbolic. The enzyme becomes saturated at high substrate concentrations, leading to a plateau in the reaction velocity at  $V_{\max}$ .

**Question 147:** When will the population density increase, under special conditions?

When the number of :

### Options:

- (1) Deaths exceeds number of births and also number of emigrants equals number of immigrants.
- (2) Births plus number of immigrants equals number of deaths plus number of emigrants.
- (3) Births plus number of emigrants is more than the number of deaths plus number of immigrants.
- (4) Births plus number of immigrants is more than the sum of number of deaths and number of emigrants.

**Correct Answer:** (4) Births plus number of immigrants is more than the sum of number of deaths and number of emigrants.

**Solution:**

Let:

$N_t$  = Population density at time  $t$

$B$  = Number of births

$D$  = Number of deaths

$I$  = Number of immigrants

$E$  = Number of emigrants

The population density at time  $t+1$  ( $N_{t+1}$ ) can be calculated as:

$$N_{t+1} = N_t + (B + I) - (D + E)$$

Population density will increase when  $N_{t+1} > N_t$ . This means:

$$N_t + (B + I) - (D + E) > N_t$$

$$(B + I) - (D + E) > 0$$

$$(B + I) > (D + E)$$

Therefore, population density increases when the number of births plus the number of immigrants ( $B + I$ ) is greater than the number of deaths plus the number of emigrants ( $D + E$ ).

**💡 Quick Tip**

Population density increases when the combined effect of births and immigration exceeds the combined effect of deaths and emigration.

---

**Question 148:** When a tall pea plant with round seeds was selfed, it produced the progeny of :

(a) Tall plants with round seeds and

(b) Tall plants with wrinkled seeds.

Identify the genotype of the parent plant.

**Options:**

(1)  $TtRr$

(2)  $TtRR$

(3)  $TTRR$

(4)  $TTRr$

**Correct Answer: (4) TTRr**

**Solution:**

Let's analyze the given information:

Tall (T) is dominant over dwarf (t). Round (R) is dominant over wrinkled (r).

The parent plant is tall with round seeds. Since some offspring have wrinkled seeds (rr), the parent plant must carry the recessive allele (r). Because all offspring are tall, the parent plant must carry at least one dominant allele (T).

The offspring phenotypes are:

Tall, Round: Could be TTRR, TTRr, TtRR, or TtRr

Tall, Wrinkled: Must be Ttrr

To produce both round and wrinkled seeds, the parent must be heterozygous for seed shape (Rr). Since all offspring are tall, and wrinkled offspring appear, the parent plant must be homozygous dominant for height (TT). If the parent was heterozygous for height (Tt), then some offspring would have been dwarf (tt), which isn't observed.

Therefore, the parent's genotype must be TTRr.

 Quick Tip

When analyzing inheritance patterns, consider the dominant and recessive traits and the possible genotypes of the parents and offspring. The presence of recessive phenotypes in the offspring reveals information about the parents' genotypes.

**Question 149: Match List-I with List-II:**

| List-I |                            | List-II |                                              |
|--------|----------------------------|---------|----------------------------------------------|
| A.     | Biodiversity hotspot       | I.      | Khasi and Jantia hills in Meghalaya          |
| B.     | Sacred groves              | II.     | World Summit on Sustainable Development 2002 |
| C.     | Johannesburg, South Africa | III.    | <i>Parthenium</i>                            |
| D.     | Alien species invasion     | IV.     | Western Ghats                                |

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

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

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

Solution:

**A. Biodiversity hotspot:** The Western Ghats is a recognized biodiversity hotspot. A-IV

**B. Sacred groves:** Sacred groves are forest fragments traditionally protected by local communities. They are often found in the Khasi and Jantia hills of Meghalaya. B-I

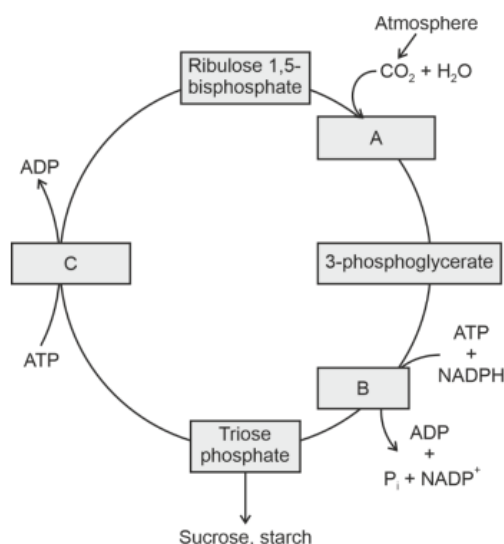
**C. Johannesburg, South Africa:** The World Summit on Sustainable Development 2002 was held in Johannesburg, South Africa. C-II

**D. Alien species invasion:** *Parthenium* (commonly known as congress grass) is an invasive alien species in India. D-III

#### 💡 Quick Tip

Biodiversity hotspots are regions with high species richness and endemism. Sacred groves are examples of traditional conservation practices. Invasive alien species can pose a threat to native biodiversity.

**Question 150:** Observe the given figure. Identify the different stages labelled with alphabets by selecting the correct option.



Options:

- (1) A-Carboxylation, B-Regeneration, C-Reduction
- (2) A-Reduction, B-Decarboxylation, C-Regeneration

- (3) A-Carboxylation, B-Reduction, C-Regeneration  
(4) A-Reduction, B-Carboxylation, C-Regeneration

**Correct Answer: (3) A-Carboxylation, B-Reduction, C-Regeneration**

**Solution:**

The figure represents the Calvin cycle.

A represents carboxylation ( $\text{CO}_2$  fixation).

B represents reduction (using ATP and NADPH).

C represents regeneration of RuBP.

**💡 Quick Tip**

The Calvin cycle involves three main stages: carboxylation, reduction, and regeneration of RuBP.

## Zoology

### Section - A

**Question 151: Match List-I with List-II:**

| List I           | List II                  |
|------------------|--------------------------|
| A. Predator      | I. <i>Ophrys</i>         |
| B. Mutualism     | II. <i>Pisaster</i>      |
| C. Parasitism    | III. Female wasp and fig |
| D. Sexual deceit | IV. <i>Plasmodium</i>    |

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

**Options:**

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

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

**Solution:**

The correct matches are:

Predator - II. Pisaster: Pisaster is a sea star that is a predator of mussels and other organisms.

Mutualism - III. Female wasp and fig: The relationship between female wasps and fig trees is an example of mutualism, where both organisms benefit.

Parasitism - IV. Plasmodium: Plasmodium is a parasite that causes malaria in humans.

Sexual deceit - I. Ophrys: The orchid Ophrys employs sexual deceit to attract pollinators.

Therefore, the correct option is (4): A-II, B-III, C-IV, D-I.

 Quick Tip

Understanding different types of ecological interactions (predation, mutualism, parasitism, etc.) is important in ecology.

**Question 152: Match List-I with List-II:**

| List I<br>Location of Joint |                                           | List II<br>Type of Joint |                       |
|-----------------------------|-------------------------------------------|--------------------------|-----------------------|
| A.                          | Joint between humerus and pectoral girdle | I.                       | Gliding joint         |
| B.                          | Knee joint                                | II.                      | Ball and Socket joint |
| C.                          | Joint between atlas and axis              | III.                     | Hinge joint           |
| D.                          | Joint between carpals                     | IV.                      | Pivot joint           |

Chose the correct answer from the options given below:

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

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

**Solution:**

A. Joint between humerus and pectoral girdle: This is the shoulder joint, which is a ball-and-socket joint, allowing for a wide range of motion. A-II

B. Knee joint: The knee joint is a hinge joint, allowing for flexion and extension. B-III

C. Joint between atlas and axis: This joint between the first two cervical vertebrae (atlas and axis) is a pivot joint, allowing for rotation of the head. C-IV

D. Joint between carpals: The joints between the carpal bones in the wrist are gliding joints, allowing for sliding and some rotational movement. D-I

 Quick Tip

Different types of joints allow for different ranges of motion. Ball-and-socket joints are the most mobile, while hinge joints allow movement in one plane. Pivot joints allow rotation, and gliding joints permit sliding movements.

**Question 153: Following are the steps involved in the action of toxin in Bt cotton:**

- A. The inactive toxin converted into an active form due to the alkaline pH of the gut of the insect.
- B. *Bacillus thuringiensis* produces crystals with toxic insecticidal proteins.
- C. The alkaline pH solubilizes the crystals.
- D. The activated toxin binds to the surface of midgut cells, creates pores, and causes the death of the insect.
- E. The toxin proteins exist as inactive protoxins in bacteria.

**Choose the correct sequence of steps from the options given below:**

**Options:**

- (1)  $E \rightarrow C \rightarrow B \rightarrow A \rightarrow D$
- (2)  $B \rightarrow C \rightarrow A \rightarrow E \rightarrow D$
- (3)  $A \rightarrow E \rightarrow B \rightarrow D \rightarrow C$
- (4)  $B \rightarrow E \rightarrow C \rightarrow A \rightarrow D$

**Correct Answer: (4)  $B \rightarrow E \rightarrow C \rightarrow A \rightarrow D$**

**Solution:**

The correct sequence of events is:

1. *Bacillus thuringiensis* produces crystals containing inactive protoxins (B).
2. These protoxins are initially inactive (E).
3. In the alkaline gut of the insect, the crystals dissolve (C).
4. The alkaline pH converts the inactive protoxins into their active form (A).
5. The active toxin binds to midgut cells, creating pores and causing insect death (D).

Therefore, the correct sequence is  $B \rightarrow E \rightarrow C \rightarrow A \rightarrow D$ .

 Quick Tip

Bt toxin's mode of action involves the conversion of an inactive protoxin into an active form within the insect gut, leading to cell damage and insect mortality.

**Question 154: Match List-I with List-II:**

| List I |                | List II |                                             |
|--------|----------------|---------|---------------------------------------------|
| A.     | Gene pool      | I.      | Stable within a generation                  |
| B.     | Genetic drift  | II.     | Change in gene frequency by chance          |
| C.     | Gene flow      | III.    | Transfer of genes into or out of population |
| D.     | Gene frequency | IV.     | Total number of genes and their alleles     |

Choose the correct answer from the options given below:

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

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

**Solution:**

A. Gene pool: A gene pool represents the total number of genes and their alleles present in a population. A-IV

B. Genetic drift: Genetic drift refers to random fluctuations in allele frequencies within a population due to chance events. This can lead to the loss of some alleles and the fixation of others. B-II

C. Gene flow: Gene flow is the transfer of genetic material (genes) between populations through migration. C-III

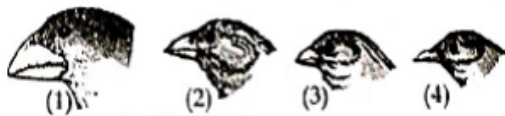
D. Gene frequency: Gene frequency refers to the proportion of a particular allele within a population. This frequency can be stable within a generation but can change across generations due to evolutionary forces. D-I



 Quick Tip

Understanding the concepts of gene pool, genetic drift, gene flow, and gene frequency is fundamental to understanding population genetics and evolution.

**Question 155:** Which evolutionary phenomenon is depicted by the sketch given in figure?



**Options:**

- (1) Artificial selection
- (2) Genetic drift
- (3) Convergent evolution
- (4) Adaptive radiation

**Correct Answer:** (4) Adaptive radiation

**Solution:**

The image depicts the variation in beak shapes of Darwin's finches. This is a classic example of **adaptive radiation**. Adaptive radiation occurs when a single ancestral species diversifies into multiple new species, each adapted to a different ecological niche. In the case of Darwin's finches, the ancestral finch species that colonized the Galapagos Islands diversified into various species with different beak shapes adapted to different food sources, such as insects, seeds, and fruits.

 Quick Tip

Adaptive radiation is characterized by the rapid diversification of a single ancestral species into multiple new species, each adapted to a specific niche. Darwin's finches are a prime example of this phenomenon.

**Question 156:** A person with blood group  $ARh^-$  can receive a blood transfusion from which of the following types?

- A.  $BRh^-$
- B.  $ABRh^-$

- C.  $ORh^-$
- D.  $ARh^-$
- E.  $ARh^+$

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

A person with  $ARh^-$  blood can receive blood from individuals with blood types that do not contain the anti-A antibody, anti-B antibody, or the Rh factor. The options are evaluated:

- $ARh^-$  (D): Compatible, as it lacks A and B antigens and the Rh factor.
- $ORh^-$  (C): Compatible, as it lacks A and B antigens and the Rh factor.

The other options have either A or B antigens, or the Rh factor, and are thus incompatible with  $ARh^-$  blood.

 Quick Tip

Blood group compatibility depends on the presence or absence of antigens (A, B, Rh) in the donor and recipient blood.

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**Question 157:** Enzymes that catalyse the removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds, are known as :

**Options:**

- (1) Transferases
- (2) Oxidoreductases
- (3) Dehydrogenases
- (4) Lyases

**Correct Answer: (4) Lyases**

**Solution:**

Lyases are a class of enzymes that catalyze the cleavage of C-C, C-O, C-N, and other bonds by means other than hydrolysis or oxidation. They often form double bonds or rings in the process. The other options are incorrect:

Transferases: Catalyze the transfer of a functional group from one molecule to another.

Oxidoreductases: Catalyze oxidation-reduction reactions.

Dehydrogenases: A subclass of oxidoreductases that specifically catalyze the removal of hydrogen atoms.

 **Quick Tip**

Lyases often create double bonds or rings when they cleave bonds. Remember that they perform these reactions without using hydrolysis or oxidation.

**Question 158: Match List-I with List-II.**

| List-I<br>Event |                                | List-II<br>Stage of Prophase-I (Meiosis-I) |            |
|-----------------|--------------------------------|--------------------------------------------|------------|
| A.              | Chiasmata formation            | I.                                         | Pachytene  |
| B.              | Crossing over                  | II.                                        | Diakinesis |
| C.              | Synaptonemal complex formation | III.                                       | Diplotene  |
| D.              | Terminalisation of chiasmata   | IV.                                        | Zygotene   |

Choose the correct answer from the options given below :

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

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

**Solution:**

A. Chiasmata formation: Chiasmata, the points where homologous chromosomes cross over, become visible during Diplotene. A-III

B. Crossing over: Crossing over, the exchange of genetic material between homologous

chromosomes, occurs during Pachytene. B-I

C. Synaptonemal complex formation: The synaptonemal complex, a protein structure that facilitates homologous chromosome pairing, forms during Zygotene. C-IV

D. Terminalisation of chiasmata: Terminalisation, the movement of chiasmata towards the ends of the chromosomes, occurs during Diakinesis. D-II

 Quick Tip

The stages of Prophase-I are Leptotene, Zygotene, Pachytene, Diplotene, and Diakinesis. Remembering the key events that occur in each stage is essential for understanding meiosis.

**Question 159: Match List-I with List-II.**

| List-I |                                 | List-II |                               |
|--------|---------------------------------|---------|-------------------------------|
| A.     | Primary structure of protein    | I.      | Human haemoglobin             |
| B.     | Secondary structure of protein  | II.     | Disulphide bonds              |
| C.     | Tertiary structure of protein   | III.    | Polypeptide chain             |
| D.     | Quaternary structure of protein | IV.     | Alpha helix and $\beta$ sheet |

Choose the correct answer from the options given below:

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

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

**Solution:**

A. Primary structure of protein: The primary structure is the linear sequence of amino acids in a polypeptide chain. A-III

B. Secondary structure of protein: The secondary structure refers to local folded structures within the polypeptide chain, stabilized by hydrogen bonds. Common secondary structures include alpha helices and beta sheets. B-IV

C. Tertiary structure of protein: The tertiary structure is the overall 3D arrangement of a

polypeptide chain, stabilized by various interactions, including disulfide bonds, hydrogen bonds, hydrophobic interactions, and ionic bonds. C-II

D. Quaternary structure of protein: The quaternary structure is the arrangement of multiple polypeptide chains (subunits) in a protein complex. Human hemoglobin, composed of four subunits, is an example of a protein with quaternary structure. D-I

 Quick Tip

Protein structure is hierarchical, with primary, secondary, tertiary, and quaternary levels. Each level builds upon the previous one, contributing to the protein's overall shape and function.

**Question 160: Match List-I with List-II.**

| List-I |             | List-II |                           |
|--------|-------------|---------|---------------------------|
| A.     | Epinephrine | I.      | Hyperglycemia             |
| B.     | Thyroxine   | II.     | Smooth muscle contraction |
| C.     | Oxytocin    | III.    | Basal metabolic rate      |
| D.     | Glucagon    | IV.     | Emergency hormone         |

Choose the correct answer from the options given below :

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

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

**Solution:**

- A. Epinephrine: Also known as adrenaline, epinephrine is an emergency hormone released in response to stress. A-IV
- B. Thyroxine: A thyroid hormone that regulates the basal metabolic rate. B-III
- C. Oxytocin: A hormone involved in smooth muscle contraction, particularly in the uterus during childbirth and in the mammary glands during lactation. C-II
- D. Glucagon: A hormone that increases blood glucose levels (hyperglycemia). D-I

 Quick Tip

Hormones play crucial roles in regulating various physiological processes. Understanding their specific functions is essential for understanding human biology.

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**Question 161:** Which of the following statements is *correct* about the type of junction and their role in our body?

**Options:**

- (1) Adhering junctions facilitate the cells to communicate with each other.
- (2) Tight junctions help to stop substances from leaking across a tissue.
- (3) Tight junctions help to perform cementing to keep neighbouring cells together.
- (4) Gap junctions help to create gap between the cells and tissues.

**Correct Answer:** (2) Tight junctions help to stop substances from leaking across a tissue.

**Solution:**

Tight junctions: Create a seal between adjacent cells, preventing the leakage of substances across the tissue. This is crucial in epithelial tissues, such as those lining the digestive tract, where they prevent the passage of molecules between cells.

The other options are incorrect because: Adhering junctions: Provide strong mechanical attachments between adjacent cells, acting like “spot welds.” They don’t facilitate communication.

Gap junctions: Form channels between adjacent cells, allowing for the passage of ions, small molecules, and signals. They facilitate communication, not create gaps.

 Quick Tip

Tight junctions seal, adhering junctions anchor, and gap junctions communicate.

---

**Question 162:** Select the restriction endonuclease enzymes whose restriction sites are present for the tetracycline resistance ( $tet^R$ ) gene in the pBR322 cloning vector.

**Options:**

- (1) Bam HI and Sal I
- (2) Sal I and Pst I
- (3) Pst I and Pvu I
- (4) Pvu I and Bam HI

**Correct Answer: (1) Bam HI and Sal I**

**Solution:**

The pBR322 plasmid contains the tetracycline resistance ( $\text{tet}^R$ ) gene. The restriction sites for Bam HI and Sal I are located within the  $\text{tet}^R$  gene. Cutting the plasmid with either of these enzymes will disrupt the  $\text{tet}^R$  gene, allowing for the selection of recombinant plasmids (those that have taken up a foreign DNA insert).

 Quick Tip

pBR322 is a commonly used cloning vector. Knowing the locations of key genes and restriction sites within the plasmid is important for designing cloning experiments.

**Question 163: Match List-I with List-II.**

| List-I |                | List-II |                    |
|--------|----------------|---------|--------------------|
| A.     | Chondrichthyes | I.      | <i>Clarias</i>     |
| B.     | Cyclostomata   | II.     | <i>Carcharodon</i> |
| C.     | Osteichthyes   | III.    | <i>Myxine</i>      |
| D.     | Amphibia       | IV.     | <i>Ichthyophis</i> |

Choose the correct answer from the options given below:

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

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

**Solution:**

A. Chondrichthyes: Cartilaginous fishes, such as sharks (e.g., *Carcharodon*). A-II

- B. Cyclostomata: Jawless fishes, such as hagfish (e.g., Myxine). B-III  
C. Osteichthyes: Bony fishes, such as catfish (e.g., Clarias). C-I  
D. Amphibia: Amphibians, such as caecilians (e.g., Ichthyophis). D-IV

**💡 Quick Tip**

These classes represent different evolutionary lineages of vertebrates. Chondrichthyes have cartilaginous skeletons, Cyclostomata lack jaws, Osteichthyes have bony skeletons, and Amphibia are adapted to both aquatic and terrestrial life.

**Question 164: Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.**

**Assertion A:** During the menstrual cycle, the ovulation takes place approximately on the 14<sup>th</sup> day.

**Reason R:** Rapid secretion of LH in the middle of the menstrual cycle induces the rupture of the Graafian follicle and thereby the release of ovum.

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

**Options:**

- (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:**

Both Assertion A and Reason R are correct, and R provides a valid explanation for A. The LH surge in the middle of the menstrual cycle triggers ovulation.

**💡 Quick Tip**

Ovulation is triggered by a surge in luteinizing hormone (LH) levels.

**Question 165: Match List-I with List-II with respect to convergent evolution:**



| List-I              | List-II                 |
|---------------------|-------------------------|
| A. Lemur            | I. Flying phalanger     |
| B. Bobcat           | II. Numbat              |
| C. Anteater         | III. Spotted cuscus     |
| D. Flying squirrels | IV. Tasmanian tiger cat |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

Convergent evolution involves the independent evolution of similar traits in different species due to similar environmental pressures. The correct matches are:

- A. Lemur - III. Spotted cuscus (both are arboreal mammals with similar adaptations)
- B. Bobcat - IV. Tasmanian tiger cat (both are carnivorous mammals with similar body structures)
- C. Anteater - II. Numbat (both are insectivores with long snouts and tongues)
- D. Flying squirrels - I. Flying phalanger (both are gliding mammals with patagium)

Therefore, the correct option is (1): A-III, B-IV, C-II, D-I.

 **Quick Tip**

Convergent evolution leads to analogous structures—similar traits in unrelated species due to similar environmental pressures.

**Question 166: Match List-I with List-II.**

| List-I |                                                 | List-II |                      |
|--------|-------------------------------------------------|---------|----------------------|
| A.     | Cells are metabolically active and proliferate  | I.      | G <sub>2</sub> phase |
| B.     | DNA replication takes place                     | II.     | G <sub>1</sub> phase |
| C.     | Proteins are synthesized                        | III.    | G <sub>0</sub> phase |
| D.     | Quiescent stage with metabolically active cells | IV.     | S phase              |

Choose the correct answer from the options given below:

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

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

**Solution:**

A. Cells are metabolically active and proliferate: This occurs during the  $G_1$  phase of the cell cycle, where the cell grows and prepares for DNA replication. A-II

B. DNA replication takes place: This occurs during the S phase (synthesis phase). B-IV

C. Proteins are synthesized: Protein synthesis occurs throughout the cell cycle but is particularly active during the  $G_1$  and  $G_2$  phases. C-I, and since  $G_1$  has already been assigned then it should be  $G_2$  making it C-I

D. Quiescent stage with metabolically active cells: This describes the  $G_0$  phase, a non-dividing state where cells remain metabolically active but do not proliferate. D-III

**Quick Tip**

The cell cycle consists of interphase ( $G_1$ , S,  $G_2$ ) and the mitotic phase (M). Cells can exit the cycle and enter a quiescent  $G_0$  phase.

**Question 167: Match List-I with List-II.**

| List-I |                                                                                      | List-II |                           |
|--------|--------------------------------------------------------------------------------------|---------|---------------------------|
| A.     | Migratory flamingoes and resident fish in South American lakes                       | I.      | Interference competition  |
| B.     | Abingdon tortoise became extinct after introduction of goats in their habitat        | II.     | Competitive release       |
| C.     | <i>Chathamalus</i> expands its distributional range in the absence of <i>Balanus</i> | III.    | Resource Partitioning     |
| D.     | Five closely related species of Warblers feeding in different locations on same tree | IV.     | Interspecific competition |

Choose the correct answer from the options given below:

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

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

**Solution:**

A. Migratory flamingoes and resident fish: Flamingoes and fish likely compete for some shared resources in the lakes, representing interspecific competition. A-IV

B. Abingdon tortoise extinction: Goats outcompeted the tortoises for resources, leading to their extinction. This illustrates interference competition, where one species directly prevents another from accessing resources. B-I

C. *Chathamalus* range expansion: With *Balanus* absent, *Chathamalus* experiences competitive release, expanding its range as it's no longer limited by competition. C-II

D. Warblers feeding in different locations: These warblers have likely evolved to partition resources by feeding in distinct areas of the tree, reducing competition. This is Resource Partitioning. D-III

 **Quick Tip**

Different types of competition exist in nature, affecting species coexistence and evolution. Competitive release occurs when a species is freed from competition, allowing it to expand its niche. Resource partitioning reduces competition by utilizing different parts of the same resource.

**Question 168: Match List-I with List-II relating to microbes and their products:**

| <b>List-I<br/>(Microbes)</b>     | <b>List-II<br/>(Products)</b> |
|----------------------------------|-------------------------------|
| A. <i>Streptococcus</i>          | I. Citric acid                |
| B. <i>Trichoderma polysporum</i> | II. Clot buster               |
| C. <i>Monascus purpureus</i>     | III. Cyclosporin A            |
| D. <i>Aspergillus niger</i>      | IV. Statins                   |

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

**Options:**

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

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

**Solution:**

The correct matches are:

*Streptococcus* is used for producing clot buster. Thus, A-II.

*Trichoderma polysporum* is used for producing cyclosporin A. Thus, B-III.

*Monascus purpureus* is used for producing statins. Thus, C-IV.

*Aspergillus niger* is used for producing citric acid. Thus, D-I.

Therefore, the correct option is (1): A-II, B-III, C-IV, D-I.

 Quick Tip

Microbes are used in biotechnology for producing various valuable products.

**Question 169: Match List-I with List-II.**

| List-I |                          | List-II |                 |
|--------|--------------------------|---------|-----------------|
| A.     | F <sub>1</sub> Particles | I.      | Chromosomes     |
| B.     | Histones                 | II.     | Cilia           |
| C.     | Axoneme                  | III.    | Golgi apparatus |
| D.     | Cisternae                | IV.     | Mitochondria    |

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

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

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

**Solution:**

A. F<sub>1</sub> Particles: These are ATP synthase complexes found on the inner mitochondrial membrane. They are responsible for the synthesis of ATP during oxidative phosphorylation. A-IV

B. Histones: These are proteins that package and order DNA into structural units called nucleosomes. They are associated with chromosomes. B-I

C. Axoneme: This is the central core of cilia and flagella, responsible for their movement. C-II

D. Cisternae: These are flattened, membrane-bound sacs that are the building blocks of the Golgi apparatus. D-III

 Quick Tip

Understanding the structure and function of cellular components is essential for understanding cell biology.  $F_1$  particles are involved in ATP synthesis, histones package DNA, axonemes drive cilia/flagella movement, and cisternae form the Golgi apparatus.

**Question 170: Match List-I with List-II relating to examples of various kinds of IUDs and barriers:**

| List-I                   | List-II           |
|--------------------------|-------------------|
| A. Copper releasing IUD  | I. Vaults         |
| B. Non-medicated IUD     | II. Multiload 375 |
| C. Contraceptive barrier | III. LNG-20       |
| D. Hormone releasing IUD | IV. Lippes loop   |

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

**Options:**

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

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

**Solution:**

The correct matches are:

Copper releasing IUD: Multiload 375 (A-II)

Non-medicated IUD: Lippes loop (B-IV)

Contraceptive barrier: Vaults (C-I)

Hormone releasing IUD: LNG-20 (D-III)

Therefore, the correct option is (4): A-II, B-IV, C-I, D-III

 Quick Tip

Intrauterine devices (IUDs) and contraceptive barriers are used for birth control. Different types have different mechanisms of action.

**Question 171: Given below are two statements:**

**Statement I:** Antibiotics are chemicals produced by microbes that kill other microbes.

**Statement II:** Antibodies are chemicals formed in body that eliminate microbes.

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: Antibiotics are indeed chemical substances produced by certain microorganisms (like bacteria and fungi) that can inhibit the growth of or kill other microbes. This statement is correct.

Statement II: Antibodies are proteins produced by the immune system (specifically by plasma cells) that recognize and neutralize foreign substances, including microbes. While antibodies themselves don't directly kill microbes, they mark them for destruction by other immune cells or neutralize their toxic effects. Therefore, the statement "Antibodies are chemicals formed in body that eliminate microbes" is a slightly simplified but generally correct description of their function. Thus, this statement is also correct.

 Quick Tip

Antibiotics are produced by microbes to kill or inhibit other microbes, while antibodies are produced by the immune system to target and neutralize foreign substances, including microbes.

**Question 172: Arrange the following parts in human mammary gland, traversing the route of milk ejection:**

- A. Mammary duct
- B. Lactiferous duct
- C. Mammary alveolus
- D. Ampulla
- E. Mammary tubule

Choose the correct answer from the options given below:

**Options:**

- (1)  $D \rightarrow C \rightarrow E \rightarrow A \rightarrow B$
- (2)  $C \rightarrow E \rightarrow B \rightarrow A \rightarrow D$
- (3)  $C \rightarrow E \rightarrow A \rightarrow D \rightarrow B$
- (4)  $A \rightarrow C \rightarrow E \rightarrow D \rightarrow B$

**Correct Answer:** (3)  $C \rightarrow E \rightarrow A \rightarrow D \rightarrow B$

**Solution:**

The correct route of milk ejection in the mammary gland is:

Mammary alveolus  $\rightarrow$  Mammary tubule  $\rightarrow$  Mammary duct  $\rightarrow$  Mammary ampulla  $\rightarrow$  Lactiferous duct

In the question, the given structures are represented as:  $C \rightarrow E \rightarrow A \rightarrow D \rightarrow B$

 **Quick Tip**

Milk is produced in the mammary alveoli, passes through the mammary tubules and ducts, and is stored in the ampulla before being released through the lactiferous ducts.

---

**Question 173:** Which of the following are correct about EcoRI?

- A. Cut the DNA with blunt end
- B. Cut the DNA with sticky end
- C. Recognise a specific palindromic sequence
- D. Cut the DNA between the base G and A when encounters the DNA sequence 'GAATTC'
- E. Exonuclease

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

EcoRI is a restriction endonuclease that recognizes the palindromic sequence GAATTC and cuts the DNA between G and A, producing sticky ends. It does not produce blunt ends or act as an exonuclease.

 Quick Tip

Restriction enzymes are used in molecular biology to cut DNA at specific sequences. EcoRI produces sticky ends.

---

**Question 174:** Which of the following is/are present in a female cockroach?

- A. Collateral gland
- B. Mushroom gland
- C. Spermatheca
- D. Anal style
- E. Phallic gland

**Choose the most appropriate answer from the options given below:**

**Options:**

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

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

**Solution:**

In the female cockroach:



- Collateral glands are present. They secrete a sticky substance.
- Mushroom glands secrete oothecae (egg cases).
- Spermatheca stores the sperm received from the male.
- Anal styles are absent. They are found only in male cockroaches.
- Phallic glands are absent; they are found only in male cockroaches.

Therefore, collateral glands (A) and spermatheca (C) are present in the female cockroach.

#### 💡 Quick Tip

The anatomy of male and female cockroaches shows distinct differences, particularly in their reproductive systems.

#### Question 175: Match List-I with List-II:

| List I                   | List II             |
|--------------------------|---------------------|
| A. Malignant tumors      | I. Destroy tumors   |
| B. MALT                  | II. AIDS            |
| C. NACO                  | III. Metastasis     |
| D. $\alpha$ -Interferons | IV. Lymphoid tissue |

Choose the correct answer from the options given below:

#### Options:

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

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

#### Solution:

The correct matches are:

Malignant tumors are characterized by metastasis (the spread of cancer cells). Thus, A-III.

MALT (Mucosa-associated lymphoid tissue) is a type of lymphoid tissue. Thus, B-IV.

NACO (National AIDS Control Organisation) is related to AIDS. Thus, C-II.

Alpha-interferons are used to destroy tumors (they have anti-cancer properties). Thus, D-I.

Therefore, the correct option is (1): A-III, B-IV, C-II, D-I.

 Quick Tip

Malignant tumors show metastasis. MALT is lymphoid tissue. Interferons are used in cancer treatment.

---

**Question 176: Open Circulatory system is present in:**

**Options:**

- (1) *Palaemon*, *Nereis*, *Balanoglossus*
- (2) *Hirudinaria*, *Bombyx*, *Salpa*
- (3) *Anopheles*, *Limax*, *Limulus*
- (4) *Pheretima*, *Musca*, *Pila*

**Correct Answer: (3) *Anopheles*, *Limax*, *Limulus***

**Solution:**

An open circulatory system is characterized by the absence of blood vessels, and the hemolymph (blood-like fluid) directly bathes the tissues.

*Anopheles* (mosquito) is an arthropod, and arthropods have open circulatory systems.

*Limax* (slug) is a mollusc, and most molluscs (except cephalopods) have open circulatory systems.

*Limulus* (horseshoe crab) is an arthropod and has an open circulatory system.

The organisms in the other options have closed circulatory systems (*Nereis*, *Balanoglossus*, *Hirudinaria*, *Salpa*, *Pheretima*, *Musca*, *Pila*).

 Quick Tip

In an open circulatory system, the hemolymph directly bathes the tissues. Arthropods and most molluscs have open circulatory systems.

---

**Question 177: In which of the following connective tissues, the cells secrete fibres of collagen or elastin?**

- A. Cartilage
- B. Bone
- C. Adipose tissue
- D. Blood
- E. Areolar tissue

Choose the **most appropriate** answer from the options given below :

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

**Correct Answer: (2) A, B, C, and E only**

**Solution:**

Fibroblasts are the primary cells responsible for secreting collagen and elastin fibers in connective tissues.

Cartilage, Bone, Adipose tissue, and Areolar tissue: All contain fibroblasts or related cell types (chondrocytes in cartilage, osteoblasts in bone, adipocytes in adipose tissue) that produce collagen or elastin fibers.

Blood: Blood does not contain fibroblasts. Its matrix (plasma) contains various proteins, but these are not secreted by blood cells in the same way that fibroblasts secrete collagen and elastin.

 **Quick Tip**

Fibroblasts are key cells in connective tissues that secrete collagen and elastin, providing structural support. Blood lacks fibroblasts and therefore doesn't produce these fibers in the same way.

---

**Question 178: Which of the following pairs is an *incorrect* match?**

**Options:**

- (1) Annelids and arthropods-Bilateral symmetry
- (2) Sponges-Acoelomates
- (3) Coelenterates and Ctenophores-Radial symmetry
- (4) Platyhelminthes-Diploblastic organisation

**Correct Answer: (4) Platyhelminthes-Diploblastic organisation**

**Solution:**

Annelids and arthropods - Bilateral symmetry: Correct. Both phyla exhibit bilateral symmetry.

Sponges - Acoelomates: Correct. Sponges lack a coelom (body cavity).

Coelenterates and Ctenophores - Radial symmetry: Correct. Both phyla exhibit radial symmetry.

Platyhelminthes - Diploblastic organisation: Incorrect.

Platyhelminthes (flatworms) are triploblastic, meaning they have three germ layers (ectoderm, mesoderm, and endoderm). Diploblastic organisms only have two germ layers (ectoderm and endoderm).

**💡 Quick Tip**

Pay close attention to the germ layers (diploblastic vs. triploblastic) and body symmetry (radial vs. bilateral) when classifying invertebrates.

**Question 179: Match List-I with List-II:**

| List-I |                     | List-II |                                                                       |
|--------|---------------------|---------|-----------------------------------------------------------------------|
| A.     | Residual Volume     | I.      | Maximum volume of air that can be breathed in after forced expiration |
| B.     | Vital Capacity      | II.     | Volume of air inspired or expired during normal respiration           |
| C.     | Expiratory Capacity | III.    | Volume of air remaining in lungs after forcible expiration            |
| D.     | Tidal Volume        | IV.     | Total volume of air expired after normal inspiration                  |

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

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

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

**Solution:**

A. Residual Volume: The volume of air remaining in the lungs even after forceful expiration. A-III

B. Vital Capacity: The maximum volume of air that can be exhaled after a maximum

inhalation. It represents the largest volume of air that can be moved in or out of the lungs. B-I

C. Expiratory Capacity: The total volume of air that can be expired after a normal inspiration. This includes the tidal volume and the expiratory reserve volume. C-IV

D. Tidal Volume: The volume of air inspired or expired during a normal breath. D-II

 Quick Tip

Understanding lung volumes and capacities is crucial for understanding respiratory physiology. Vital capacity is a key indicator of lung function.

**Question 180: Match List-I with List-II.**

| List-I |                 | List-II |                        |
|--------|-----------------|---------|------------------------|
| A.     | Living Fossil   | I.      | Elongated canine teeth |
| B.     | Connecting Link | II.     | Vermiform appendix     |
| C.     | Vestigial Organ | III.    | <i>Echidna</i>         |
| D.     | Atavism         | IV.     | <i>Latimeria</i>       |

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

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

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

**Solution:**

A. Living Fossil: *Latimeria* (coelacanth) is a living fossil, a species that has remained relatively unchanged for millions of years and closely resembles ancient fossil forms. A-IV

B. Connecting Link: *Echidna* (spiny anteater) exhibits characteristics of both reptiles and mammals and is considered a connecting link between these two classes of vertebrates. B-III

C. Vestigial Organ: The vermiform appendix is a vestigial organ in humans, a structure that has lost most or all of its original function through evolution. C-II

D. Atavism: Elongated canine teeth (sometimes referred to as "vampire teeth") are an example of atavism in humans, the reappearance of an ancestral trait that had been lost in previous generations. D-I

**💡 Quick Tip**

Living fossils provide insights into evolutionary history. Connecting links exhibit traits of different groups, illustrating evolutionary relationships. Vestigial organs are remnants of structures that were functional in ancestors. Atavisms are the reappearance of ancestral traits.

**Question 181: Match List-I with List-II**

| List-I                | List-II             |
|-----------------------|---------------------|
| A. Schwann cells      | I. Neurotransmitter |
| B. Synaptic knob      | II. Cerebral cortex |
| C. Bipolar neurons    | III. Myelin sheath  |
| D. Multipolar neurons | IV. Retina          |

Choose the correct answer from the options given below:

**Options:**

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

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

**Solution:**

The correct matches are:

- Schwann cells form the myelin sheath around axons. (A-III)
- The synaptic knob contains neurotransmitters. (B-I)
- Bipolar neurons are found in the retina. (C-IV)
- Multipolar neurons are found in the cerebral cortex. (D-II)

Therefore, the correct option is (1): A-III, B-I, C-IV, D-II.

 Quick Tip

Review the structure and function of different components of the nervous system, including Schwann cells, synaptic knobs, and types of neurons.

---

**Question 182: Diuresis is prevented by:**

**Options:**

- (1) Renin from JG cell via switching off the osmoreceptors
- (2) ANF from atria of the heart
- (3) Aldosterone from adrenal medulla
- (4) Vasopressin from Neurohypophysis

**Correct Answer: (4) Vasopressin from Neurohypophysis**

**Solution:**

Vasopressin (antidiuretic hormone) from the neurohypophysis prevents diuresis (increased urine production) by increasing water reabsorption in the kidneys.

 Quick Tip

Vasopressin, also known as antidiuretic hormone (ADH), regulates water balance in the body by acting on the kidneys.

---

**Question 183: Following is the list of STDs. Select the diseases which are *not* completely curable.**

- A. Genital warts
- B. Genital herpes
- C. Syphilis
- D. Hepatitis-B
- E. Trichomoniasis

Choose the correct answer from the options given below:

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

**Correct Answer: (2) B and D only**

**Solution:**

Genital warts, Syphilis, and Trichomoniasis: These STDs are generally curable with appropriate treatment.

Genital herpes (B) and Hepatitis-B (D): These are viral infections that are typically not completely curable. While antiviral medications can manage symptoms and reduce outbreaks, the viruses can remain latent in the body and reactivate later.

 **Quick Tip**

While many STDs are curable, viral STDs like genital herpes and hepatitis-B are often manageable but not completely eradicated.

---

**Question 184: What is the correct order (old to recent) of periods in Paleozoic era?**

**Options:**

- (1) Silurian, Devonian, Permian, Carboniferous
- (2) Silurian, Devonian, Carboniferous, Permian
- (3) Permian, Devonian, Silurian, Carboniferous
- (4) Silurian, Carboniferous, Permian, Devonian

**Correct Answer: (2) Silurian, Devonian, Carboniferous, Permian**

**Solution:**

The correct order of periods in the Paleozoic Era from oldest to most recent is:

- 1. Cambrian
- 2. Ordovician
- 3. Silurian
- 4. Devonian
- 5. Carboniferous
- 6. Permian



The given options only include four of these periods. Within those given, the order remains consistent with the full sequence: Silurian, Devonian, Carboniferous, Permian.

**💡 Quick Tip**

A mnemonic to remember the order of Paleozoic periods is “Camels Often Sit Down Carefully Perhaps Their Joints Creak.” (Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian.)

**Question 185: 'Lub' sound of Heart is caused by the \_\_\_\_\_.**

**Options:**

- (1) closure of the semilunar valves
- (2) opening of tricuspid and bicuspid valves
- (3) opening of the semilunar valves
- (4) closure of the tricuspid and bicuspid valves

**Correct Answer: (4) closure of the tricuspid and bicuspid valves**

**Solution:**

The “lub” sound (S1) of the heart is caused by the closure of the atrioventricular valves (tricuspid and bicuspid/mitral valves) at the beginning of ventricular systole (contraction). This prevents blood from flowing back into the atria.

The “dub” sound (S2) is caused by the closure of the semilunar valves (pulmonary and aortic valves).

**💡 Quick Tip**

The “lub-dub” heart sounds are associated with the closing of heart valves. “Lub” is the atrioventricular valves (tricuspid and mitral), and “dub” is the semilunar valves (pulmonary and aortic).

**Section - B**

**Question 186:** Match List-I with List-II relating to human female external genitalia.

| List I<br>(Structures) |               | List II<br>(Features) |                                                         |
|------------------------|---------------|-----------------------|---------------------------------------------------------|
| A.                     | Mons pubis    | I.                    | A fleshy fold of tissue surrounding the vaginal opening |
| B.                     | Clitoris      | II.                   | Fatty cushion of cells covered by skin and hair         |
| C.                     | Hymen         | III.                  | Tiny finger-like structure above labia minora           |
| D.                     | Labina majora | IV.                   | A thin membrane-like structure covering vaginal opening |

Choose the correct answer from the option given below :

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

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

**Solution:**

- A. Mons pubis: A fatty cushion of cells covered by skin and pubic hair. A-II  
B. Clitoris: A small, sensitive, erectile organ located above the urethral opening. It is homologous to the penis in males. B-III  
C. Hymen: A thin membrane that partially covers the vaginal opening. C-IV  
D. Labia majora: Fleshy folds of tissue that extend down from the mons pubis and surround the labia minora and vaginal opening. D-I

**💡 Quick Tip**

Understanding the anatomy of the female reproductive system is important for sexual and reproductive health.

**Question 187:** Aneuploidy is a chromosomal disorder where chromosome number is not the exact copy of its haploid set of chromosomes, due to :

- A. Substitution
- B. Addition
- C. Deletion
- D. Translocation
- E. Inversion

Choose the **most appropriate** answer from the options given below:

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

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

**Solution:**

Aneuploidy refers to an abnormal number of chromosomes, which is not a multiple of the haploid set. This arises due to errors during chromosome segregation in meiosis.

Addition (B) and Deletion (C): These directly lead to aneuploidy. Nondisjunction, where chromosomes fail to separate correctly, can result in the addition or deletion of chromosomes in gametes.

Substitution (A): Involves replacing one nucleotide with another and does not change the chromosome number.

Translocation (D): Involves the transfer of a segment of a chromosome to a nonhomologous chromosome. While potentially causing other genetic disorders, balanced translocations do not directly cause aneuploidy because the total number of chromosomes remains the same.

Inversion (E): A segment of the chromosome is reversed end-to-end. This doesn't change the chromosome number.

**💡 Quick Tip**

Aneuploidy results from the addition or deletion of chromosomes, often due to nondisjunction during meiosis. Examples include Down syndrome (trisomy 21) and Turner syndrome (monosomy X).

---

**Question 188: Given below are two statements :**

**Statement I :** RNA interference takes place in all Eukaryotic organisms as method of cellular defense.

**Statement II :** RNAi involves the silencing of a specific mRNA due to a complementary single-stranded RNA molecule that binds and prevents translation of mRNA.

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:**

Statement I: RNA interference (RNAi) is a mechanism found in many eukaryotic organisms that is used as a cellular defense mechanism against viruses and other foreign genetic material. It also plays a role in regulating gene expression. Thus, Statement I is true.

Statement II: RNAi involves the silencing of mRNA by **double-stranded RNA** (dsRNA), not single-stranded RNA (ssRNA). The dsRNA is processed into small interfering RNAs (siRNAs), which then guide the RNA-induced silencing complex (RISC) to the target mRNA. The RISC cleaves the target mRNA, leading to its degradation and preventing translation. Thus, statement II is false.

 **Quick Tip**

RNAi is a powerful gene silencing mechanism involving double-stranded RNA. It plays a crucial role in cellular defense and gene regulation.

---

**Question 189: Identify the wrong statements :**

- A. Erythropoietin is produced by juxtaglomerular cells of the kidney
- B. Leydig cells produce Androgens
- C. Atrial Natriuretic factor, a peptide hormone is secreted by the seminiferous tubules of the testes
- D. Cholecystokinin is produced by gastrointestinal tract
- E. Gastrin acts on intestinal wall and helps in the production of pepsinogen

Choose the **most appropriate** answer from the options given below :

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

(4) A and C only

**Correct Answer: (3) C and E only**

**Solution:**

Let's examine each statement:

**A. Erythropoietin production:** Erythropoietin (EPO) is produced primarily by the kidneys, but by interstitial fibroblasts in the renal cortex near the proximal convoluted tubule.

**B. Leydig cell function:** Leydig cells in the testes are responsible for producing androgens, such as testosterone. This statement is correct.

**C. Atrial Natriuretic factor secretion:** Atrial Natriuretic Peptide (ANP) is secreted by the atria of the heart, not the seminiferous tubules of the testes (which produce sperm). This statement is incorrect.

**D. Cholecystokinin production:** Cholecystokinin (CCK) is a hormone produced by the cells of the duodenum (part of the gastrointestinal tract). This statement is correct.

**E. Gastrin function:** Gastrin is a hormone produced by the stomach lining that stimulates the secretion of gastric acid and pepsinogen (precursor to pepsin). However it acts on the parietal cells of the stomach, not the intestinal wall to promote pepsinogen secretion. This statement is incorrect.

Thus the correct answer is C, and E.

 **Quick Tip**

Hormones have specific sites of production and target tissues where they exert their effects. Understanding these relationships is key to comprehending endocrine function.

---

**Question 190: Following are the steps involved in the process of PCR:**

- A. Annealing
- B. Amplification ( 1 billion times)
- C. Denaturation
- D. Treatment with Taq polymerase and deoxynucleotides
- E. Extension

**Choose the correct sequence of steps of PCR from the options given below:**

**Options:**

- (1)  $C \rightarrow A \rightarrow D \rightarrow E \rightarrow B$
- (2)  $A \rightarrow B \rightarrow E \rightarrow D \rightarrow C$
- (3)  $A \rightarrow C \rightarrow E \rightarrow D \rightarrow B$
- (4)  $D \rightarrow B \rightarrow E \rightarrow C \rightarrow A$

**Correct Answer:** (1)  $C \rightarrow A \rightarrow D \rightarrow E \rightarrow B$

**Solution:**

The correct sequence of steps in PCR is: C. Denaturation A. Annealing D. Treatment with Taq polymerase and deoxynucleotides E. Extension B. Amplification ( 1 billion times)

Thus,  $C \rightarrow A \rightarrow D \rightarrow E \rightarrow B$

 Quick Tip

PCR involves cycles of denaturation, annealing, extension, and amplification. The order of these steps is crucial for successful amplification.

---

**Question 191: Given below are two statements:**

**Statements I:** Concentrated urine is formed due to a counter current mechanism in the nephron.

**Statement II:** Counter current mechanism helps to maintain osmotic gradient in the medullary interstitium.

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

**Options:**

- (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:**

Both statements are correct. The counter-current mechanism in the nephron's loop of Henle establishes an osmotic gradient in the medullary interstitium, which is essential for the formation of concentrated urine.

 Quick Tip

The counter-current mechanism is crucial for water reabsorption and the production of hyperosmotic urine in mammals.

**Question 192: Given below are two statements:**

**Statement I:** Concentrically arranged cisternae of the Golgi complex are arranged near the nucleus with distinct convex cis or maturing and concave trans or forming face.

**Statement II:** A number of proteins are modified in the cisternae of the Golgi complex before they are released from the cis face.

**In the light of the above statements, choose the correct answer from the option given below.**

**Options:**

- (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:**

Statement I is incorrect. The Golgi cisternae are not concentrically arranged; they are arranged in a cis-to-trans direction, with the cis face receiving proteins from the endoplasmic reticulum and the trans face releasing modified proteins.

Statement II is also incorrect. Protein modification occurs in the cisternae of the Golgi complex as they move from the cis to the trans face, not just at the cis face.

 Quick Tip

The Golgi apparatus is involved in the modification and packaging of proteins. The Golgi cisternae are organized in a polarized manner (cis and trans faces) to facilitate the sequential processing of proteins.

**Question 193: Match List-I with List-II.**

| List I |             | List II |                                        |
|--------|-------------|---------|----------------------------------------|
| A.     | Parturition | I.      | Several antibodies for new-born babies |
| B.     | Placenta    | II.     | Collection of ovum after ovulation     |
| C.     | Colostrum   | III.    | Foetal ejection reflex                 |
| D.     | Fimbriae    | IV.     | Secretion of the hormone hCG           |

Choose the correct answer from the option given below:

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

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

**Solution:**

A. Parturition: Parturition refers to childbirth, which is initiated by the foetal ejection reflex. A-III

B. Placenta: The placenta is an organ that develops during pregnancy and is responsible for secreting the hormone human chorionic gonadotropin (hCG). B-IV

C. Colostrum: Colostrum, the first milk produced by mammals after giving birth, is rich in antibodies that provide passive immunity to newborns. C-I

D. Fimbriae: Finger-like projections at the end of the fallopian tubes that help collect the ovum (egg) after ovulation. D-II

 Quick Tip

The placenta secretes hCG, colostrum provides antibodies, fimbriae collect the ovum, and parturition is triggered by the foetal ejection reflex.

**Question 194:** Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.

**Assertion A:** Members of subphylum vertebrata possess notochord during the embryonic period. The notochord is replaced by a cartilaginous or bony vertebral column in the adult.

**Reason R:** Thus all chordates are vertebrates; not all vertebrates are chordates.

**In the light of the above statements choose the correct answer from the option given below.**

**Options:**

- (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: (1) A is true but R is false.**

**Solution:**

Assertion A is correct. Vertebrates possess a notochord during embryonic development, which is later replaced by a vertebral column.

Reason R is incorrect. All vertebrates are chordates, but not all chordates are vertebrates (e.g., tunicates, cephalochordates). The presence of a notochord at some stage in development is a defining characteristic of chordates. The relationship between chordates and vertebrates is not accurately described in R.

 Quick Tip

The notochord is a defining feature of chordates. Vertebrates are a subphylum within the phylum Chordata.

---

**Question 195:** The mother has A+ blood group, the father has B+ and the child is A+. What can be the possibility of genotypes of all three, respectively?

- A.  $I^A I^A \mid I^B i \mid I^A i$
- B.  $I^A i \mid I^B i \mid I^A i$
- C.  $I^B i \mid I^A I^A \mid I^A I^B$
- D.  $I^A i \mid I^B I^B \mid I^A i$
- E.  $I^A i \mid I^B i \mid I^A i$

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

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

**Correct Answer: (4) B and E**

**Solution:**

Let's consider the ABO blood group system and the Rh factor separately.

ABO blood groups:

Mother (A+): Possible genotypes are  $I^A I^A$  or  $I^A i$ .

Father (B+): Possible genotypes are  $I^B I^B$  or  $I^B i$ .

Child (A+): Possible genotypes are  $I^A I^A$  or  $I^A i$ .

Since the child is A+, they must have received at least one  $I^A$  allele. Since the father is B+, if the child received an  $I^A$  allele from the mother, then they must have received an  $i$  allele from the father. This means both the mother and father must carry the  $i$  allele, so both must be heterozygous. Therefore, for the ABO blood group system alone, the genotypes must be  $I^A i$ ,  $I^B i$ , and  $I^A i$  for mother, father, and child, respectively.

Rh factor:

Mother (+): Possible genotypes are ++ or +−.

Father (+): Possible genotypes are ++ or +−.

Child (+): Possible genotypes are ++ or +−.

Since both parents are Rh-positive, they can either be homozygous (++) or heterozygous (+−). The child can inherit either a + or − allele from each parent, resulting in either ++ or +−.

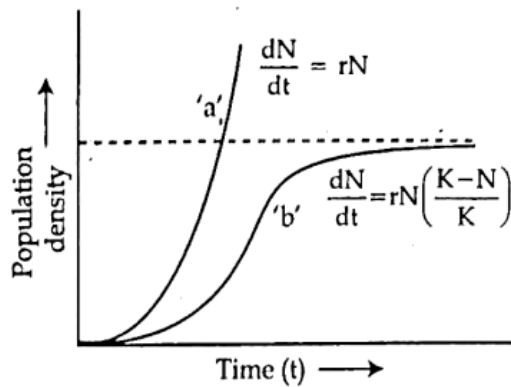
Therefore, since the child is A+, and both parents are positive, the only possible genotype combination from the provided options that yields an A+ child is:  $I^A i \mid I^B i \mid I^A i$ , which are options B and E.

**💡 Quick Tip**

Remember that blood groups are determined by multiple alleles and follow Mendelian inheritance patterns. Consider the possible genotypes for each blood group and the possible combinations that could result in the child's blood group. Punnett squares can be helpful for visualizing these combinations.

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**Question 196:** What do 'a' and 'b' represent in the following population growth curve?



**Options:**

- (1) 'a' represents exponential growth when responses are not limiting the growth; and 'b' represents logistic growth when responses are limiting the growth.
- (2) 'a' represents logistic growth when responses are not limiting the growth; 'b' represents exponential growth when responses are limiting the growth.
- (3) 'a' represents carrying capacity and 'b' shows logistic growth when responses are limiting the growth.
- (4) 'a' represents exponential growth when responses are not limiting the growth and 'b' shows carrying capacity.

**Correct Answer:** (1) 'a' represents exponential growth when responses are not limiting the growth; and 'b' represents logistic growth when responses are limiting the growth.

**Solution:**

Curve 'a' represents exponential growth. This occurs when resources are unlimited, and the population grows at its intrinsic rate of increase ( $r$ ). The equation for exponential growth is:

$$\frac{dN}{dt} = rN$$

where:

$N$  is the population size

$t$  is time

$r$  is the per capita rate of increase

Curve 'b' represents logistic growth. This occurs when resources become limited, and the population growth slows down as it approaches the carrying capacity ( $K$ ) of the environment. The equation for logistic growth is:

$$\frac{dN}{dt} = rN \left( \frac{K - N}{K} \right)$$

where  $K$  represents the carrying capacity.

The dashed horizontal line at the top represents carrying capacity which is the maximum population size that can be supported. It is labelled K.

 Quick Tip

Exponential growth is J-shaped, while logistic growth is S-shaped. Logistic growth accounts for environmental limitations.

**Question 197: Select the correct statements regarding mechanism of muscle contraction.**

- A. It is initiated by a signal sent by CNS via sensory neuron.
- B. Neurotransmitter generates action potential in the sarcolemma.
- C. Increased  $\text{Ca}^{2+}$  level leads to the binding of calcium with troponin on action filaments.
- D. Masking of active site for actin is activated.
- E. Utilising the energy from ATP hydrolysis to form cross bridge.

Choose the most appropriate answer from the options given below:

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

**Correct Answer: (1) B, C and E only**

**Solution:**

Muscle contraction is a complex process involving several steps. Let's analyze the given statements:

**A. Initiation by CNS via sensory neuron:** Muscle contraction is initiated by signals from the CNS, but these signals are sent via **motor neurons**, not sensory neurons. Sensory neurons carry signals from the periphery to the CNS. So, statement A is incorrect.

**B. Neurotransmitter and action potential:** Neurotransmitters (e.g., acetylcholine) released from motor neurons bind to receptors on the muscle cell membrane (sarcolemma), generating an action potential that spreads across the sarcolemma and into the T-tubules. So, statement B is correct.

**C. Calcium binding to troponin:** The action potential triggers the release of calcium ions ( $\text{Ca}^{2+}$ ) from the sarcoplasmic reticulum. The increased  $\text{Ca}^{2+}$  concentration in the cytoplasm leads to the binding of calcium with troponin, a protein complex on the actin filaments. This binding causes a conformational change in tropomyosin, exposing the

myosin-binding sites on actin. So, statement C is correct.

**D. Masking of active site for actin:** The active sites on actin are initially masked by tropomyosin, not activated. The increased  $\text{Ca}^{2+}$  level and its binding to troponin causes tropomyosin to move away from the myosin-binding sites on actin, **unmasking** them. So, statement D is incorrect.

**E. ATP hydrolysis and cross-bridge formation:** ATP hydrolysis provides the energy for myosin heads to bind to the exposed active sites on actin, forming cross-bridges. The subsequent "power stroke" of the myosin heads pulls the actin filaments towards the center of the sarcomere, resulting in muscle shortening (contraction). So, statement E is correct.

 Quick Tip

Muscle contraction involves a sequence of events: signal from motor neuron, neurotransmitter release, action potential, calcium release, troponin binding, tropomyosin shift, cross-bridge formation, and power stroke.

**Question 198: Match List-I with List-II:**

| List - I                | List - II                            |
|-------------------------|--------------------------------------|
| A. Squamous Epithelium  | I. Goblet cells of alimentary canal  |
| B. Ciliated Epithelium  | II. Inner lining of pancreatic ducts |
| C. Glandular Epithelium | III. Walls of blood vessels          |
| D. Compound Epithelium  | IV. Inner surface of Fallopian tubes |

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

**Options:**

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

The correct matches are:

Squamous epithelium is found in the walls of blood vessels. (A-III)

Ciliated epithelium lines the inner surface of the Fallopian tubes. (B-IV)

Glandular epithelium contains goblet cells, which are present in the alimentary canal.

(C-I)

Compound epithelium is found in the inner lining of pancreatic ducts. (D-II)

Therefore, the correct option is (4): A-III, B-IV, C-I, D-II.

 Quick Tip

Different types of epithelium are adapted to their specific functions. Remember the locations and characteristics of squamous, ciliated, glandular, and compound epithelium.

**Question 199: Match List I with List II :**

| List - I |               | List - II |                                                      |
|----------|---------------|-----------|------------------------------------------------------|
| A.       | B-Lymphocytes | I.        | Passive immunity                                     |
| B.       | Interferons   | II.       | Cell mediated immunity                               |
| C.       | T-Lymphocytes | III.      | Produce an army of proteins in response to pathogens |
| D.       | Colostrum     | IV.       | Innate immunity                                      |

Choose the correct answer from the options given below :

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

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

**Solution:**

A. B-Lymphocytes: B-lymphocytes are a type of white blood cell that produce antibodies, which are proteins that recognize and neutralize pathogens. They are responsible for humoral immunity and produce an army of proteins (antibodies) in response to pathogens. Thus, A-III.

B. Interferons: Interferons are a group of signaling proteins produced and released by host cells in response to the presence of several pathogens, such as viruses, bacteria, parasites, and also tumor cells. They are part of the innate immune system. Thus, B-IV.

C. T-Lymphocytes: T-lymphocytes, or T cells, are a type of white blood cell that play a central role in cell-mediated immunity. They directly attack infected cells or help activate other immune cells. Thus, C-II.

D. Colostrum: Colostrum is the first milk produced by mammals after giving birth. It's rich in antibodies that provide passive immunity to newborns. Thus, D-I.

 Quick Tip

B-lymphocytes produce antibodies (humoral immunity), T-lymphocytes are involved in cell-mediated immunity, interferons are part of innate immunity, and colostrum provides passive immunity.

**Question 200:** Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.

**Assertion A:** During the transportation of gases, about 20-25 percent of  $\text{CO}_2$  is carried by haemoglobin as carbamino-haemoglobin.

**Reason R:** This binding is related to high  $\text{pCO}_2$  and low  $\text{pO}_2$  in tissues.

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

**Options:**

- (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:** (3) Both A and R are true and R is the correct explanation of A.

**Solution:**

Both Assertion A and Reason R are correct, and R is the correct explanation of A. About 20-25% of  $\text{CO}_2$  is transported in the blood as carbaminohaemoglobin. The formation of carbaminohaemoglobin is favored by high  $\text{pCO}_2$  and low  $\text{pO}_2$ , conditions that prevail in the tissues.

 Quick Tip

$\text{CO}_2$  transport in blood occurs through multiple mechanisms: bicarbonate, carbamino compounds, and dissolved  $\text{CO}_2$ . The conditions in tissues (high  $\text{pCO}_2$ , low  $\text{pO}_2$ ) favor carbaminohaemoglobin formation.