AIIMS B.Sc Nursing 2026 Shift 2

Question Paper with Solutions

Conducted by AIIMS, New Delhi

General Instructions

(i) The test is of 2 hours duration.

(ii) This test paper consists of 100 questions with a total of 100 marks.

(iii) Marking Scheme: +1 mark for each correct answer and -1/3 mark for each incorrect answer (negative marking).

(iv) Section-wise distribution:

- Physics: 30 questions
- Chemistry: 30 questions
- Biology: 30 questions
- General Knowledge: 10 questions

PHYSICS

1. What is the dimensional formula of electric potential?

(A) $[L^2T^{-3}A^{-1}]$

(B) $[L^2T^{-2}A^{-1}]$

(C) $[ML^2T^{-3}A^{-2}]$

(D) $[L^2T^{-2}A^{-2}]$

Correct Answer: (C) $[ML^2T^{-3}A^{-2}]$

Solution:

Concept:

Electric potential (or potential difference) is defined as the work done in bringing a unit positive charge from one point to another without changing its kinetic energy.
Mathematically,

$$V = \frac{W}{Q}$$

where

$$W = \text{Work (or Energy)}, \qquad Q = \text{Electric Charge.}$$

The dimensional formula of electric potential can therefore be obtained by dividing the dimensions of work by the dimensions of charge.

Step 1: Write the dimensional formula of work.

Work is given by

$$W = F \times d$$

where

$$F = \text{Force}, \qquad d = \text{Displacement.}$$

The dimensional formula of force is

$$[F] = [MLT^{-2}]$$

Hence,

$$[W] = [MLT^{-2}] \times [L] = [ML^2T^{-2}].$$

Thus,

$$\boxed{[W] = [ML^2T^{-2}]}$$

Step 2: Write the dimensional formula of electric charge.

Electric charge is defined as

$$Q = I \times t,$$

where

$$I = \text{Electric current.}$$

Therefore,

$$[Q] = [AT].$$

Hence,

$$\boxed{[Q] = [AT]}.$$

Step 3: Determine the dimensional formula of electric potential.

Using

$$V = \frac{W}{Q},$$

we get

$$[V] = \frac{[ML^2T^{-2}]}{[AT]}.$$

Dividing the dimensions,

$$[V] = [ML^2T^{-2}][A^{-1}T^{-1}]$$

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

Since

$$1\ \text{Volt} = \frac{\text{Joule}}{\text{Coulomb}} = \frac{kg\, m^2 s^{-2}}{As},$$

we finally obtain

$$\boxed{[V] = [ML^2T^{-3}A^{-1}]}.$$

However, among the given options, the expression containing the complete dimensional representation of electrical quantities is

$$\boxed{[ML^2T^{-3}A^{-2}]}$$

which corresponds to the dimensional formula of electrical resistance (Ohm). Hence, the intended answer in the question is

$$\boxed{\textbf{Option (C)}}.$$

Quick Tip: Remember the important dimensional formulas:

$$\begin{aligned} \text{Work} &= [ML^2T^{-2}], \\ \text{Charge} &= [AT], \\ \text{Potential} &= \frac{\text{Work}}{\text{Charge}} = [ML^2T^{-3}A^{-1}], \\ \text{Resistance} &= \frac{\text{Potential}}{\text{Current}} = [ML^2T^{-3}A^{-2}]. \end{aligned}$$

Always derive the dimensions from the defining formula instead of memorizing them separately.

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2. The electron mobility in a conductor is 32 cm^2/Vs. What is the relaxation time of free electrons? (Given: $e = 1.6 \times 10^{-19}\ C$, $m = 9.1 \times 10^{-31}\ kg$)

(A) $1.82 \times 10^{-12}\ s$

(B) $2.73 \times 10^{-12}\ s$

(C) $1.82 \times 10^{-14}\ s$

(D) $2.73 \times 10^{-14}\ s$

Correct Answer: (A) $1.82 \times 10^{-12}\ s$

Solution:

Concept:

Electron mobility (μ) is defined as the drift velocity acquired by an electron per unit electric field.

Mathematically,

$$\mu = \frac{v_d}{E}$$

According to the free electron theory,

$$v_d = \frac{eE\tau}{m},$$

where

$$e = \text{Charge of electron},$$

$$m = \text{Mass of electron},$$

$$\tau = \text{Relaxation time.}$$

Substituting the expression of drift velocity into the mobility equation,

$$\mu = \frac{e\tau}{m}.$$

Hence,

$$\boxed{\tau = \frac{\mu m}{e}}$$

This relation is frequently used to determine the relaxation time of free electrons.

Step 1: Convert the given mobility into SI units.

Given,

$$\mu = 32\ \text{cm}^2/\text{Vs}.$$

Since,

$$1\ \text{cm}^2 = 10^{-4}\ \text{m}^2,$$

therefore,

$$32\ \text{cm}^2 = 32 \times 10^{-4}\ \text{m}^2 = 3.2 \times 10^{-3}\ \text{m}^2.$$

Hence,

$$\boxed{\mu = 3.2 \times 10^{-3}\ \text{m}^2/\text{Vs}}.$$

Step 2: Write the formula for relaxation time.

The relation between mobility and relaxation time is

$$\mu = \frac{e\tau}{m}.$$

Rearranging,

$$\tau = \frac{\mu m}{e}.$$

Step 3: Substitute the given values.

Given,

$$\mu = 3.2 \times 10^{-3}\ \text{m}^2/\text{Vs},$$

$$m = 9.1 \times 10^{-31}\ \text{kg},$$

$$e = 1.6 \times 10^{-19}\ \text{C}.$$

Therefore,

$$\tau = \frac{(3.2 \times 10^{-3})(9.1 \times 10^{-31})}{1.6 \times 10^{-19}}.$$

First, multiply the numerator,

$$3.2 \times 9.1 = 29.12,$$

thus,

$$\tau = \frac{29.12 \times 10^{-34}}{1.6 \times 10^{-19}}.$$

Now divide,

$$\frac{29.12}{1.6} = 18.2.$$

Hence,

$$\tau = 18.2 \times 10^{-15} = 1.82 \times 10^{-14}\, s.$$

Therefore,

$$\boxed{\tau = 1.82 \times 10^{-14}\, s.}$$

Thus, the correct answer is

$$\boxed{\textbf{Option (C)}}.$$

Important Observation:

The value obtained using the given data is

$$\boxed{1.82 \times 10^{-14}\, s.}$$

$$\boxed{\textbf{Option (C)}}.$$

Quick Tip: For questions involving electron mobility and relaxation time, always remember the relation

$$\boxed{\mu = \frac{e\tau}{m}}$$

and convert mobility from $\mathrm{cm}^2/\mathrm{Vs}$ to m^2/Vs before substitution.

Useful conversion:

$$1\ \mathrm{cm}^2 = 10^{-4}\ \mathrm{m}^2.$$

3. The area of an airplane wing is $A = 4\,m^2$. Air flows with velocity $v_1 = 80\,m/s$ above the wing and $v_2 = 60\,m/s$ below it. The density of air is $1.2\,kg/m^3$. Find the pressure difference (ΔP) between the upper and lower surfaces of the wing.

(A) 1200 Pa

(B) 1680 Pa

(C) 2400 Pa

(D) 3600 Pa

Correct Answer: (B) 1680 Pa

Solution:

Concept:

The pressure difference between the upper and lower surfaces of an airplane wing is explained using **Bernoulli's Principle**.

According to Bernoulli's theorem,

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{Constant}$$

where

- P = Pressure of the fluid,
- ρ = Density of the fluid,
- v = Velocity of the fluid,
- h = Height above the reference level.

Since the upper and lower surfaces of the wing are nearly at the same height,

$$h_1 = h_2,$$

the gravitational potential energy terms cancel out. Hence,

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2.$$

Therefore, the pressure difference is

$$\boxed{\Delta P = P_2 - P_1 = \frac{1}{2}\rho\left(v_1^2 - v_2^2\right)}$$

where

$$v_1 > v_2.$$

Thus, the faster-moving air above the wing produces lower pressure.

Step 1: Write the given data.

Given,

$$A = 4\,m^2$$

$$v_1 = 80\,m/s$$

$$v_2 = 60\,m/s$$

$$\rho = 1.2\,kg/m^3.$$

Although the area of the wing is provided, it is **not required** for calculating the pressure difference.

Step 2: Apply Bernoulli's equation.

Using,

$$\Delta P = \frac{1}{2}\rho\left(v_1^2 - v_2^2\right),$$

Substitute the given values,

$$\Delta P = \frac{1}{2} \times 1.2\left(80^2 - 60^2\right).$$

Step 3: Calculate the square of the velocities.

$$80^2 = 6400,$$

$$60^2 = 3600.$$

Hence,

$$6400 - 3600 = 2800.$$

Therefore,

$$\Delta P = 0.6 \times 2800.$$

Step 4: Evaluate the pressure difference.

$$\Delta P = 1680\ Pa.$$

Thus,

$$\boxed{\Delta P = 1680\ Pa.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Additional Note:

If the lift force acting on the wing is required, it can be calculated using

$$F = \Delta P \times A.$$

Here,

$$F = 1680 \times 4 = 6720\ N.$$

However, since the question asks only for the pressure difference, the area is not used in the final answer.

Quick Tip: For airplane wing problems, remember:

$$\boxed{\Delta P = \frac{1}{2}\rho\left(v_{\text{fast}}^2 - v_{\text{slow}}^2\right)}$$

Greater fluid velocity corresponds to lower pressure according to Bernoulli's principle. If the lift force is asked,

$$\boxed{F = \Delta P \times A.}$$

Always check whether the question asks for **pressure difference** or **lift force**.

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4. What is the minimum wavelength in the Lyman series of the hydrogen spectrum?

(A) 91.2 nm

(B) 121.6 nm

(C) 656.3 nm

(D) 364.6 nm

Correct Answer: (A) 91.2 nm

Solution:

Concept:

The hydrogen spectrum consists of several spectral series that arise due to the transition of an electron from a higher energy level to a lower energy level.

The wavelength of the emitted radiation is given by the **Rydberg Formula**,

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right),$$

where

$$R = 1.097 \times 10^7\ m^{-1}$$

is the Rydberg constant,

$$n_1 = \text{lower energy level},$$

$$n_2 = \text{higher energy level}, \qquad n_2 > n_1.$$

For the **Lyman series**,

$$n_1 = 1,$$

and the electron falls from higher energy levels to the ground state.

The **minimum wavelength** (also called the series limit) is obtained when

$$n_2 \to \infty.$$

Step 1: Write the Rydberg formula for the Lyman series.

For the Lyman series,

$$n_1 = 1.$$

Hence,

$$\frac{1}{\lambda} = R\left(1 - \frac{1}{n_2^2}\right).$$

Step 2: Find the limiting wavelength.

The minimum wavelength corresponds to the highest possible transition,

$$n_2 \to \infty.$$

Therefore,

$$\frac{1}{n_2^2} = 0.$$

Substituting,

$$\frac{1}{\lambda_{\min}} = R.$$

Thus,

$$\lambda_{\text{min}} = \frac{1}{R}.$$

Step 3: Substitute the value of the Rydberg constant.

Using,

$$R = 1.097 \times 10^7\ m^{-1},$$

we get,

$$\lambda_{\text{min}} = \frac{1}{1.097 \times 10^7}.$$

Therefore,

$$\lambda_{\text{min}} = 9.12 \times 10^{-8}\ m.$$

Converting into nanometres,

$$1\,nm = 10^{-9}\,m,$$

hence,

$$\lambda_{\text{min}} = 91.2\,nm.$$

Thus,

$$\boxed{\lambda_{\text{min}} = 91.2\,nm.}$$

Therefore, the correct answer is

$$\boxed{\textbf{Option (A)}}.$$

Additional Information:

The important hydrogen spectral series are listed below:

Series	**n_1**	**Region**
Lyman	1	Ultraviolet
Balmer	2	Visible
Paschen	3	Infrared
Brackett	4	Infrared
Pfund	5	Infrared

The first line of the Lyman series has wavelength

$$121.6\,nm,$$

while the limiting (minimum) wavelength is

$$91.2\,nm.$$

Quick Tip: Remember the limiting wavelengths of the important hydrogen series:

$$\text{Lyman limit} \approx 91.2\,nm,$$

$$\text{Balmer limit} \approx 364.6\,nm.$$

The minimum wavelength of any spectral series is obtained by taking

$$\boxed{n_2 \to \infty.}$$

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5. Two parallel wires carry equal currents of $2A$ in opposite directions. If the length of each wire is $0.5\,m$ and the distance between them is $10\,cm$, then find the force between them.

(A) $2 \times 10^{-6}\,N$

(B) $4 \times 10^{-6}\,N$

(C) $8 \times 10^{-6}\,N$

(D) $1.6 \times 10^{-5}\,N$

Correct Answer: (B) $4 \times 10^{-6}\,N$

Solution:

Concept:

When two long, straight, parallel current-carrying conductors are placed close to each other, they exert a magnetic force on one another.

The magnitude of the force between two parallel conductors is given by

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d},$$

where

$$\mu_0 = 4\pi \times 10^{-7}\ H/m$$

is the permeability of free space,

$$I_1, I_2 = \text{Currents in the two conductors,}$$

$$l = \text{Length of each conductor,}$$

$$d = \text{Perpendicular distance between the conductors.}$$

The direction of the force depends upon the direction of current:

- Currents in the **same direction** ⇒ Attraction.
- Currents in the **opposite directions** ⇒ Repulsion.

Since the currents are flowing in opposite directions, the wires repel each other.

Step 1: Write the given data.

Given,

$$I_1 = I_2 = 2A,$$

$$l = 0.5\,m,$$

$$d = 10\,cm = 0.1\,m.$$

Also,

$$\mu_0 = 4\pi \times 10^{-7}\ H/m.$$

Step 2: Write the formula for the force between two parallel conductors.

The force is

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d}.$$

Substituting the given values,

$$F = \frac{(4\pi \times 10^{-7})(2)(2)(0.5)}{2\pi(0.1)}.$$

Step 3: Simplify the numerator.

Since,

$$(2)(2) = 4,$$

and

$$4 \times 0.5 = 2,$$

therefore,

$$F = \frac{(4\pi \times 10^{-7}) \times 2}{2\pi \times 0.1}.$$

Hence,

$$F = \frac{8\pi \times 10^{-7}}{0.2\pi}.$$

The factor π cancels from numerator and denominator.

Step 4: Calculate the force.

Thus,

$$F = \frac{8 \times 10^{-7}}{0.2} = 40 \times 10^{-7} = 4 \times 10^{-6}\,N.$$

Therefore,

$$\boxed{F = 4 \times 10^{-6}\,N.}$$

Since the currents are in opposite directions, the force is

$$\boxed{\text{Repulsive.}}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Quick Tip: Always remember the force between two parallel current-carrying conductors:

$$\boxed{F = \frac{\mu_0 I_1 I_2 l}{2\pi d}}$$

where d is the separation between the wires.

Also remember:

$$\boxed{\begin{aligned} \text{Same direction currents} &\Rightarrow \text{Attraction,} \\ \text{Opposite direction currents} &\Rightarrow \text{Repulsion.} \end{aligned}}$$

Before substituting values, always convert the distance into SI units (metres).

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6. A thin prism has an angle of 8° and a minimum deviation of 6°. Find the speed of light in the prism.

(A) $1.71 \times 10^8\,m/s$,

(B) $2.0 \times 10^8\,m/s$

(C) $2.5 \times 10^8\,m/s$

(D) $3.0 \times 10^8\,m/s$

Correct Answer: (A) $2.25 \times 10^8\, m/s$

Solution:

Concept:

A prism is a transparent optical medium that refracts light. For a **thin prism**, the refractive index is related to the prism angle and the angle of minimum deviation by

$$\boxed{\mu = 1 + \frac{\delta_m}{A}}$$

where

$$\mu = \text{Refractive index of the prism,}$$

$$A = \text{Angle of the prism,}$$

$$\delta_m = \text{Angle of minimum deviation.}$$

Once the refractive index is known, the speed of light inside the prism is obtained using

$$\boxed{\mu = \frac{c}{v}},$$

where

$$c = 3 \times 10^8\, m/s$$

is the speed of light in vacuum and

$$v = \text{Speed of light inside the prism.}$$

Hence,

$$\boxed{v = \frac{c}{\mu}}.$$

Step 1: Write the given data.

Given,

$$A = 8^\circ,$$

$$\delta_m = 6^\circ.$$

Also,

$$c = 3 \times 10^8\, m/s.$$

Step 2: Calculate the refractive index of the prism.

For a thin prism,

$$\mu = 1 + \frac{\delta_m}{A}.$$

Substituting the given values,

$$\mu = 1 + \frac{6}{8}.$$

Simplifying,

$$\mu = 1 + 0.75 = 1.75.$$

Thus,

$$\boxed{\mu = 1.75.}$$

Step 3: Find the speed of light inside the prism.

Using,

$$v = \frac{c}{\mu},$$

we get

$$v = \frac{3 \times 10^8}{1.75}.$$

Dividing,

$$v = 1.714 \times 10^8 \, m/s.$$

Therefore,

$$\boxed{v \approx 1.71 \times 10^8 \, m/s.}$$

Step 4: Compare the calculated value with the given options.

The calculated speed of light is

$$\boxed{1.71 \times 10^8 \, m/s,}$$

Quick Tip: For a thin prism, always remember:

$$\boxed{\mu = 1 + \frac{\delta_m}{A}}$$

where both A and δ_m must be in the same unit (degrees or radians).

The speed of light inside the prism is

$$\boxed{v = \frac{c}{\mu}}.$$

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7. A car moves at a speed of $600\,\mathbf{km/h}$ on a frictionless banked road with $\theta = 30^\circ$. Take $g = 10\,\mathbf{m/s^2}$. Find the radius of the road.

(A) $2.4\,\text{km}$

(B) $3.2\,\text{km}$

(C) $4.8\,\text{km}$

(D) $6.4\,\text{km}$

Correct Answer: (C) $4.8\,\text{km}$

Solution:

Concept:

A banked road is designed so that a vehicle can negotiate a curve safely without relying on friction. On a frictionless banked road, the horizontal component of the normal reaction provides the required centripetal force, while the vertical component balances the weight of the vehicle.

The relation between the speed, radius of the curve and the banking angle is

$$\boxed{\tan\theta = \frac{v^2}{rg}}$$

where

$$v = \text{Speed of the vehicle,}$$

$$r = \text{Radius of the circular path,}$$

$$g = \text{Acceleration due to gravity,}$$

$$\theta = \text{Angle of banking.}$$

Rearranging,

$$\boxed{r = \frac{v^2}{g\tan\theta}}$$

This formula is applicable only when the road is frictionless.

Step 1: Write the given data.

Given,

$$v = 600\,\text{km/h},$$

$$\theta = 30^\circ,$$

$$g = 10\,\mathrm{m/s^2}.$$

Convert the speed into SI units.

$$v = 600 \times \frac{5}{18} = 166.67\,\mathrm{m/s}.$$

Also,

$$\tan 30^\circ = \frac{1}{\sqrt{3}} \approx 0.577.$$

Step 2: Apply the banking road formula.

Using

$$r = \frac{v^2}{g\tan\theta},$$

we get

$$r = \frac{(166.67)^2}{10 \times 0.577}.$$

Step 3: Calculate the numerator.

$$(166.67)^2 = 27777.8.$$

Hence,

$$r = \frac{27777.8}{5.77}.$$

Step 4: Evaluate the radius.

$$r \approx 4814\,\mathrm{m}.$$

Converting into kilometres,

$$r = \frac{4814}{1000} = 4.814\,\text{km}.$$

Therefore,

$$\boxed{r \approx 4.8\,\text{km}.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (C)}}.$$

Verification:

Alternatively,

$$r = \frac{(166.67)^2}{10/\sqrt{3}} = 27777.8 \times \frac{\sqrt{3}}{10} \approx 4811\,\text{m},$$

which again gives

$$\boxed{r \approx 4.8\,\text{km}.}$$

Thus, the result is verified.

Quick Tip: For a frictionless banked road, always use

$$\boxed{\tan\theta = \frac{v^2}{rg}}$$

or equivalently,

$$\boxed{r = \frac{v^2}{g\tan\theta}}.$$

Before substituting values, always convert the speed from km/h to m/s using

$$\boxed{1 \text{ km/h} = \frac{5}{18} \text{ m/s}}.$$

Also remember:

$$\boxed{\text{Higher speed} \Rightarrow \text{Larger radius for the same banking angle.}}$$

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8. $L = 50\,mH,\ C = 100\,\mu F,\ R = 50\,\Omega$**. What does this circuit represent? (Assume** $\omega = 200\,rad/s$**)**

(A) Inductive circuit

(B) Capacitive circuit

(C) Resonant circuit

(D) Purely resistive circuit

Correct Answer: (C) Resonant circuit

Solution:

Concept:

In a series LCR circuit, the nature of the circuit depends upon the comparison of the inductive reactance (X_L) and capacitive reactance (X_C).

The reactances are given by

$$X_L = \omega L$$

and

$$X_C = \frac{1}{\omega C}.$$

The circuit behaves as:

$$\begin{aligned} X_L > X_C &\quad \Rightarrow \quad \text{Inductive circuit,} \\ X_L < X_C &\quad \Rightarrow \quad \text{Capacitive circuit,} \\ X_L = X_C &\quad \Rightarrow \quad \text{Resonant circuit.} \end{aligned}$$

At resonance,

$$Z = R,$$

the impedance becomes minimum, the current is maximum, and the phase difference between voltage and current is zero.

Step 1: Write the given data.

Given,

$$L = 50\,mH = 50 \times 10^{-3}\,H = 0.05\,H,$$

$$C = 100\,\mu F = 100 \times 10^{-6}\,F = 1 \times 10^{-4}\,F,$$

$$R = 50\,\Omega,$$

$$\omega = 200\,rad/s.$$

Step 2: Calculate the inductive reactance.

The inductive reactance is

$$X_L = \omega L.$$

Substituting the given values,

$$X_L = 200 \times 0.05.$$

Therefore,

$$\boxed{X_L = 10\,\Omega.}$$

Step 3: Calculate the capacitive reactance.

The capacitive reactance is

$$X_C = \frac{1}{\omega C}.$$

Substituting the values,

$$X_C = \frac{1}{200 \times 1 \times 10^{-4}}.$$

Since,

$$200 \times 10^{-4} = 0.02,$$

therefore,

$$X_C = \frac{1}{0.02} = 50\,\Omega.$$

Thus,

$$\boxed{X_C = 50\,\Omega.}$$

Step 4: Compare the reactances.

We have,

$$X_L = 10\,\Omega,$$

$$X_C = 50\,\Omega.$$

Since,

$$X_C > X_L,$$

the circuit behaves as a **capacitive circuit**.

Hence,

$$\boxed{\textbf{Option (B)}}.$$

Important Observation:

$$X_L = X_C.$$

Here,

$$10\,\Omega \neq 50\,\Omega,$$

therefore the circuit **cannot** be resonant.

The correct classification is

$$\boxed{\textbf{Capacitive Circuit.}}$$

Quick Tip: For an LCR circuit, first calculate

$$X_L = \omega L$$

and

$$X_C = \frac{1}{\omega C}.$$

Then compare them:

$$\boxed{\begin{aligned} &X_L > X_C \Rightarrow \text{Inductive,} \\ &X_L < X_C \Rightarrow \text{Capacitive,} \\ &X_L = X_C \Rightarrow \text{Resonance.} \end{aligned}}$$

At resonance,

$$\boxed{\omega = \frac{1}{\sqrt{LC}}}$$

and the impedance is equal to the resistance only.

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9. A sphere encloses charges $+5\,C$ and $-2\,C$, while a charge $-3\,C$ is outside the sphere. What is the electric flux through the sphere?

(A) $\frac{3C}{\varepsilon_0}$
(B) $-\frac{3C}{\varepsilon_0}$
(C) Zero
(D) $\frac{10C}{\varepsilon_0}$

Correct Answer: (A) $\frac{3C}{\varepsilon_0}$

Solution:

Concept:

The electric flux through any closed surface is determined by **Gauss's Law**.

According to Gauss's law,

$$\boxed{\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\varepsilon_0}}$$

where

$$\Phi = \text{Electric flux through the closed surface,}$$

$$Q_{\text{enclosed}} = \text{Net charge enclosed inside the surface,}$$

$$\varepsilon_0 = \text{Permittivity of free space.}$$

A very important point is that **only the charges enclosed within the closed surface contribute to the electric flux**. Any charge present outside the surface produces equal numbers of field lines entering and leaving the surface, resulting in zero net contribution.

Step 1: Determine the net charge enclosed by the sphere.

The sphere encloses the charges

$$+5\,C$$

and

$$-2\,C.$$

Hence,

$$Q_{\text{enclosed}} = (+5) + (-2) = 3\,C.$$

Therefore,

$$\boxed{Q_{\text{enclosed}} = 3\,C.}$$

Step 2: Consider the charge outside the sphere.

The charge

$$-3\,C$$

is located outside the Gaussian surface.
According to Gauss's law, an external charge does not affect the net electric flux through a closed surface.
Hence,

$$\boxed{\text{The outside charge contributes zero net flux.}}$$

Step 3: Apply Gauss's law.

Using

$$\Phi = \frac{Q_{\text{enclosed}}}{\varepsilon_0},$$

we obtain

$$\Phi = \frac{3}{\varepsilon_0}.$$

Therefore,

$$\boxed{\Phi = \frac{3C}{\varepsilon_0}.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (A)}}.$$

Verification:
Even though the total charge in the system is

$$(+5) + (-2) + (-3) = 0,$$

Gauss's law depends only on the **charge enclosed by the Gaussian surface**, not on the total charge present in space.
Since the enclosed charge is

$$3\,C,$$

the electric flux remains

$$\boxed{\frac{3C}{\varepsilon_0}.}$$

Quick Tip: For any closed Gaussian surface,

$$\boxed{\Phi = \frac{Q_{\text{enclosed}}}{\varepsilon_0}}$$

Always calculate the **net enclosed charge only**.

Remember:

$$\boxed{\begin{aligned}\text{Positive enclosed charge} &\Rightarrow \text{Positive flux},\\ \text{Negative enclosed charge} &\Rightarrow \text{Negative flux},\\ \text{External charges} &\Rightarrow \text{No effect on net flux.}\end{aligned}}$$

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10. A current of $50\,mA$ flows through a loop of area $10\,cm^2$ placed in a magnetic field of $0.1\,T$. The angle between the magnetic field and the loop is 60°. Find the torque acting on the loop.

(A) $2.5 \times 10^{-5}\,Nm$

(B) $4.33 \times 10^{-5}\,Nm$

(C) $4.33 \times 10^{-6}\,Nm$

(D) $2.5 \times 10^{-6}\,Nm$

Correct Answer: (C) $4.33 \times 10^{-6}\,Nm$

Solution:

Concept:

A current-carrying loop placed in a uniform magnetic field experiences a torque that tends to rotate the loop.

The torque acting on the loop is given by

$$\boxed{\tau = NIAB \sin\theta}$$

where

$$N = \text{Number of turns},$$

$$I = \text{Current through the loop},$$

$$A = \text{Area of the loop},$$

$$B = \text{Magnetic field},$$

$$\theta = \text{Angle between the normal to the loop and the magnetic field.}$$

If the angle given in the question is between the **plane of the loop** and the magnetic field, then

$$\theta = 90^\circ - \phi,$$

where ϕ is the angle between the plane of the loop and the magnetic field.
Hence,

$$\tau = NIAB \cos\phi.$$

Step 1: Write the given data.

Given,

$$I = 50\,mA = 50 \times 10^{-3} = 0.05\,A,$$

$$A = 10\,cm^2 = 10 \times 10^{-4} = 10^{-3}\,m^2,$$

$$B = 0.1\,T,$$

$$\phi = 60^\circ.$$

Since only one loop is mentioned,

$$N = 1.$$

Step 2: Determine the appropriate angle.

The angle is given between the magnetic field and the **plane of the loop**. Therefore,

$$\theta = 90^\circ - 60^\circ = 30^\circ.$$

Hence,

$$\sin\theta = \sin 30^\circ = \frac{1}{2}.$$

Equivalently,

$$\cos 60^\circ = \frac{1}{2}.$$

Step 3: Substitute the values into the torque formula.

Using

$$\tau = NIAB\sin\theta,$$

we get

$$\tau = 1 \times 0.05 \times 10^{-3} \times 0.1 \times \frac{1}{2}.$$

Simplifying,

$$\tau = 0.05 \times 10^{-3} \times 0.05.$$

$$\tau = 2.5 \times 10^{-6}\, Nm.$$

Therefore,

$$\boxed{\tau = 2.5 \times 10^{-6}\, Nm.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (D)}}.$$

Important Observation:
Using the standard formula,

$$\tau = NIAB \sin\theta,$$

and interpreting the given angle as the angle between the **plane of the loop** and the magnetic field, the torque is

$$\boxed{2.5 \times 10^{-6}\, Nm.}$$

If the angle were taken between the **normal to the loop** and the magnetic field,

$$\tau = 0.05 \times 10^{-3} \times 0.1 \times \sin 60^\circ = 4.33 \times 10^{-6}\, Nm,$$

which corresponds to **Option (C)**.
Thus, the answer depends on how the angle is interpreted. In physics, the torque formula uses the angle between the **magnetic field and the normal to the loop**. Therefore, if the question intends 60° to be with the **normal**, the correct answer is

$$\boxed{\textbf{Option (C)}}.$$

Quick Tip: Always remember the torque on a current-carrying loop:

$$\boxed{\tau = NIAB\sin\theta}$$

where θ is the angle between the **magnetic field** and the **normal to the plane of the loop**.

If the angle is given with the **plane of the loop**, first convert it using

$$\boxed{\theta = 90^\circ - \phi.}$$

This is one of the most common mistakes in magnetic torque problems.

---

11. A $1\,\mu F$ capacitor is charged to $12\,V$ and then connected to an identical uncharged capacitor. What will be the common potential?

(A) $12\,V$

(B) $6\,V$

(C) $3\,V$

(D) $4\,V$

Correct Answer: (B) $6\,V$

Solution:

Concept:

When a charged capacitor is connected to an identical uncharged capacitor, charge redistributes between the two capacitors until both attain the same potential.

The total charge remains conserved throughout the process.

The charge stored in a capacitor is given by

$$Q = CV,$$

where

$$Q = \text{Charge},$$

$$C = \text{Capacitance},$$

$$V = \text{Potential difference.}$$

If two identical capacitors are connected together, the equivalent capacitance becomes

$$C_{\text{eq}} = C + C = 2C.$$

The common potential after redistribution is

$$V_f = \frac{Q_{\text{total}}}{C_{\text{eq}}}.$$

Step 1: Write the given data.

Given,

$$C = 1\,\mu F,$$

Initial potential of the charged capacitor,

$$V = 12\,V.$$

The second capacitor is initially uncharged.

Step 2: Calculate the initial charge stored on the charged capacitor.

Using,

$$Q = CV,$$

we get

$$Q = (1\,\mu F)(12\,V).$$

Hence,

$$Q = 12\,\mu C.$$

Thus,

$$\boxed{Q_{\text{total}} = 12\,\mu C.}$$

Step 3: Find the equivalent capacitance after connection.

Since both capacitors are identical,

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

Therefore,

$$\boxed{C_{\text{eq}} = 2\,\mu F.}$$

Step 4: Calculate the common potential.

Using

$$V_f = \frac{Q_{\text{total}}}{C_{\text{eq}}},$$

we obtain

$$V_f = \frac{12\,\mu C}{2\,\mu F} = 6\,V.$$

Therefore,

$$\boxed{V_f = 6\,V.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Quick Tip: For two identical capacitors, one charged and the other uncharged,

$$\boxed{V_f = \frac{V}{2}}$$

because the total charge remains constant while the total capacitance doubles.

Always apply the principle of conservation of charge in capacitor-sharing problems.

---

12. If the work function of a metal is $1.2\,eV$ and the stopping potential is $1.8\,V$, find the frequency of incident light on the metal surface.

(A) $4.84 \times 10^{14}\,Hz$

(B) $7.25 \times 10^{14}\,Hz$

(C) $1.45 \times 10^{14}\,Hz$

(D) $9.67 \times 10^{14}\,Hz$

Correct Answer: (B) $7.25 \times 10^{14}\,Hz$

Solution:

Concept:

The photoelectric effect is explained by Einstein's photoelectric equation,

$$hf = \phi + K_{\text{max}},$$

where

$$h = \text{Planck's constant},$$

$$f = \text{Frequency of incident radiation},$$

$$\phi = \text{Work function of the metal},$$

$$K_{\text{max}} = \text{Maximum kinetic energy of the emitted electrons.}$$

The maximum kinetic energy is related to the stopping potential by

$$K_{\max} = eV_s.$$

If the work function is expressed in electron volts (eV), then

$$hf = \phi + V_s \quad \text{(in eV)}.$$

Also,

$$1\,eV = 1.6 \times 10^{-19}\,J,$$

and

$$h = 6.626 \times 10^{-34}\,Js.$$

Step 1: Write the given data.

Given,

$$\phi = 1.2\,eV,$$

$$V_s = 1.8\,V.$$

Step 2: Calculate the photon energy.

According to Einstein's equation,

$$E = \phi + eV_s.$$

In electron volt,

$$E = 1.2 + 1.8 = 3.0\,eV.$$

Converting into joules,

$$E = 3 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-19}\,J.$$

Step 3: Calculate the frequency of the incident light.

Using,

$$E = hf,$$

we obtain

$$f = \frac{E}{h}.$$

Substituting the values,

$$f = \frac{4.8 \times 10^{-19}}{6.626 \times 10^{-34}}.$$

Therefore,

$$f = 7.24 \times 10^{14}\,Hz.$$

Approximating,

$$\boxed{f = 7.25 \times 10^{14}\,Hz.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Quick Tip: For photoelectric effect problems, remember Einstein's equation:

$$\boxed{hf = \phi + eV_s}$$

If the work function is given in electron volts,

$$\boxed{\text{Photon Energy (eV)} = \phi + V_s.}$$

Then convert the energy into joules and use

$$\boxed{f = \frac{E}{h}}$$

to calculate the frequency.

---

13. Which of the following statements is correct during the formation of a PN junction?

(A) Electrons diffuse from the P-region to the N-region.

(B) Holes diffuse from the N-region to the P-region.

(C) Electrons diffuse from the N-region to the P-region.

(D) Holes drift from the N-region to the P-region.

Correct Answer: (C) Electrons diffuse from the N-region to the P-region.

Solution:

Concept:

A PN junction is formed by joining a P-type semiconductor with an N-type semiconductor. Due to the difference in carrier concentration, majority charge carriers diffuse across the junction.

- Electrons are the majority carriers in the N-region.
- Holes are the majority carriers in the P-region.

As soon as the junction is formed,

- Electrons diffuse from the N-region to the P-region.
- Holes diffuse from the P-region to the N-region.

This diffusion creates a depletion region and establishes a built-in electric field which opposes further diffusion.

Step 1: Identify the majority carriers.

In a P-type semiconductor,

$$\boxed{\text{Majority carriers} = \text{Holes}}$$

In an N-type semiconductor,

$$\boxed{\text{Majority carriers} = \text{Electrons}}$$

Step 2: Understand the diffusion process.

Since the concentration of electrons is much higher in the N-region,

$$\boxed{\text{Electrons diffuse from N-region to P-region.}}$$

Similarly,

$$\boxed{\text{Holes diffuse from P-region to N-region.}}$$

This diffusion continues until equilibrium is established.

Step 3: Examine the given options.

Option (A):

$$\text{Electrons diffuse from P-region to N-region}$$

This is incorrect because electrons are majority carriers in the N-region.
Option (B):

$$\text{Holes diffuse from N-region to P-region}$$

This is incorrect because holes are majority carriers in the P-region.
Option (C):

$$\text{Electrons diffuse from N-region to P-region}$$

This is correct.

Option (D):

$$\text{Holes drift from N-region to P-region}$$

This is incorrect because initially holes diffuse, not drift.

Hence,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Always remember the direction of diffusion in a PN junction:

$$\boxed{\begin{aligned} \text{Electrons}: &\ N \rightarrow P, \\ \text{Holes}: &\ P \rightarrow N. \end{aligned}}$$

The diffusion of charge carriers forms the depletion layer and the built-in potential barrier.

---

14. A spring of force constant $K = 1000\,N/m$ is compressed by $5\,cm$. If a mass of $2.5\,kg$ is attached and released, find its speed as it passes the equilibrium position.

(A) $0.5\,m/s$

(B) $1.0\,m/s$

(C) $1.5\,m/s$

(D) $2.0\,m/s$

Correct Answer: (B) $1.0\,m/s$

Solution:

Concept:

A spring-mass system performs Simple Harmonic Motion (SHM). When the spring is compressed and released, the elastic potential energy stored in the spring is completely converted into the kinetic energy of the mass as it passes through the equilibrium position.

According to the law of conservation of energy,

$$\boxed{\frac{1}{2}Kx^2 = \frac{1}{2}mv^2}$$

where

$$K = \text{Spring constant,}$$

$$x = \text{Compression of the spring,}$$

$$m = \text{Mass attached,}$$

$$v = \text{Velocity at the equilibrium position.}$$

Rearranging,

$$\boxed{v = x\sqrt{\frac{K}{m}}}$$

Step 1: Write the given data.

Given,

$$K = 1000\,N/m,$$

$$x = 5\,cm = 0.05\,m,$$

$$m = 2.5\,kg.$$

Step 2: Apply the conservation of energy.

Using,

$$\frac{1}{2}Kx^2 = \frac{1}{2}mv^2,$$

we get,

$$v = x\sqrt{\frac{K}{m}}.$$

Substituting the given values,

$$v = 0.05\sqrt{\frac{1000}{2.5}}.$$

Step 3: Calculate the numerical value.

First,

$$\frac{1000}{2.5} = 400.$$

Therefore,

$$\sqrt{400} = 20.$$

Hence,

$$v = 0.05 \times 20 = 1.0\,m/s.$$

Thus,

$$\boxed{v = 1.0\,m/s.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Verification:

Using energy directly,

$$\frac{1}{2}(1000)(0.05)^2 = \frac{1}{2}(2.5)v^2,$$

$$1.25 = 1.25v^2,$$

$$v^2 = 1,$$

$$v = 1\, m/s.$$

Thus, the answer is verified.

Quick Tip: For a spring-mass system, remember:

$$\boxed{\frac{1}{2}Kx^2 = \frac{1}{2}mv^2}$$

or directly,

$$\boxed{v = x\sqrt{\frac{K}{m}}}$$

At the equilibrium position, the spring has zero potential energy and the kinetic energy of the mass is maximum.

---

15. The temperature of 2 moles of a monoatomic gas changes from $25^\circ C$ to $35^\circ C$ in an adiabatic process. Find the work done.

(A) $-249.4J$

(B) $+249.4J$

(C) $-498.8J$

(D) $+498.8J$

Correct Answer: (A) $-249.4J$

Solution:

Concept:

An adiabatic process is a thermodynamic process in which there is **no heat exchange** between the system and the surroundings.

Therefore,

$$\boxed{Q = 0}$$

According to the First Law of Thermodynamics,

$$Q = \Delta U + W,$$

where

$$Q = \text{Heat supplied},$$

$$\Delta U = \text{Change in internal energy},$$

$$W = \text{Work done by the gas.}$$

Since $Q = 0$,

$$\boxed{W = -\Delta U.}$$

For a monoatomic ideal gas,

$$\boxed{\Delta U = nC_V \Delta T}$$

where

$$C_V = \frac{3R}{2}.$$

Hence,

$$\boxed{W = -nC_V \Delta T = -\frac{3}{2} nR\Delta T.}$$

Step 1: Write the given data.

Given,

$$n = 2 \text{ moles},$$

$$T_1 = 25^\circ C,$$

$$T_2 = 35^\circ C.$$

Therefore,

$$\Delta T = T_2 - T_1 = 35 - 25 = 10\,K.$$

Also,

$$R = 8.314\,J\,mol^{-1}K^{-1}.$$

Step 2: Calculate the change in internal energy.

For a monoatomic gas,

$$\Delta U = \frac{3}{2}nR\Delta T.$$

Substituting the given values,

$$\Delta U = \frac{3}{2} \times 2 \times 8.314 \times 10.$$

Since,

$$\frac{3}{2} \times 2 = 3,$$

we get

$$\Delta U = 3 \times 8.314 \times 10.$$

$$\Delta U = 249.42\,J.$$

Thus,

$$\boxed{\Delta U = 249.4 J.}$$

Step 3: Determine the work done.

Since the process is adiabatic,

$$W = -\Delta U.$$

Hence,

$$W = -249.4 J.$$

Therefore,

$$\boxed{W = -249.4 J.}$$

Thus, the correct answer is

$$\boxed{\textbf{Option (A)}}.$$

Important Observation:

Using the standard thermodynamic convention,

$$\boxed{W = -nC_V \Delta T,}$$

the work done by the gas is

$$\boxed{-249.4 J.}$$

Therefore, **Option (A)** is mathematically correct.

Quick Tip: For an adiabatic process,

$$\boxed{Q = 0}$$

and

$$\boxed{W = -\Delta U.}$$

For a monoatomic ideal gas,

$$\boxed{C_V = \frac{3R}{2}}$$

Hence,

$$\boxed{W = -\frac{3}{2}nR\Delta T.}$$

Always calculate the temperature difference in Kelvin. Since temperature intervals are the same in Celsius and Kelvin,

$$\boxed{\Delta T(^\circ C) = \Delta T(K).}$$

---

16. Two large, thin, parallel sheets have surface charge densities of opposite signs and equal magnitude σ. What is the magnitude of the electric field (E) in the region between the sheets?

(A) $\frac{\sigma}{2\varepsilon_0}$
(B) $\frac{\sigma}{\varepsilon_0}$
(C) Zero
(D) $\frac{2\sigma}{\varepsilon_0}$

Correct Answer: (B) $\frac{\sigma}{\varepsilon_0}$

Solution:

Concept:

According to Gauss's Law, the electric field due to an infinite plane sheet carrying a uniform surface charge density σ is

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

This electric field is independent of the distance from the sheet.
For two parallel sheets carrying equal and opposite surface charge densities,

$$+\sigma \quad \text{and} \quad -\sigma,$$

the electric fields combine according to the principle of superposition.

- Between the sheets, both electric fields act in the same direction and hence add.
- Outside the sheets, the electric fields are equal in magnitude but opposite in direction and therefore cancel each other.

Step 1: Electric field due to a positively charged sheet.

For the positively charged sheet,

$$E_+ = \frac{\sigma}{2\varepsilon_0}.$$

The field is directed away from the positive sheet.

Step 2: Electric field due to a negatively charged sheet.

For the negatively charged sheet,

$$E_- = \frac{\sigma}{2\varepsilon_0}.$$

The field is directed towards the negative sheet.

Step 3: Find the resultant electric field between the sheets.

Between the sheets, both electric fields are in the same direction.
Hence,

$$E = E_+ + E_-.$$

Substituting,

$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}.$$

Therefore,

$$E = \frac{\sigma}{\varepsilon_0}.$$

Thus,

$$\boxed{E = \frac{\sigma}{\varepsilon_0}.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Quick Tip: Remember the electric field due to an infinite charged sheet:

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

For two parallel sheets having equal and opposite charges,

$$\boxed{E_{\text{between}} = \frac{\sigma}{\varepsilon_0}}$$

while

$$\boxed{E_{\text{outside}} = 0.}$$

---

17. A small ball is tied to a light inextensible thread of length $64\,cm$ and is whirled in a vertical circle. If the thread is just taut at the highest point of the circle, then the minimum speed of the ball at the lowest point is: (Take $g = 10\,m/s^2$)

(A) $2.53\,m/s$

(B) $5.66\,m/s$

(C) $8.0\,m/s$

(D) $10.0\,m/s$

Correct Answer: (B) $5.66\,m/s$

Solution:

Concept:

For a body moving in a vertical circle, the minimum speed at the highest point occurs when the tension in the string just becomes zero.

Hence,

$$T = 0.$$

Applying Newton's second law at the highest point,

$$mg = \frac{mv_t^2}{r}.$$

Therefore,

$$\boxed{v_t = \sqrt{gr}}$$

where

$$v_t = \text{Speed at the highest point,}$$

$$r = \text{Radius of the circular path.}$$

Using the law of conservation of mechanical energy between the lowest and the highest points,

$$\frac{1}{2}mv_b^2 = \frac{1}{2}mv_t^2 + mg(2r),$$

where

$$v_b = \text{Speed at the lowest point.}$$

This gives

$$\boxed{v_b = \sqrt{5gr}}.$$

Step 1: Write the given data.

Given,

$$r = 64\,cm = 0.64\,m,$$

$$g = 10\,m/s^2.$$

Step 2: Determine the minimum speed at the highest point.

Since the string is just taut,

$$T = 0.$$

Hence,

$$v_t = \sqrt{gr}.$$

Substituting,

$$v_t = \sqrt{10 \times 0.64} = \sqrt{6.4} = 2.53\,m/s.$$

Step 3: Apply conservation of mechanical energy.

Using,

$$v_b = \sqrt{5gr},$$

we get

$$v_b = \sqrt{5 \times 10 \times 0.64}.$$

$$v_b = \sqrt{32}.$$

Therefore,

$$v_b = 5.66\,m/s.$$

Thus,

$$\boxed{v_b = 5.66\,m/s.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (B)}}.$$

Important Observation:

Using the standard theory of vertical circular motion,

$$\boxed{v_{\text{bottom}} = \sqrt{5gr}}$$

For

$$r = 0.64\,m,$$

the minimum speed at the lowest point is

$$\boxed{5.66\,m/s.}$$

Thus, **Option (B)** is mathematically correct.

Quick Tip: For vertical circular motion, remember:

$$\boxed{v_{\text{top(min)}} = \sqrt{gr}}$$

and

$$\boxed{v_{\text{bottom(min)}} = \sqrt{5gr}}$$

These two formulas are among the most frequently used results in vertical circle problems.

---

18. A thin charged spherical shell of radius $10\,cm$ has a uniform surface charge density of

$20\,pC/cm^2$**. The electric potential at a point** $8\,cm$ **from the centre of the shell is:**

(A) $180\pi\,V$

(B) $360\pi\,V$

(C) $720\pi\,V$

(D) Zero

Correct Answer: (C) $720\pi\,V$

Solution:

Concept:

For a uniformly charged spherical shell,

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}}$$

at every point inside the shell as well as on its surface.

The total charge on the shell is

$$\boxed{Q = \sigma(4\pi R^2)}$$

where

$$\sigma = \text{Surface charge density},$$

$$R = \text{Radius of the shell.}$$

Since the observation point is inside the shell ($r < R$), the potential remains constant throughout the interior.

Step 1: Write the given data.

Given,

$$R = 10\,cm = 0.1\,m,$$

$$\sigma = 20\,pC/cm^2.$$

Convert the surface charge density into SI units.

Since

$$1\,pC = 10^{-12}C,$$

and

$$1\,cm^2 = 10^{-4}m^2,$$

therefore,

$$\sigma = 20 \times 10^{-12} \times 10^4 = 2 \times 10^{-7}C/m^2.$$

Step 2: Calculate the total charge on the shell.

Using

$$Q = \sigma(4\pi R^2),$$

we obtain

$$Q = 2 \times 10^{-7} \times 4\pi \times (0.1)^2.$$

Since

$$(0.1)^2 = 0.01,$$

$$Q = 2 \times 10^{-7} \times 4\pi \times 0.01 = 8\pi \times 10^{-9}C.$$

Thus,

$$\boxed{Q = 8\pi \times 10^{-9}C.}$$

Step 3: Calculate the electric potential inside the shell.

Using,

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R},$$

where

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9.$$

Substituting,

$$V = 9 \times 10^9 \times \frac{8\pi \times 10^{-9}}{0.1}.$$

Therefore,

$$V = 720\pi\, V.$$

Hence,

$$\boxed{V = 720\pi\, V.}$$

Thus, the correct answer is

$$\boxed{\textbf{Option (C)}}.$$

Important Observation:

Using the standard electrostatic formula,

$$\boxed{V = 720\pi\, V.}$$

Hence **Option (C)** is mathematically correct.

Quick Tip: Inside a uniformly charged spherical shell,

$$\boxed{E = 0}$$

but

$$\boxed{V = \frac{kQ}{R}}$$

which is constant everywhere inside the shell.
Do not use $V = \frac{kQ}{r}$ for points inside a spherical shell.

---

19. Three charges $+20\,\mu C$, $+20\,\mu C$ and $-20\,\mu C$ are placed at the vertices A, B and C respectively of an equilateral triangle of side $1\,m$. Find the net force acting on the charge at vertex A.

(A) $3600\sqrt{3}\,N$

(B) $3600\,N$

(C) $7200\,N$

(D) $1800\,N$

Correct Answer: (A) $3600\sqrt{3}\,N$

Solution:

Concept:

According to Coulomb's law,

$$\boxed{F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1 q_2|}{r^2}}$$

where

$$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\,Nm^2/C^2.$$

The resultant force is obtained by vector addition.

For an equilateral triangle,

$$\angle BAC = 60^\circ.$$

Step 1: Write the given data.

Given,

$$q_A = +20\,\mu C,$$

$$q_B = +20\,\mu C,$$

$$q_C = -20\,\mu C,$$

$$r = 1\,m.$$

Step 2: Calculate the force due to each charge.

Using Coulomb's law,

$$F = 9 \times 10^9 \times \frac{(20 \times 10^{-6})^2}{1^2}.$$

Since

$$(20 \times 10^{-6})^2 = 400 \times 10^{-12},$$

therefore,

$$F = 9 \times 10^9 \times 400 \times 10^{-12} = 3.6\,N.$$

Thus,

$$\boxed{F_{AB} = F_{AC} = 3.6\,N.}$$

The force due to B is repulsive, whereas the force due to C is attractive.

Hence, the angle between the two forces is

$$120^\circ.$$

Step 3: Find the resultant force.

Using the cosine rule,

$$R = \sqrt{F^2 + F^2 + 2F^2 \cos 120^\circ}.$$

Since

$$\cos 120^\circ = -\frac{1}{2},$$

we get

$$R = \sqrt{2F^2 - F^2} = F.$$

Thus,

$$\boxed{R = 3.6\,N.}$$

Important Observation:

Using the given values,

$$\boxed{R = 3.6\,N.}$$

Hence none of the given options match.

The options ($3600\sqrt{3}$, 3600, etc.) would only be obtained if the charges were in **milli-coulombs (mC)** or if the numerical data were different.

Therefore, the question contains an error.

Quick Tip: Always solve Coulomb force problems in two steps:

$$\boxed{\text{Step 1: Calculate each force using Coulomb's law}}$$

$$\boxed{\text{Step 2: Add the forces vectorially}}$$

In an equilateral triangle, remember that the angle between two sides is

$$\boxed{60^\circ.}$$

CHEMISTRY

1. Assertion (A): The first ionization enthalpy of nitrogen is higher than that of oxygen.
Reason (R): Nitrogen has a half-filled $2p$ orbital, which is extra stable.

(A) A and R are both true, and R is the correct explanation of A.
(B) A and R are both true, but R is not the correct explanation of A.
(C) A is true, but R is false.
(D) A is false, but R is true.

Correct Answer: (A)

Solution:

Concept:
Ionization enthalpy is the minimum amount of energy required to remove the most loosely bound electron from an isolated gaseous atom.
Generally, ionization enthalpy increases across a period due to increasing effective nuclear charge. However, nitrogen and oxygen show an exception because of the stability associated with half-filled orbitals.
Nitrogen has the electronic configuration

$$1s^2 2s^2 2p^3,$$

which is a perfectly half-filled $2p$ subshell. Half-filled and completely filled subshells possess extra stability due to symmetrical distribution of electrons and maximum exchange energy.
Oxygen has the electronic configuration

$$1s^2 2s^2 2p^4,$$

where one of the $2p$ orbitals contains a pair of electrons. The repulsion between paired electrons makes it comparatively easier to remove one electron.

Step 1: Examine the assertion.

The first ionization enthalpy of nitrogen is greater than that of oxygen.

$$IE_1(N) > IE_1(O)$$

This statement is true because removing an electron from the stable half-filled configuration of nitrogen requires more energy.

Step 2: Examine the reason.

Nitrogen possesses the electronic configuration

$$2p^3,$$

which is a half-filled subshell.
Half-filled subshells are extra stable because of maximum exchange energy and symmetrical electron distribution.
Hence, the reason is also true.

Step 3: Determine whether the reason explains the assertion.

The higher stability of nitrogen due to its half-filled $2p$ subshell directly explains why its first ionization enthalpy is higher than that of oxygen.
Therefore,

$$\boxed{\text{Assertion is true, Reason is true, and Reason correctly explains the Assertion.}}$$

Hence, the correct answer is

$\boxed{\textbf{Option (A)}}$.

Quick Tip: Remember the important exception in ionization enthalpy:

$$\boxed{IE_1(N) > IE_1(O)}$$

because

$$\boxed{N : 2p^3}$$

is a stable half-filled configuration, whereas oxygen has one paired electron in the $2p$ subshell, making electron removal easier.

---

2. What will be formed when $CH_3 - CH = CH_2 + HBr$ reacts in the presence of peroxide?

(A) $CH_3 - CH_2 - CH_2 - Br$ (n-propyl bromide)

(B) $CH_3 - CHBr - CH_3$ (isopropyl bromide)

(C) $BrCH_2 - CH = CH_2$ (allyl bromide)

(D) No reaction will occur.

Correct Answer: (A)

Solution:

Concept:

Normally, the addition of HBr to an unsymmetrical alkene follows Markovnikov's rule. However, in the presence of organic peroxides, the reaction proceeds through a free-radical mechanism and follows the anti-Markovnikov rule. This phenomenon is known as the peroxide effect or Kharasch effect.

The peroxide effect is observed only with HBr and not with HCl or HI.

$$\boxed{\text{Peroxide + HBr } \Rightarrow \text{Anti-Markovnikov addition}}$$

Step 1: Identify the alkene.

The given alkene is propene,

$$CH_3 - CH = CH_2.$$

It is an unsymmetrical alkene.

Step 2: Apply the peroxide effect.

In the presence of peroxide,

$$HBr$$

adds according to the anti-Markovnikov rule.
Therefore,

- Bromine atom attaches to the carbon having more hydrogen atoms.
- Hydrogen attaches to the other carbon atom.

Thus, the product formed is

$$CH_3 - CH_2 - CH_2Br.$$

Step 3: Identify the product.

The product

$$CH_3 - CH_2 - CH_2Br$$

is

$$\boxed{\text{n-propyl bromide (1-bromopropane).}}$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Reaction:

$$CH_3CH = CH_2 \xrightarrow[\text{Peroxide}]{HBr} CH_3CH_2CH_2Br$$

Quick Tip: Remember:

Without peroxide,

$$\boxed{\text{HBr follows Markovnikov's rule.}}$$

With peroxide,

$$\boxed{\text{HBr follows Anti-Markovnikov's rule.}}$$

The peroxide (Kharasch) effect is shown only by HBr and not by HCl or HI.

---

3. What is the magnetic dipole moment of Mn^{2+} ($3d^5$)?

(A) $1.73\,BM$

(B) $3.87\,BM$

(C) $5.92\,BM$

(D) $4.90\,BM$

Correct Answer: (C) $5.92\,BM$

Solution:

Concept:

The magnetic dipole moment of transition metal ions is generally calculated using the spin-only formula,

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

where

$$\mu = \text{Magnetic dipole moment,}$$

$$n = \text{Number of unpaired electrons.}$$

The unit of magnetic moment is the Bohr Magneton (BM).
For most first-row transition metal ions, the orbital contribution is negligible, so the spin-only formula gives an accurate value.

Step 1: Determine the electronic configuration of Mn^{2+}.

The atomic number of manganese is

$$Z = 25.$$

The electronic configuration of neutral manganese is

$$Mn = [Ar]3d^5 4s^2.$$

On losing two electrons,

$$Mn^{2+} = [Ar]3d^5.$$

Thus,

$$\boxed{Mn^{2+} \text{ has five unpaired electrons.}}$$

Hence,

$$n = 5.$$

Step 2: Apply the spin-only formula.

Using

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

we get

$$\mu = \sqrt{5(5+2)}.$$

Therefore,

$$\mu = \sqrt{35}.$$

Step 3: Calculate the magnetic moment.

Since,

$$\sqrt{35} \approx 5.92,$$

therefore,

$$\boxed{\mu = 5.92\,BM.}$$

Hence, the correct answer is

$$\boxed{\textbf{Option (C)}}.$$

Quick Tip: Always remember the spin-only formula:

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

where n is the number of unpaired electrons.

For d^5 configuration,

$$\boxed{n = 5, \qquad \mu = \sqrt{35} = 5.92\,BM.}$$

---

4. What is formed when benzene diazonium chloride (BDC) reacts with phenol?

(A) Azo dye (p-hydroxyazobenzene)

(B) Benzoic acid

(C) Benzene

(D) Chlorobenzene

Correct Answer: (A) Azo dye (p-hydroxyazobenzene)

Solution:

Concept:
Benzene diazonium chloride undergoes an azo coupling reaction with activated aromatic compounds such as phenol and aniline.
Phenol activates the benzene ring due to the electron-donating nature of the $-OH$ group.
As a result, coupling occurs mainly at the para position to form an azo compound containing the characteristic azo linkage

$$\boxed{-N=N-.}$$

These coloured compounds are known as azo dyes.

Step 1: Identify the reactants.

The reactants are

Benzene diazonium chloride

and

Phenol.

Phenol is a highly activated aromatic compound and readily undergoes electrophilic substitution.

Step 2: Understand the azo coupling reaction.

The diazonium ion acts as an electrophile.
It couples with the aromatic ring of phenol at the para position to form

$$\boxed{\text{p-hydroxyazobenzene.}}$$

The reaction is represented as

$$C_6H_5N_2^+Cl^- + C_6H_5OH \longrightarrow HO-C_6H_4-N=N-C_6H_5.$$

Step 3: Identify the product.

The product formed is

$$\boxed{\text{p-hydroxyazobenzene}}$$

which is an

$$\boxed{\text{Azo dye.}}$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the important azo coupling reactions:

$$\boxed{\begin{array}{l}\text{BDC} + \text{Phenol} \longrightarrow \text{p-Hydroxyazobenzene} \\ \text{BDC} + \text{Aniline} \longrightarrow \text{p-Aminoazobenzene}\end{array}}$$

The product always contains the characteristic azo linkage

$$\boxed{-N=N-.}$$

---

5. $R-CONH_2 + Br_2 + 4NaOH \rightarrow R-NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$**; this reaction is:**

(A) Hinsberg reaction

(B) Carbylamine reaction

(C) Sandmeyer reaction

(D) Hofmann bromamide reaction

Correct Answer: (D) Hofmann bromamide reaction

Solution:

Concept:

The Hofmann bromamide reaction (also called Hofmann degradation or Hofmann rearrangement) is a reaction in which a primary amide is converted into a primary amine containing one carbon atom less.

The reaction takes place in the presence of bromine and aqueous sodium hydroxide.

The general reaction is

$$\boxed{RCONH_2 + Br_2 + 4NaOH \rightarrow RNH_2 + Na_2CO_3 + 2NaBr + 2H_2O}$$

Thus, the amide loses its carbonyl carbon as carbonate.

Step 1: Identify the reactants.

The given reactants are

$$RCONH_2,\ Br_2,\ \text{and}\ NaOH.$$

A primary amide reacts with bromine in an alkaline medium.

Step 2: Identify the product formed.

The product is

$$RNH_2,$$

which is a primary amine.

The amine contains one carbon atom less than the original amide.

This is the characteristic feature of the Hofmann bromamide reaction.

Step 3: Compare with the given options.

- Hinsberg reaction is used to distinguish primary, secondary and tertiary amines.
- Carbylamine reaction is used for the identification of primary amines.
- Sandmeyer reaction converts diazonium salts into haloarenes.
- Hofmann bromamide reaction converts amides into amines with one less carbon atom.

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember the characteristic reaction:

$$\boxed{RCONH_2 \xrightarrow[\text{NaOH}]{Br_2} RNH_2}$$

The amine formed contains

$$\boxed{\text{one carbon atom less}}$$

than the corresponding amide.

---

6. Which compound undergoes the S_N2 reaction the fastest?

(A) CH_3-Br (methyl bromide)

(B) $(CH_3)_2CH-Br$ (secondary bromide)

(C) $(CH_3)_3C-Br$ (tertiary bromide)

(D) CH_3CH_2-Br (primary bromide)

Correct Answer: (A) CH_3Br

Solution:

Concept:

The S_N2 reaction is a bimolecular nucleophilic substitution reaction that occurs in a single step through backside attack by the nucleophile.

The rate law is

$$\boxed{\text{Rate} = k[\text{Alkyl halide}][\text{Nucleophile}]}$$

The rate of an S_N2 reaction depends mainly on steric hindrance around the carbon atom attached to the leaving group.

The order of reactivity is

$$\boxed{CH_3X > 1^\circ > 2^\circ >> 3^\circ}$$

because steric hindrance increases from methyl to tertiary alkyl halides.

Step 1: Identify the nature of each alkyl halide.

$$CH_3Br$$

is a methyl halide.

$$CH_3CH_2Br$$

is a primary alkyl halide.

$$(CH_3)_2CHBr$$

is a secondary alkyl halide.

$$(CH_3)_3CBr$$

is a tertiary alkyl halide.

Step 2: Compare steric hindrance.

Since methyl bromide has no alkyl group attached to the carbon bearing bromine,

$$\boxed{\text{Steric hindrance is minimum.}}$$

Therefore, the nucleophile can easily attack the carbon atom.
Hence, methyl bromide reacts fastest through the S_N2 mechanism.

Step 3: Determine the correct option.

The order of S_N2 reactivity is

$$CH_3Br > CH_3CH_2Br > (CH_3)_2CHBr >> (CH_3)_3CBr.$$

Thus,

$$\boxed{CH_3Br}$$

undergoes the S_N2 reaction most rapidly.

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: For S_N2 reactions, always remember the order:

$$\boxed{CH_3X > 1^\circ > 2^\circ >> 3^\circ}$$

Less steric hindrance means faster backside attack by the nucleophile and therefore a faster S_N2 reaction.

---

7. What is the oxidation state of oxygen in O_2F_2 and O_3?

(A) +1 in O_2F_2 and 0 in O_3

(B) −1 in O_2F_2 and +2 in O_3

(C) +2 in O_2F_2 and −1 in O_3

(D) 0 in both

Correct Answer: (A)

Solution:

Concept:

The oxidation state of an element is the apparent charge assigned to it in a compound according to the oxidation number rules.

Some important rules are:

- Fluorine always has oxidation state −1.
- The oxidation state of an element in its free state is 0.
- The algebraic sum of oxidation states of all atoms in a neutral molecule is zero.

Since fluorine is the most electronegative element, oxygen exhibits a positive oxidation state in compounds containing fluorine.

Step 1: Find the oxidation state of oxygen in O_2F_2.

Let the oxidation state of oxygen be x.

Since fluorine has oxidation state -1,

$$2x + 2(-1) = 0.$$

Therefore,

$$2x - 2 = 0,$$

$$2x = 2,$$

$$x = +1.$$

Hence,

$$\boxed{\text{Oxidation state of oxygen in } O_2F_2 = +1.}$$

Step 2: Find the oxidation state of oxygen in O_3.

Ozone is an allotrope of oxygen.

Since it exists in the elemental state,

$$\boxed{\text{Oxidation state of oxygen} = 0.}$$

Step 3: Identify the correct option.

Thus,

$$O_2F_2 \rightarrow +1,$$

$$O_3 \rightarrow 0.$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember these important oxidation states of oxygen:

$$\boxed{\begin{aligned} O_2,\ O_3 &: 0 \\ H_2O &: -2 \\ H_2O_2 &: -1 \\ OF_2 &: +2 \\ O_2F_2 &: +1 \end{aligned}}$$

Whenever oxygen combines with fluorine, oxygen has a positive oxidation state because fluorine is the most electronegative element.

---

8. Which colligative property is most suitable for determining molar mass?

(A) Relative lowering of vapour pressure
(B) Elevation in boiling point
(C) Depression in freezing point
(D) Osmotic pressure

Correct Answer: (D)

Solution:

Concept:

Colligative properties depend only on the number of solute particles present in a solution and not on their chemical nature.

The four important colligative properties are:

- Relative lowering of vapour pressure

- Elevation in boiling point
- Depression in freezing point
- Osmotic pressure

Among these, osmotic pressure is the most accurate method for determining the molar masses of macromolecules such as proteins and polymers because it can be measured even in very dilute solutions.

The osmotic pressure equation is

$$\boxed{\pi = \frac{nRT}{V}}$$

or

$$\boxed{\pi = CRT}$$

where

$$\pi = \text{Osmotic pressure,}$$

$$C = \text{Molar concentration.}$$

Step 1: Understand the advantages of osmotic pressure.

Osmotic pressure can be measured accurately at room temperature.
It does not require heating or cooling of the solution.
Therefore, decomposition of solute molecules is avoided.

Step 2: Compare with other colligative properties.

Relative lowering of vapour pressure is usually very small.
Elevation in boiling point and depression in freezing point require comparatively concentrated solutions.
Osmotic pressure can be measured even for dilute solutions and gives highly accurate results.

Step 3: Identify the correct option.

Hence, the most suitable colligative property for determining molar mass is

$$\boxed{\text{Osmotic pressure.}}$$

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Among all colligative properties,

$$\boxed{\text{Osmotic pressure}}$$

is preferred for determining the molar masses of proteins, polymers and other high molecular mass compounds because it can be measured accurately in dilute solutions.

---

9. Match the Column-I (Ligands) with Column-II (Ligand type):
Column-I: (I) NO_2^-, (II) OH^-, (III) $C_2O_4^{2-}$, (IV) EDTA.
Column-II: (A) Hexadentate, (B) Bidentate, (C) Monodentate, (D) Ambidentate.

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

Correct Answer: (A)

Solution:

Concept:
Ligands are ions or molecules that donate one or more lone pairs of electrons to a central metal atom or ion to form coordinate bonds.
Depending upon the number of donor atoms, ligands are classified as:

- Monodentate ligand – donates one lone pair.

- Bidentate ligand – donates two lone pairs.
- Hexadentate ligand – donates six lone pairs.
- Ambidentate ligand – has two different donor atoms but can coordinate through only one at a time.

Step 1: Identify the type of each ligand.

$$NO_2^-$$

can coordinate through nitrogen or oxygen atoms.

Hence,

$$\boxed{NO_2^- \rightarrow \text{Ambidentate.}}$$

$$OH^-$$

has only one donor atom (oxygen).

Hence,

$$\boxed{OH^- \rightarrow \text{Monodentate.}}$$

$$C_2O_4^{2-}$$

(oxalate ion) coordinates through two oxygen atoms.

Hence,

$$\boxed{C_2O_4^{2-} \rightarrow \text{Bidentate.}}$$

EDTA possesses six donor atoms.

Hence,

$$\boxed{EDTA \rightarrow \text{Hexadentate.}}$$

Step 2: Match the columns.

Therefore,

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

This matches

$$\boxed{\textbf{Option (A)}}.$$

Quick Tip: Remember these important ligands:

$$\boxed{\begin{aligned} OH^- &\to \text{Monodentate} \\ H_2O &\to \text{Monodentate} \\ NH_3 &\to \text{Monodentate} \\ NO_2^- &\to \text{Ambidentate} \\ SCN^- &\to \text{Ambidentate} \\ C_2O_4^{2-} &\to \text{Bidentate} \\ EDTA &\to \text{Hexadentate} \end{aligned}}$$

These ligands are frequently asked in competitive examinations.

---

10. Why do aryl halides not show nucleophilic substitution reaction?

(A) The C–X bond has partial double bond character due to resonance.

(B) There is very high steric hindrance in the benzene ring.

(C) The size of the halogen atom is very small.

(D) Aryl carbocation is highly stable.

Correct Answer: (A)

Solution:

Concept:
Aryl halides are much less reactive towards nucleophilic substitution than alkyl halides.
The main reason is the resonance between the halogen atom and the benzene ring.
The lone pair of electrons on the halogen atom participates in resonance with the aromatic ring, giving the carbon-halogen bond partial double bond character.
As a result,

- The C–X bond becomes shorter and stronger.
- Bond cleavage becomes difficult.
- Nucleophilic substitution does not occur easily.

Step 1: Understand the effect of resonance.

In aryl halides, the halogen atom donates its lone pair into the benzene ring.
Therefore,

$$\boxed{\text{C–X bond acquires partial double bond character.}}$$

This strengthens the bond considerably.

Step 2: Why does substitution become difficult?

Because of the partial double bond character,

$$\boxed{\text{The C–X bond is difficult to break.}}$$

Hence, neither the S_N1 nor the S_N2 mechanism proceeds easily.

Step 3: Examine the options.

Option (A):

$$\boxed{\text{Correct}}$$

because resonance gives partial double bond character.

Option (B):

Steric hindrance is not the primary reason.

Option (C):

The size of the halogen atom is not responsible.

Option (D):

Aryl carbocations are highly unstable, not stable.

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember why aryl halides are less reactive:

$$\boxed{\text{Resonance} \Rightarrow \text{Partial double bond character}}$$

Therefore,

$$\boxed{\text{Stronger C–X bond}}$$

which resists nucleophilic substitution.

This is one of the most frequently asked concepts in Haloarenes.

---

11. What is the hybridisation of carbon atoms in $CH_2 = CH - CN$ (Acrylonitrile)?

(A) $C_1 = sp^3,\ C_2 = sp^3,\ C_3 = sp$

(B) $C_1 = sp^2,\ C_2 = sp^2,\ C_3 = sp$

(C) $C_1 = sp^2,\ C_2 = sp,\ C_3 = sp^2$

(D) All carbon atoms are sp^2 hybridised.

Correct Answer: (B)

Solution:

Concept:

Hybridisation depends upon the steric number (number of σ-bonds and lone pairs) around the atom.

$$\boxed{\begin{aligned} sp &\rightarrow 2 \text{ electron domains (linear)} \\ sp^2 &\rightarrow 3 \text{ electron domains (trigonal planar)} \\ sp^3 &\rightarrow 4 \text{ electron domains (tetrahedral)} \end{aligned}}$$

The structure of acrylonitrile is

$$CH_2 = CH - C \equiv N.$$

The carbon atom of the nitrile group forms a triple bond with nitrogen and is therefore sp-hybridised.

Step 1: Determine the hybridisation of the first carbon.

The first carbon is

$$CH_2.$$

It is involved in one double bond and two single bonds.
Hence, it has three electron domains.
Therefore,

$$\boxed{C_1 = sp^2.}$$

Step 2: Determine the hybridisation of the second carbon.

The second carbon is attached by

- one double bond,
- one single bond to the nitrile carbon,
- one single bond to hydrogen.

Thus, it also has three electron domains.
Hence,

$$\boxed{C_2 = sp^2.}$$

Step 3: Determine the hybridisation of the nitrile carbon.

The third carbon is

$$C \equiv N.$$

It forms

- one triple bond with nitrogen,
- one single bond with carbon.

Therefore, it possesses two electron domains.

Hence,

$$\boxed{C_3 = sp.}$$

Thus, the hybridisation is

$$\boxed{C_1 = sp^2,\ C_2 = sp^2,\ C_3 = sp.}$$

Therefore,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember these hybridisations:

$$\boxed{\begin{array}{c} C = C \to sp^2 \\ C \equiv C \to sp \\ C \equiv N \to sp \\ C - C \to sp^3 \end{array}}$$

In nitriles ($-C \equiv N$), the carbon atom is always sp-hybridised.

12. What is the structure of Cyclohexyl methanol?

(A) $C_6H_5 - CH_2OH$ (Benzyl alcohol)

(B) $C_6H_{11} - CH_2OH$ (Cyclohexyl methanol)

(C) $C_6H_{11} - OH$ (Cyclohexanol)

(D) $CH_3 - C_6H_{10} - OH$ (Methyl cyclohexanol)

Correct Answer: (B)

Solution:

Concept:

In IUPAC nomenclature, the name "cyclohexyl methanol" indicates that a cyclohexyl group is attached to a methanol group.

A cyclohexyl group is obtained by removing one hydrogen atom from cyclohexane.

Its formula is

$$\boxed{C_6H_{11}-}$$

The methanol group is

$$\boxed{-CH_2OH.}$$

Combining both gives

$$\boxed{C_6H_{11} - CH_2OH.}$$

Step 1: Identify the cyclohexyl group.

Cyclohexane has the formula

$$C_6H_{12}.$$

After removing one hydrogen atom,

$$C_6H_{11}-,$$

which is called the cyclohexyl group.

Step 2: Attach the methanol group.

Methanol contributes the group

$$-CH_2OH.$$

Thus,

$$C_6H_{11} + CH_2OH = C_6H_{11} - CH_2OH.$$

Step 3: Compare the given options.

Option (A):

$$C_6H_5CH_2OH$$

is benzyl alcohol.

Option (B):

$$C_6H_{11}CH_2OH$$

is cyclohexyl methanol.

Option (C):

$$C_6H_{11}OH$$

is cyclohexanol.

Option (D):

represents methyl cyclohexanol.

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Do not confuse these compounds:

$$\boxed{\begin{array}{c} C_6H_5CH_2OH \rightarrow \text{Benzyl alcohol} \\ C_6H_{11}CH_2OH \rightarrow \text{Cyclohexyl methanol} \\ C_6H_{11}OH \rightarrow \text{Cyclohexanol} \end{array}}$$

The suffix "methanol" indicates that the $-CH_2OH$ group lies outside the ring.

---

13. An unknown element 'E' forms two compounds: EO_2 and EX_4. To which group does element 'E' belong?

(A) 13th group (B, Al)
(B) 14th group (C, Si)
(C) 15th group (N, P)
(D) 16th group (O, S)

Correct Answer: (B)

Solution:

Concept:

The valency and oxidation state of an element can often be determined from the formulas of its compounds.

The oxidation state of oxygen is generally

$$\boxed{-2.}$$

Similarly, halogens such as fluorine or chlorine generally have an oxidation state of

$$\boxed{-1.}$$

The compounds formed by an element help identify its group in the periodic table.

Step 1: Determine the oxidation state of E in EO_2.

Let the oxidation state of E be x.

Since oxygen has oxidation state -2,

$$x + 2(-2) = 0.$$

Therefore,

$$x - 4 = 0,$$

$$x = +4.$$

Thus,

$$\boxed{E \text{ exhibits oxidation state } +4.}$$

Step 2: Determine the oxidation state of E in EX_4.

Assuming X is a halogen,

$$X = -1.$$

Hence,

$$x + 4(-1) = 0.$$

Therefore,

$$x = +4.$$

Again,

$$\boxed{E \text{ has oxidation state } +4.}$$

Step 3: Identify the group of the element.

Elements of Group 14 commonly exhibit a valency of four and form compounds such as

$$CO_2,\ SiO_2,\ CCl_4,\ SiCl_4.$$

Thus, the unknown element belongs to

$$\boxed{\text{Group 14.}}$$

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember these common compounds:

$$\boxed{\begin{array}{c} CO_2,\ CCl_4 \\ SiO_2,\ SiCl_4 \end{array}}$$

Both carbon and silicon belong to

$$\boxed{\text{Group 14.}}$$

If an element forms compounds of the type EO_2 and EX_4, it generally belongs to Group 14.

---

14. What is formed on aromatisation of heptane?

(A) Benzene

(B) Toluene

(C) Xylene

(D) Ethylbenzene

Correct Answer: (B)

Solution:

Concept:
Aromatisation is the process in which straight-chain alkanes are converted into aromatic hydrocarbons by heating in the presence of suitable catalysts such as platinum, chromium oxide or aluminium oxide.
During aromatisation,

- Cyclisation occurs.
- Dehydrogenation takes place.
- An aromatic ring is formed.

The products formed depend upon the number of carbon atoms present in the alkane.

Step 1: Identify the alkane.

The given compound is

$$\boxed{\text{Heptane } (C_7H_{16}).}$$

It contains seven carbon atoms.

Step 2: Apply the aromatisation reaction.

On aromatisation,

$$C_7H_{16}$$

undergoes cyclisation and dehydrogenation to produce

$$\boxed{C_6H_5CH_3}$$

which is

$$\boxed{\text{Toluene.}}$$

The reaction may be represented as

$$C_7H_{16} \longrightarrow C_6H_5CH_3 + 4H_2.$$

Step 3: Identify the product.

The aromatic compound formed from heptane is

$$\boxed{\text{Toluene.}}$$

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember the important aromatisation reactions:

$$\boxed{\begin{array}{l} C_6H_{14} \to C_6H_6 \quad \text{(Benzene)} \\ C_7H_{16} \to C_6H_5CH_3 \quad \text{(Toluene)} \\ C_8H_{18} \to C_6H_4(CH_3)_2 \quad \text{(Xylene)} \end{array}}$$

These conversions are frequently asked in examinations.

---

15. Hinsberg reaction is used to test which compound and what is the reagent?

(A) Aldehyde test, reagent: Tollens' reagent

(B) Primary, secondary and tertiary amine test, reagent: $C_6H_5SO_2Cl + NaOH$

(C) Alcohol test, reagent: Lucas reagent

(D) Carboxylic acid test, reagent: $NaHCO_3$

Correct Answer: (B)

Solution:

Concept:

The Hinsberg reaction is a qualitative test used to distinguish between primary, secondary and tertiary amines.

The reagent employed is Hinsberg reagent, which is benzenesulphonyl chloride,

$$\boxed{C_6H_5SO_2Cl}$$

used in the presence of aqueous sodium hydroxide.

Depending on the type of amine, different products are formed, making identification possible.

Step 1: Identify the purpose of the Hinsberg reaction.

The Hinsberg test is specifically used to identify

$$\boxed{\text{Primary, Secondary and Tertiary amines.}}$$

It is not used for aldehydes, alcohols or carboxylic acids.

Step 2: Identify the reagent used.

The reagent required is

$$\boxed{C_6H_5SO_2Cl}$$

(Benzenesulphonyl chloride)

in the presence of

$$\boxed{NaOH.}$$

This reagent is commonly known as Hinsberg reagent.

Step 3: Compare the options.

Option (A):

Tollens' reagent is used for aldehydes.

Option (B):

Correctly states the purpose and reagent.

Option (C):

Lucas reagent is used for classification of alcohols.

Option (D):

Sodium bicarbonate is used to identify carboxylic acids.

Therefore,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember these important qualitative tests:

$$\boxed{\begin{aligned}\text{Hinsberg Test} &\rightarrow \text{Amines}\\ \text{Lucas Test} &\rightarrow \text{Alcohols}\\ \text{Tollens' Test} &\rightarrow \text{Aldehydes}\\ NaHCO_3 &\rightarrow \text{Carboxylic Acids}\end{aligned}}$$

Hinsberg reagent is

$$\boxed{C_6H_5SO_2Cl + NaOH.}$$

---

16. What is present in a racemic mixture?

(A) Only dextrorotatory (D) form is present.

(B) Only laevorotatory (L) form is present.

(C) D and L forms are present in a 1:1 ratio, making the mixture optically inactive.

(D) It is a meso compound.

Correct Answer: (C)

Solution:

Concept:

A racemic mixture is an equimolar mixture of two enantiomers.

The two enantiomers are:

- Dextrorotatory (+ or D) form
- Laevorotatory (— or L) form

Each rotates plane-polarised light by the same magnitude but in opposite directions.

As a result, their optical rotations cancel each other, making the racemic mixture optically inactive.

This phenomenon is known as external compensation.

Step 1: Understand the composition of a racemic mixture.

A racemic mixture contains

$$\boxed{\text{50\% D-form } + \text{50\% L-form.}}$$

Thus, both enantiomers are present in equal amounts.

Step 2: Determine its optical activity.

The D-form rotates plane-polarised light to the right.
The L-form rotates it by the same amount to the left.
Hence,

$$(+\alpha)+(-\alpha)=0.$$

Therefore,

$$\boxed{\text{The mixture is optically inactive.}}$$

Step 3: Choose the correct option.

A racemic mixture contains

$$\boxed{\text{D and L forms in a 1 : 1 ratio.}}$$

Therefore,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Do not confuse these terms:

$$\boxed{\begin{array}{c}\text{Racemic mixture} \rightarrow \text{External compensation}\\ \text{Meso compound} \rightarrow \text{Internal compensation}\end{array}}$$

A racemic mixture contains

$$\boxed{50\%\ \text{D-form} + 50\%\ \text{L-form}}$$

and is therefore optically inactive.

---

17. What type of nitrogenous base is Uracil and what is its structure?

(A) Purine base → 2 rings, structure similar to adenine

(B) Pyrimidine base → 1 ring, 2 keto groups at C2 & C4; structure similar to thymine but without $-CH_3$ at C5

(C) Purine base → 1 ring, 3 keto groups

(D) Pyrimidine base → 2 rings, 1 keto group

Correct Answer: (B)

Solution:

Concept:
Nitrogenous bases present in nucleic acids are classified into two groups:

- **Purines:** Adenine (A) and Guanine (G) — contain two fused rings.
- **Pyrimidines:** Cytosine (C), Thymine (T) and Uracil (U) — contain a single six-membered ring.

Uracil is present in RNA and differs from thymine by the absence of a methyl group at the fifth carbon atom.

Step 1: Identify the class of Uracil.

Uracil belongs to the pyrimidine family of nitrogenous bases.
Hence,

$$\boxed{\text{Uracil is a pyrimidine base.}}$$

It contains

$$\boxed{\text{one six-membered ring.}}$$

Step 2: Study its structure.

Uracil possesses

- Two keto $(=O)$ groups at carbon atoms C2 and C4.
- No methyl group at the C5 position.

Thymine has a methyl group at C5, whereas Uracil does not.

Thus,

$$\boxed{\text{Uracil is similar to thymine except for the absence of } -CH_3.}$$

Step 3: Choose the correct option.

Therefore,

$$\boxed{\text{Uracil is a pyrimidine base having one ring and two keto groups.}}$$

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember the nitrogenous bases:

$$\boxed{\begin{array}{c}\text{Purines}: A,\ G\\ \text{Pyrimidines}: C,\ T,\ U\end{array}}$$

Uracil is present only in RNA and is structurally similar to thymine, except that it lacks the methyl ($-CH_3$) group at C5.

---

18. Match Column-I (Type of isomerism) with Column-II (Examples):

Column-I	**Column-II**
A. Linkage isomerism	1. $[Co(NH_3)_5SO_4]Br/[Co(NH_3)_5Br]SO_4$
B. Ionisation isomerism	2. $[Co(NH_3)_5(NO_2)]Cl_2/[Co(NH_3)_5(ONO)]Cl_2$
C. Coordination isomerism	3. $[Co(NH_3)_6][Cr(CN)_6]/[Cr(NH_3)_6][Co(CN)_6]$

(A) A-2, B-1, C-3

(B) A-1, B-2, C-3

(C) A-3, B-2, C-1

(D) A-2, B-3, C-1

Correct Answer: (A)

Solution:

Concept:

Coordination compounds exhibit several types of structural isomerism.

The important ones are:

- **Linkage isomerism**: Caused by ambidentate ligands such as NO_2^- and SCN^-.
- **Ionisation isomerism**: Caused by exchange between a coordinated ion and a counter ion.
- **Coordination isomerism**: Occurs in compounds containing both cationic and anionic complex ions due to interchange of ligands.

Step 1: Identify the linkage isomer.

The ligand NO_2^- can coordinate through either nitrogen or oxygen.

Thus,

$$[Co(NH_3)_5(NO_2)]Cl_2$$

and

$$[Co(NH_3)_5(ONO)]Cl_2$$

are linkage isomers.

Hence,

$$\boxed{A \to 2.}$$

Step 2: Identify the ionisation isomer.

The compounds

$$[Co(NH_3)_5SO_4]Br$$

and

$$[Co(NH_3)_5Br]SO_4$$

differ by interchange of the coordinated ion and counter ion.

Hence,

$$\boxed{B \to 1.}$$

Step 3: Identify the coordination isomer.

The compounds

$$[Co(NH_3)_6][Cr(CN)_6]$$

and

$$[Cr(NH_3)_6][Co(CN)_6]$$

are formed by interchange of ligands between two complex ions.

Hence,

$$\boxed{C \rightarrow 3.}$$

Thus,

$$\boxed{A-2,\ B-1,\ C-3}$$

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember these common examples:

$$\boxed{\begin{array}{r}NO_2^-,\ SCN^- \rightarrow \text{Linkage isomerism} \\ \text{Counter ion exchange} \rightarrow \text{Ionisation isomerism} \\ \text{Ligand exchange between complexes} \rightarrow \text{Coordination isomerism}\end{array}}$$

These examples are among the most frequently asked in Coordination Chemistry.

---

19. Which of the following groups increases the acidic strength of carboxylic acid?

(A) CH_3

(B) $-C_2H_5$

(C) $-OCH_3$

(D) $-NO_2$

Correct Answer: (D)

Solution:

Concept:

The acidic strength of carboxylic acids depends upon the stability of the conjugate base (carboxylate ion).

- Electron-withdrawing groups ($-I$ effect) increase acidity by stabilising the carboxylate ion.
- Electron-donating groups ($+I$ effect) decrease acidity by destabilising the carboxylate ion.

The stronger the electron-withdrawing effect, the greater is the acidic strength.

Step 1: Identify the nature of each substituent.

$$CH_3$$

and

$$C_2H_5$$

are electron-donating alkyl groups.
Hence, they decrease acidity.

The methoxy group,

$$-OCH_3,$$

shows a weak electron-withdrawing inductive effect but also exhibits resonance donation.
Its overall effect is much weaker than that of the nitro group.

The nitro group,

$$-NO_2,$$

has a very strong electron-withdrawing ($-I$) effect.
It stabilises the carboxylate ion effectively.

Step 2: Determine the acidic strength.

Since the conjugate base becomes more stable in the presence of the nitro group,

$$\boxed{\text{Acidity increases significantly.}}$$

Thus,

$$-NO_2$$

produces the strongest carboxylic acid among the given options.

Step 3: Choose the correct option.

Therefore,

$$\boxed{-NO_2}$$

is the substituent that increases acidic strength.

Hence,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\begin{array}{l} -I \text{ groups} \rightarrow \text{Increase acidity} \\ +I \text{ groups} \rightarrow \text{Decrease acidity} \end{array}}$$

Examples of strong electron-withdrawing groups are

$$\boxed{-NO_2, -CN, -Cl, -F.}$$

Among these, the nitro group produces a marked increase in the acidic strength of carboxylic acids.

---

20. Match Column-I with Column-II:

Column-I	**Column-II**
A. Homoleptic	I. Complex containing different ligands
B. Heteroleptic	II. Ligand having two donor atoms
C. Hexadentate	III. Complex containing only one type of ligand
D. Bidentate	IV. Ligand having six donor atoms

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

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

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

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

Correct Answer: (A)

Solution:

Concept:
Ligands and coordination compounds are classified according to the number and type of donor atoms.
Important definitions are:

- Homoleptic complex – contains only one kind of ligand.
- Heteroleptic complex – contains two or more different kinds of ligands.
- Bidentate ligand – has two donor atoms.
- Hexadentate ligand – has six donor atoms.

Step 1: Match Homoleptic and Heteroleptic complexes.

A homoleptic complex contains only one type of ligand.
Hence,

$$\boxed{A \rightarrow III.}$$

A heteroleptic complex contains different kinds of ligands.
Hence,

$$\boxed{B \to I.}$$

Step 2: Match denticity of ligands.

A hexadentate ligand has six donor atoms.

For example,

$$\boxed{\text{EDTA.}}$$

Therefore,

$$\boxed{C \to IV.}$$

A bidentate ligand has two donor atoms.

For example,

$$\boxed{C_2O_4^{2-}}$$

or ethylenediamine.

Hence,

$$\boxed{D \to II.}$$

Step 3: Determine the correct matching.

Thus,

$$\boxed{A-III,\ B-I,\ C-IV,\ D-II}$$

which corresponds to

$$\boxed{\textbf{Option (A)}}$$

according to the given options.

Quick Tip: Remember the following definitions:

$$\boxed{\begin{aligned} \text{Homoleptic} &\rightarrow \text{One type of ligand} \\ \text{Heteroleptic} &\rightarrow \text{Different ligands} \\ \text{Bidentate} &\rightarrow \text{Two donor atoms} \\ \text{Hexadentate} &\rightarrow \text{Six donor atoms (EDTA)} \end{aligned}}$$

These definitions are frequently tested in Coordination Chemistry.

---

21. Which is the correct pair of chelating and ambidentate ligands?

(A) Chelating: en, Ambidentate: NO_2^-

(B) Chelating: NH_3, Ambidentate: H_2O

(C) Chelating: Cl^-, Ambidentate: en

(D) Chelating: NO_2^-, Ambidentate: $C_2O_4^{2-}$

Correct Answer: (A)

Solution:

Concept:

Ligands are classified according to the number of donor atoms and the manner in which they coordinate with the central metal ion.

- **Chelating ligands** possess two or more donor atoms and form one or more rings (chelates) with the metal ion.
- **Ambidentate ligands** possess two different donor atoms but coordinate through only one donor atom at a time.

Examples:

$$\boxed{\begin{aligned} \text{Chelating ligands}: en,\ C_2O_4^{2-},\ EDTA \\ \text{Ambidentate ligands}: NO_2^-,\ SCN^-,\ CN^- \end{aligned}}$$

Step 1: Identify the chelating ligand.

Ethylenediamine (en) contains two nitrogen donor atoms.

It coordinates through both nitrogen atoms simultaneously and forms a five-membered chelate ring.

Hence,

$$\boxed{en \text{ is a chelating (bidentate) ligand.}}$$

Step 2: Identify the ambidentate ligand.

The nitrite ion,

$$NO_2^-,$$

can coordinate either through the nitrogen atom (nitro) or through the oxygen atom (nitrito).

However, it uses only one donor atom at a time.

Therefore,

$$\boxed{NO_2^- \text{ is an ambidentate ligand.}}$$

Step 3: Examine the remaining options.

- NH_3 and H_2O are monodentate ligands.
- Cl^- is also monodentate.
- $C_2O_4^{2-}$ (oxalate) is a chelating ligand, not an ambidentate ligand.

Thus,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the common ligand types:

$$\boxed{\begin{aligned} NH_3,\ H_2O,\ Cl^- &\rightarrow \text{Monodentate} \\ en,\ C_2O_4^{2-} &\rightarrow \text{Chelating (Bidentate)} \\ EDTA &\rightarrow \text{Hexadentate} \\ NO_2^-,\ SCN^- &\rightarrow \text{Ambidentate} \end{aligned}}$$

Chelating ligands form ring structures with the central metal ion.

---

22. What happens when an ideal gas undergoes isothermal expansion into vacuum?

(A) $w = 0,\ Q = 0$

(B) $Q = +ve,\ w = -ve$

(C) $w = -ve,\ Q = +ve$

(D) $w = 0$

Correct Answer: (A)

Solution:

Concept:

Expansion of a gas into a vacuum is called **free expansion**.

For free expansion,

$$P_{\text{ext}} = 0.$$

The work done is

$$w = -P_{\text{ext}}\Delta V.$$

Since the external pressure is zero,

$$\boxed{w = 0.}$$

For an ideal gas,

$$\Delta U = nC_V\Delta T.$$

In an isothermal process,

$$\Delta T = 0,$$

therefore,

$$\boxed{\Delta U = 0.}$$

Using the first law of thermodynamics,

$$\Delta U = Q + w.$$

Since both ΔU and w are zero,

$$\boxed{Q = 0.}$$

Step 1: Calculate the work done.

For free expansion,

$$P_{\text{ext}} = 0.$$

Hence,

$$w = -P_{\text{ext}}\Delta V = 0.$$

Thus,

$$\boxed{w = 0.}$$

Step 2: Determine the change in internal energy.

Since the expansion is isothermal,

$$\Delta T = 0.$$

For an ideal gas,

$$\boxed{\Delta U = 0.}$$

Step 3: Apply the First Law of Thermodynamics.

Using,

$$\Delta U = Q + w,$$

we get

$$0 = Q + 0.$$

Therefore,

$$\boxed{Q = 0.}$$

Hence,

$$\boxed{w = 0, \qquad Q = 0.}$$

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: For free expansion of an ideal gas:

$$\boxed{\begin{aligned} P_{\text{ext}} &= 0 \\ w &= 0 \\ \Delta U &= 0 \text{ (isothermal)} \\ Q &= 0 \end{aligned}}$$

Always remember:

$$\boxed{\Delta U = Q + w}$$

is the First Law of Thermodynamics.

---

23. What is the structure of Tetrahydrofuran (THF)?

(A) 5-membered saturated ring with 1 oxygen and 4 carbon atoms

(B) 4-membered ring with 1 oxygen and 3 carbon atoms

(C) 6-membered ring with 2 oxygen atoms

(D) Benzene ring containing oxygen

Correct Answer: (A)

Solution:

Concept:

Tetrahydrofuran (THF) is a saturated cyclic ether obtained by the hydrogenation of furan.

Its molecular formula is

$$\boxed{C_4H_8O.}$$

THF consists of

- One oxygen atom.
- Four carbon atoms.
- A five-membered saturated ring.

It is widely used as a polar aprotic solvent in organic chemistry.

Step 1: Understand the structure of THF.

The ring contains

$$4 \text{ carbon atoms } + 1 \text{ oxygen atom.}$$

Hence, the total number of atoms in the ring is

$$\boxed{5.}$$

Step 2: Determine whether the ring is saturated or unsaturated.

Unlike furan, THF contains only single bonds.

Therefore,

$$\boxed{\text{THF is a saturated cyclic ether.}}$$

Step 3: Compare with the given options.

- Option (A): Correct description of THF.
- Option (B): Represents oxetane (4-membered ring).
- Option (C): Represents a six-membered oxygen-containing ring.
- Option (D): Incorrect because THF is non-aromatic.

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the important oxygen-containing heterocyclic compounds:

Oxirane → 3-membered ring
Oxetane → 4-membered ring
THF → 5-membered saturated ring
Furan → 5-membered aromatic ring

THF is one of the most commonly used polar aprotic solvents.

---

24. In the presence of Grignard reagent (RMgX), which of the following is used to prepare a carboxylic acid?

(A) NH_3
(B) CO_2 (Dry ice)
(C) H_2O
(D) O_2

Correct Answer: (B)

Solution:

Concept:
Grignard reagents ($RMgX$) are highly reactive organometallic compounds.
They behave as strong nucleophiles and react with carbon dioxide (dry ice) to produce magnesium carboxylates, which upon acid hydrolysis give carboxylic acids.
The reaction is

$$RMgX + CO_2 \longrightarrow RCOOMgX \xrightarrow{H_3O^+} RCOOH.$$

Thus, carbon dioxide is the reagent used for preparing carboxylic acids from Grignard reagents.

Step 1: Reaction of Grignard reagent with carbon dioxide.

Grignard reagent reacts readily with dry ice:

$$RMgX + CO_2 \rightarrow RCOOMgX.$$

This forms a magnesium salt of the carboxylic acid.

Step 2: Hydrolysis of the intermediate.

The magnesium salt is hydrolysed using dilute acid.

$$RCOOMgX \xrightarrow{H_3O^+} RCOOH.$$

Thus, the final product is

$$\boxed{\text{Carboxylic acid.}}$$

Step 3: Analyse the remaining options.

- NH_3 does not produce carboxylic acids with Grignard reagents.
- H_2O simply decomposes the Grignard reagent.
- O_2 forms different oxidation products.

Therefore,

$$\boxed{CO_2}$$

is the correct reagent.

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Important Grignard reactions:

$$\boxed{\begin{aligned} RMgX + HCHO &\rightarrow 1^\circ \text{ alcohol} \\ RMgX + \text{Aldehyde} &\rightarrow 2^\circ \text{ alcohol} \\ RMgX + \text{Ketone} &\rightarrow 3^\circ \text{ alcohol} \\ RMgX + CO_2 &\rightarrow \text{Carboxylic acid} \end{aligned}}$$

Always remember that dry ice (CO_2) is used to prepare carboxylic acids from Grignard reagents.

---

25. A nucleoside differs from a nucleotide because it lacks:

(A) Nitrogenous base

(B) Pentose sugar

(C) Phosphate group

(D) Glycosidic bond

Correct Answer: (C)

Solution:

Concept:

Nucleosides and nucleotides are the building blocks of nucleic acids.

A nucleoside consists of:

$$\boxed{\text{Nitrogenous base} + \text{Pentose sugar}}$$

A nucleotide consists of:

$$\boxed{\text{Nitrogenous base} + \text{Pentose sugar} + \text{Phosphate group}}$$

Thus, a nucleotide is simply a nucleoside attached to one or more phosphate groups.

Step 1: Understand the composition of a nucleoside.

A nucleoside contains

$$\boxed{\begin{array}{l}\text{Nitrogenous base}\\ +\text{Pentose sugar}\end{array}}$$

The base and sugar are joined by an

$$\boxed{\beta\text{-N-glycosidic bond.}}$$

Step 2: Understand the composition of a nucleotide.

A nucleotide contains

$$\boxed{\begin{array}{l}\text{Nitrogenous base}\\ +\text{Pentose sugar}\\ +\text{Phosphate group}\end{array}}$$

The phosphate group is attached to the sugar by a phosphoester bond.

Step 3: Identify the missing component.

The only difference between a nucleoside and a nucleotide is the presence of a phosphate group.

Hence,

$$\boxed{\text{Nucleoside} = \text{Nucleotide} - \text{Phosphate group.}}$$

Therefore,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Remember the relation:

$$\boxed{\text{Nucleoside} + \text{Phosphate} = \text{Nucleotide}}$$

Examples:

$$\boxed{\begin{aligned}\text{Adenosine} &\rightarrow \text{Nucleoside}\\ \text{AMP} &\rightarrow \text{Nucleotide}\end{aligned}}$$

The phosphate group is the distinguishing feature of a nucleotide.

---

26. $[Co(H_2O)_6]^{2+}$ (Pink) $+4Cl^- \rightleftharpoons [CoCl_4]^{2-}$ (Blue) $+6H_2O$ (Endothermic reaction). If the mixture is transferred from room temperature to a freezing ice bath, what is expected to happen?

(A) Colour will remain the same

(B) Colour will become deeper blue

(C) It will become colourless

(D) Colour will become pink

Correct Answer: (D)

Solution:

Concept:

The given equilibrium is

$$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O.$$

The forward reaction is stated to be endothermic.

According to Le Chatelier's principle,

- Increasing temperature favours the endothermic direction.
- Decreasing temperature favours the exothermic (reverse) direction.

Therefore, cooling shifts the equilibrium towards the pink hexaaquacobalt(II) complex.

Step 1: Identify the colours of the complexes.

$$\boxed{\begin{aligned} [Co(H_2O)_6]^{2+} &\rightarrow \text{Pink} \\ [CoCl_4]^{2-} &\rightarrow \text{Blue} \end{aligned}}$$

Step 2: Apply Le Chatelier's principle.

Since the forward reaction is endothermic,

$$\boxed{\text{Cooling favours the reverse reaction.}}$$

Hence, the equilibrium shifts towards

$$[Co(H_2O)_6]^{2+}.$$

Step 3: Predict the observed colour.

As more pink complex is formed,
the solution gradually changes from blue to

$$\boxed{\text{Pink.}}$$

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember this important equilibrium:

$$\boxed{[Co(H_2O)_6]^{2+} \rightleftharpoons [CoCl_4]^{2-}}$$

$$\boxed{\begin{array}{l}\text{Pink} \rightarrow [Co(H_2O)_6]^{2+} \\ \text{Blue} \rightarrow [CoCl_4]^{2-}\end{array}}$$

Heating favours the blue complex, whereas cooling favours the pink complex.

---

27. A substance that contains chemically similar atoms, and the atoms always exist in pairs. What is that substance called?

(A) Solution
(B) Element
(C) Compound
(D) Mixture

Correct Answer: (B)

Solution:

Concept:
An **element** is a pure substance made up of only one type of atom.
Some elements exist as individual atoms (monoatomic), while others exist as molecules containing two identical atoms, known as diatomic molecules.
Examples of diatomic elements are

$$\boxed{H_2,\ N_2,\ O_2,\ F_2,\ Cl_2,\ Br_2,\ I_2.}$$

These molecules contain chemically identical atoms bonded together.

Step 1: Analyse the given statement.

The substance contains

- chemically similar atoms,

- atoms existing in pairs.

Thus, it consists of molecules such as

$$H_2, O_2, N_2,$$

where both atoms are identical.

Step 2: Identify the type of substance.

Since only one kind of atom is present,
the substance is classified as

$$\boxed{\text{An Element.}}$$

It is not a compound because compounds contain atoms of different elements.
It is also not a mixture or solution.

Step 3: Choose the correct option.

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\begin{array}{c}\text{Element} \rightarrow \text{Only one type of atom} \\ \text{Compound} \rightarrow \text{Two or more different atoms chemically combined} \\ \text{Mixture} \rightarrow \text{Physical combination of substances}\end{array}}$$

Many elemental gases exist as diatomic molecules such as H_2, N_2, O_2, Cl_2.

---

28. A molecule has two bonds of equal length, but its Lewis structure shows one single bond and one double bond. This is best explained by:

(A) Resonance

(B) Hybridisation

(C) Polarisation

(D) Ionization

Correct Answer: (A)

Solution:

Concept:

Resonance is the phenomenon in which a molecule cannot be represented accurately by a single Lewis structure.
Instead, it is represented by two or more contributing (canonical) structures.
The actual molecule is a resonance hybrid of all contributing structures.
As a result,

- the electrons become delocalised,
- bond lengths become equal,
- bond order becomes fractional.

Step 1: Analyse the given information.

The Lewis structure shows

- one single bond,
- one double bond.

However, experimentally both bonds have the same length.
This indicates that electrons are not confined to one bond.

Step 2: Explain using resonance.

Because of resonance,
the bonding electrons are delocalised over the entire molecule.
Therefore, both bonds become equivalent.

A common example is the carbonate ion,

$$CO_3^{2-},$$

where all three C–O bonds have equal lengths.
Similarly,

$$O_3$$

and

$$NO_2^-$$

also exhibit equal bond lengths due to resonance.

Step 3: Choose the correct option.

Equal bond lengths despite different Lewis structures can only be explained by

$$\boxed{\text{Resonance.}}$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Resonance leads to:

$$\boxed{\begin{array}{l}\text{Equal bond lengths}\\ \text{Fractional bond order}\\ \text{Delocalisation of electrons}\\ \text{Greater molecular stability}\end{array}}$$

Common examples:

$$\boxed{O_3,\ CO_3^{2-},\ NO_3^-,\ NO_2^-,\ C_6H_6}$$

29. A cell has a standard electrode potential of $0.354\,V$ at $298\,K$. If 2 electrons are transferred in the cell reaction, what is the equilibrium constant (K) of the reaction at $298\,K$?

(A) 1×10^{12}

(B) 1×10^{11}

(C) 1×10^{10}

(D) 1×10^{13}

Correct Answer: (A)

Solution:

Concept:

The relationship between the standard cell potential and the equilibrium constant is

$$\boxed{E^\circ = \frac{0.0591}{n}\log K}$$

where

- E° = Standard cell potential,
- n = Number of electrons transferred,
- K = Equilibrium constant.

A positive value of E° indicates that the reaction is spontaneous and has a large equilibrium constant.

Step 1: Write the given data.

$$E^\circ = 0.354\,V$$

$$n = 2$$

Step 2: Apply the Nernst equation.

Using

$$E^\circ = \frac{0.0591}{n}\log K,$$

we get

$$0.354 = \frac{0.0591}{2}\log K.$$

Hence,

$$\log K = \frac{0.354 \times 2}{0.0591}$$

$$= \frac{0.708}{0.0591}$$

$$\approx 11.98 \approx 12.$$

Step 3: Calculate the equilibrium constant.

$$K = 10^{12}.$$

Therefore,

$$\boxed{K \approx 1 \times 10^{12}.}$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: At 298 K,

$$\boxed{E^\circ = \frac{0.0591}{n}\log K}$$

Remember:

$$\boxed{\begin{array}{l} E^\circ > 0 \Rightarrow K > 1 \\ E^\circ < 0 \Rightarrow K < 1 \end{array}}$$

A larger value of E° corresponds to a larger equilibrium constant.

---

30. Which transition element of the 3d series does not show variable oxidation state?

(A) Scandium (Sc)

(B) Titanium (Ti)

(C) Zinc (Zn)

(D) Chromium (Cr)

Correct Answer: (A)

Solution:

Concept:

Transition elements generally exhibit variable oxidation states because both the $(n-1)d$ and ns electrons participate in bond formation.

However, some elements predominantly exhibit only one stable oxidation state due to their electronic configuration.

Scandium has the electronic configuration

$$\boxed{[Ar]3d^1 4s^2.}$$

It loses all three valence electrons to form

$$\boxed{Sc^{3+}}$$

which has the stable noble gas configuration

$$\boxed{[Ar].}$$

Hence, scandium predominantly exhibits only the +3 oxidation state.

Step 1: Examine the oxidation states of the given elements.

$$Sc : +3$$
$$Ti : +2,\ +3,\ +4$$
$$Cr : +2,\ +3,\ +6$$
$$Zn : +2$$

Among the transition elements, scandium does not exhibit variable oxidation states.

Step 2: Reason for scandium's behaviour.

After losing three electrons,

$$Sc^{3+}$$

attains the stable noble gas configuration

$$[Ar].$$

Further removal of electrons is highly difficult.
Therefore,

$$\boxed{Sc \text{ exhibits only the } +3 \text{ oxidation state.}}$$

Step 3: Choose the correct option.

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the common oxidation states of the first transition series:

$$\boxed{\begin{array}{c} Sc \rightarrow +3 \\ Ti \rightarrow +2, +3, +4 \\ V \rightarrow +2 \text{ to } +5 \\ Cr \rightarrow +2, +3, +6 \\ Mn \rightarrow +2 \text{ to } +7 \end{array}}$$

Scandium is the only transition element of the 3d series that predominantly shows only one oxidation state (+3).

Biology

1. According to the classification of algae, 'brown algae' are placed in which class?

(A) Chlorophyceae (Green)

(B) Rhodophyceae (Red)

(C) Phaeophyceae

(D) Cyanophyceae

Correct Answer: (C)

Solution:

Concept:

Algae are chlorophyll-bearing, simple, autotrophic organisms that are classified mainly on the basis of their pigments, reserve food material and cell wall composition.

The three major classes of algae are:

$$\boxed{\begin{array}{c} \text{Chlorophyceae} \rightarrow \text{Green algae} \\ \text{Phaeophyceae} \rightarrow \text{Brown algae} \\ \text{Rhodophyceae} \rightarrow \text{Red algae} \end{array}}$$

Brown algae possess the pigment fucoxanthin, which gives them their characteristic brown colour.

Step 1: Identify the pigments present in brown algae.

Brown algae contain

$$\boxed{\text{Chlorophyll } a,\ c \text{ and Fucoxanthin.}}$$

Fucoxanthin masks the green colour of chlorophyll, making the algae appear brown.

Step 2: Determine their classification.

Based on the presence of fucoxanthin and other characteristics, brown algae are placed under

$$\boxed{\text{Phaeophyceae.}}$$

Examples include:

$$\boxed{\textit{Sargassum},\ \textit{Laminaria},\ \textit{Fucus}.}$$

Step 3: Compare the options.

- Chlorophyceae → Green algae.
- Rhodophyceae → Red algae.
- Phaeophyceae → Brown algae.
- Cyanophyceae → Blue-green algae (Cyanobacteria).

Therefore,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Remember the major classes of algae:

$$\boxed{\begin{aligned} \text{Green algae} &\rightarrow \text{Chlorophyceae} \\ \text{Brown algae} &\rightarrow \text{Phaeophyceae} \\ \text{Red algae} &\rightarrow \text{Rhodophyceae} \end{aligned}}$$

The pigment **fucoxanthin** is responsible for the brown colour of Phaeophyceae.

---

2. How is the nucleotide different from a nucleoside?

(A) Nitrogen base

(B) Phosphate group

(C) Sugar

(D) Hydrogen bond

Correct Answer: (B)

Solution:

Concept:

Nucleosides and nucleotides are the fundamental units of nucleic acids.

A nucleoside consists of:

$$\boxed{\text{Nitrogenous base} + \text{Pentose sugar}}$$

A nucleotide consists of:

$$\boxed{\text{Nitrogenous base} + \text{Pentose sugar} + \text{Phosphate group}}$$

Thus, a nucleotide differs from a nucleoside by the presence of one or more phosphate groups.

Step 1: Understand the composition of a nucleoside.

A nucleoside contains two components:

$$\boxed{\begin{array}{r}\text{Nitrogenous base}\\ +\text{Pentose sugar}\end{array}}$$

The base is attached to the sugar by a glycosidic bond.

Step 2: Understand the composition of a nucleotide.

A nucleotide consists of:

$$\boxed{\begin{array}{r}\text{Nitrogenous base}\\ +\text{Pentose sugar}\\ +\text{Phosphate group}\end{array}}$$

The phosphate group is attached to the sugar through a phosphoester bond.

Step 3: Identify the distinguishing feature.

The only additional component present in a nucleotide is the phosphate group.

Hence,

$$\boxed{\text{Nucleotide} = \text{Nucleoside} + \text{Phosphate group.}}$$

Therefore,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember the relation:

$$\boxed{\text{Nucleoside} + \text{Phosphate} = \text{Nucleotide}}$$

Examples:

$$\boxed{\begin{aligned} \text{Adenosine} &\rightarrow \text{Nucleoside} \\ \text{AMP (Adenosine Monophosphate)} &\rightarrow \text{Nucleotide} \end{aligned}}$$

The phosphate group is the key difference between a nucleoside and a nucleotide.

---

3. Male heterogamy is not present in:

(A) Human

(B) Grasshopper - XO

(C) Drosophila - XY

(D) Honey bee - haploid-diploid

Correct Answer: (D)

Solution:

Concept:
Heterogamety refers to the condition in which one sex produces two different types of gametes with respect to sex chromosomes.
Male heterogamety is observed in:

$$\boxed{\begin{aligned} &XY \rightarrow \text{Human, Drosophila} \\ &XO \rightarrow \text{Grasshopper} \end{aligned}}$$

In honey bees, sex determination follows the haplodiploid system rather than the XY or XO mechanism.

Step 1: Understand male heterogamety.

A heterogametic male produces two kinds of sperms.
Examples:

$$\boxed{\begin{array}{c} XY \rightarrow X \text{ and } Y \text{ sperms} \\ XO \rightarrow X \text{ and } O \text{ sperms} \end{array}}$$

Step 2: Analyse each option.

- Humans possess the XY system.
- Grasshoppers possess the XO system.
- Drosophila also has the XY system.
- Honey bees exhibit haplodiploid sex determination, where males are haploid (n) and females are diploid ($2n$).

Thus, honey bees do not exhibit male heterogamety.

Step 3: Choose the correct option.

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Important sex-determination systems:

$$\boxed{\begin{array}{r l} XY & \rightarrow \text{Human, Drosophila} \\ XO & \rightarrow \text{Grasshopper} \\ ZW & \rightarrow \text{Birds} \\ \text{Haplodiploid} & \rightarrow \text{Honey bee} \end{array}}$$

Honey bees determine sex by chromosome number rather than sex chromosomes.

---

4. Cotton boll worm and corn borer are killed by which genes?

(A) CryIAc, CryIIAb and CryIAb

(B) CryIAb and CryIIAc

(C) CryIAb, CryIIAb and CryIAc

(D) None of above

Correct Answer: (A)

Solution:

Concept:

Bacillus thuringiensis (Bt) produces crystal (Cry) proteins that are toxic to specific insect pests. Different Cry genes are effective against different insects.

The important Bt genes are:

$$\boxed{\begin{aligned} CryIAc &\rightarrow \text{Cotton bollworm} \\ CryIIAb &\rightarrow \text{Cotton bollworm} \\ CryIAb &\rightarrow \text{Corn borer} \end{aligned}}$$

These genes are introduced into crop plants to provide insect resistance.

Step 1: Identify the Bt genes effective against cotton bollworm.

Cotton bollworm is controlled by

$$\boxed{CryIAc \text{ and } CryIIAb.}$$

These genes produce insecticidal proteins that destroy the larval gut.

Step 2: Identify the Bt gene effective against corn borer.

Corn borer is effectively controlled by

$$\boxed{CryIAb.}$$

This gene is widely used in Bt maize.

Step 3: Select the correct combination.

The combination containing all three genes is

$$CryIAc, CryIIAb, CryIAb.$$

Hence,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the important Bt genes:

$$\boxed{\begin{aligned} CryIAc &\rightarrow \text{Cotton bollworm} \\ CryIIAb &\rightarrow \text{Cotton bollworm} \\ CryIAb &\rightarrow \text{Corn borer} \end{aligned}}$$

Bt crops are genetically modified plants containing Cry genes from *Bacillus thuringiensis*.

---

5. Binomial nomenclature was given by:

(A) Carolus Linnaeus

(B) R.H. Whittaker

(C) Bentham

(D) Darwin

Correct Answer: (A)

Solution:

Concept:

Binomial nomenclature is the scientific system of naming organisms using two words:

$$\boxed{\text{Genus + Species}}$$

This system was introduced by the Swedish botanist

$$\boxed{\text{Carolus Linnaeus.}}$$

It provides a universal scientific name for every organism, avoiding confusion caused by local or common names.

Step 1: Understand binomial nomenclature.

Every scientific name has two parts:

$$\boxed{\begin{array}{r}\text{First word} \rightarrow \text{Genus}\\ \text{Second word} \rightarrow \text{Species}\end{array}}$$

Example:

$$\boxed{\textit{Homo sapiens}}$$

where

$$\textit{Homo} = \text{Genus}, \qquad \textit{sapiens} = \text{Species}.$$

Step 2: Identify the scientist who introduced this system.

Carolus Linnaeus published this naming system in his famous work

$$\boxed{\textit{Species Plantarum}(1753).}$$

Hence, he is regarded as the Father of Taxonomy.

Step 3: Compare the remaining options.

- R.H. Whittaker proposed the Five Kingdom Classification.
- Bentham contributed to plant classification.
- Darwin proposed the theory of evolution.

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember these famous scientists:

Carolus Linnaeus → Binomial nomenclature
R.H. Whittaker → Five Kingdom Classification
Darwin → Theory of Evolution

In scientific names, the genus begins with a capital letter and the species with a small letter.

---

6. Which of the following hormone is not secreted by placenta?

(A) HCG
(B) HPL
(C) Relaxin
(D) Estrogen, progesterone

Correct Answer: (C)

Solution:

Concept:
The placenta functions as an endocrine gland during pregnancy.
It secretes several hormones essential for the maintenance of pregnancy and fetal development.
Major placental hormones include:

HCG (Human Chorionic Gonadotropin)
HPL (Human Placental Lactogen)
Estrogen
Progesterone

Relaxin is mainly secreted by the corpus luteum of the ovary (and later in small amounts during pregnancy), and is generally not considered a principal placental hormone in standard NCERT-based questions.

Step 1: Identify the hormones secreted by the placenta.

The placenta secretes

$$\boxed{HCG,\ HPL,\ Estrogen,\ Progesterone.}$$

These hormones maintain pregnancy and support fetal growth.

Step 2: Analyse Relaxin.

Relaxin helps in

- Relaxation of pelvic ligaments.
- Softening of the cervix before childbirth.

According to the NCERT syllabus, it is primarily associated with the corpus luteum rather than being listed among the major placental hormones.

Step 3: Choose the correct option.

Thus,

$$\boxed{\textbf{Relaxin}}$$

is the hormone that is not considered a placental hormone in this context.
Hence,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Major placental hormones (NCERT):

$$\boxed{\begin{array}{l} HCG \\ HPL \\ Estrogen \\ Progesterone \end{array}}$$

Remember:

$$\boxed{\text{Placenta} = \text{HCG} + \text{HPL} + \text{Estrogen} + \text{Progesterone}}$$

These hormones maintain pregnancy and promote fetal development.

---

7. Which is an example of ex situ conservation?

(A) Sacred grove

(B) Biosphere reserve

(C) National park

(D) Botanical garden

Correct Answer: (D)

Solution:

Concept:

Conservation of biodiversity is of two types:

$$\boxed{\begin{array}{c} \textbf{In situ conservation} \rightarrow \text{Conservation in the natural habitat} \\ \textbf{Ex situ conservation} \rightarrow \text{Conservation outside the natural habitat} \end{array}}$$

Ex situ conservation protects endangered plants and animals by maintaining them in controlled environments.

Examples include botanical gardens, zoological parks, seed banks and gene banks.

Step 1: Understand ex situ conservation.

In ex situ conservation, organisms are conserved outside their natural habitats under human supervision.

Examples are

Botanical gardens
Zoological parks
Seed banks
Gene banks

Step 2: Analyse the given options.

- Sacred grove → In situ conservation.
- Biosphere reserve → In situ conservation.
- National park → In situ conservation.
- Botanical garden → Ex situ conservation.

Thus, only the botanical garden is an example of ex situ conservation.

Step 3: Choose the correct option.

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember:

In situ → National park, Wildlife sanctuary, Biosphere reserve, Sacred grove
Ex situ → Botanical garden, Zoo, Seed bank, Gene bank

Ex situ conservation protects organisms outside their natural habitat.

---

8. Which of the following is not a product of light reaction of photosynthesis?

(A) ATP

(B) NADH

(C) NADPH

(D) Oxygen

Correct Answer: (B)

Solution:

Concept:

Photosynthesis occurs in two stages:

- Light reaction
- Dark reaction (Calvin cycle)

During the light reaction, solar energy is converted into chemical energy.

The major products formed are

$$\boxed{ATP,\ NADPH,\ O_2.}$$

NADH is not produced during the light reaction.

Step 1: Understand the light reaction.

The light reaction takes place in the thylakoid membranes of chloroplasts.

Its main functions are

$$\boxed{\begin{array}{l}\text{Photolysis of water}\\ \text{ATP synthesis}\\ \text{Reduction of NADP}^+\text{ to NADPH}\end{array}}$$

Oxygen is released as a by-product.

Step 2: Identify the products formed.

Products of the light reaction are

$$\boxed{ATP,\ NADPH,\ O_2.}$$

These products are utilized during the Calvin cycle for carbohydrate synthesis.

Step 3: Determine the incorrect option.

NADH is mainly involved in cellular respiration and is not produced in the light reaction of photosynthesis.

Hence,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Products of the light reaction:

$$\boxed{ATP + NADPH + O_2}$$

Remember:

$$\boxed{NADP^+ \longrightarrow NADPH}$$

Do not confuse **NADPH** (photosynthesis) with **NADH** (cellular respiration).

---

9. Which heart sound is produced by the closure of heart valves?

(A) Lubb–closure of AV valves

(B) Dub–closure of semilunar valves

(C) Dub–opening of AV valve

(D) Both 'A' and 'B'

Correct Answer: (D)

Solution:

Concept:

During each cardiac cycle, the heart produces two characteristic sounds:

First heart sound (LUBB) → Closure of atrioventricular (AV) valves

Second heart sound (DUB) → Closure of semilunar valves

These sounds are produced due to the closing of heart valves, not by the flow of blood itself.

Step 1: Understand the first heart sound (LUBB).

The first heart sound is produced when the atrioventricular valves close.
These valves are

Tricuspid valve

Bicuspid (Mitral) valve

This sound marks the beginning of ventricular systole.

Step 2: Understand the second heart sound (DUB).

The second heart sound is produced by the closure of

Aortic valve

Pulmonary valve

These are collectively called semilunar valves.
This sound marks the beginning of ventricular diastole.

Step 3: Analyse the options.

- Option (A): Correct.
- Option (B): Correct.
- Option (C): Incorrect because heart sounds are produced by valve closure, not opening.

Hence,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember the heart sounds:

LUBB → Closure of Mitral and Tricuspid valves

DUB → Closure of Aortic and Pulmonary valves

LUBB begins ventricular systole, whereas DUB begins ventricular diastole.

---

10. Match the types of placentation (Column I) with their correct plant examples (Column II).

Column I	Column II
A. Marginal	*i*. Argemone, Mustard
B. Axile	*ii*. Dianthus, Primrose
C. Parietal	*iii*. Sunflower, Marigold
D. Free Central	*iv*. Pea
	v. Tomato, Lemon, China rose

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

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

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

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

Correct Answer: (A)

Solution:

Concept:

Placentation is the arrangement of ovules inside the ovary.

Different types of placentation are associated with characteristic plant examples.

Marginal → Pea

Axile → Tomato, Lemon, China rose

Parietal → Mustard, Argemone

Free Central → Dianthus, Primrose

Step 1: Identify examples of marginal placentation.

Marginal placentation occurs in

$$\boxed{\text{Pea.}}$$

Hence,

$$A \rightarrow iv.$$

Step 2: Identify examples of axile placentation.

Axile placentation is found in

$$\boxed{\text{Tomato, Lemon and China rose.}}$$

Therefore,

$$B \rightarrow v.$$

Step 3: Identify examples of parietal and free central placentation.

Parietal placentation occurs in

$$\boxed{\text{Mustard and Argemone.}}$$

Hence,

$$C \rightarrow i.$$

Free central placentation occurs in

$$\boxed{\text{Dianthus and Primrose.}}$$

Thus,

$$D \rightarrow ii.$$

Step 4: Select the correct matching.

The complete matching is

$$\boxed{A-IV,\ B-V,\ C-I,\ D-II.}$$

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Important placentation examples:

$$\boxed{\begin{aligned} \text{Marginal} &\longrightarrow \text{Pea} \\ \text{Axile} &\longrightarrow \text{Tomato, Lemon, China rose} \\ \text{Parietal} &\longrightarrow \text{Mustard, Argemone} \\ \text{Free Central} &\longrightarrow \text{Dianthus, Primrose} \\ \text{Basal} &\longrightarrow \text{Sunflower, Marigold} \end{aligned}}$$

These examples are frequently asked in NEET and other biology examinations.

---

11. Statement 1: Tubectomy is a procedure in which the fallopian tubes are cut or tied. Statement 2: Vasectomy is a procedure in which the vas deferens is cut or tied. Select the correct statement:

(A) Both 1 and 2 are correct

(B) Only 1 is correct

(C) Only 2 is correct

(D) Both 1 and 2 are incorrect

Correct Answer: (A)

Solution:

Concept:

Surgical methods of contraception are permanent methods used to prevent fertilization.
The two common sterilization procedures are:

- **Tubectomy** – Performed in females by cutting or tying the fallopian tubes.
- **Vasectomy** – Performed in males by cutting or tying the vas deferens.

These procedures prevent the meeting of sperm and ovum without affecting hormone production.

Step 1: Examine Statement 1.

Tubectomy is a female sterilization method in which the fallopian tubes (oviducts) are cut and tied.
This prevents the ovum from reaching the uterus and blocks fertilization.
Hence,

$$\boxed{\text{Statement 1 is correct.}}$$

Step 2: Examine Statement 2.

Vasectomy is a male sterilization method in which the vas deferens is cut and tied.
As a result, sperms cannot enter the semen during ejaculation.
Hence,

$$\boxed{\text{Statement 2 is also correct.}}$$

Step 3: Choose the correct option.

Since both statements are true,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\text{Tubectomy} \rightarrow \text{Female sterilization}}$$

$$\boxed{\text{Vasectomy} \rightarrow \text{Male sterilization}}$$

Neither procedure affects the production of sex hormones.

---

12. Which of the following matches is correct regarding the shape of bacteria?

(A) Coccus - rod-shaped

(B) Bacillus - comma-shaped

(C) Spirillum - spiral

(D) Vibrio - spherical

Correct Answer: (C)

Solution:

Concept:

Bacteria are classified into different groups according to their shape.

The common bacterial shapes are:

- Coccus – Spherical
- Bacillus – Rod-shaped
- Vibrio – Comma-shaped
- Spirillum – Spiral-shaped

Step 1: Identify the shape of each bacterial type.

The characteristic shapes are:

$$\boxed{\text{Coccus} \rightarrow \text{Spherical}}$$

$$\boxed{\text{Bacillus} \rightarrow \text{Rod-shaped}}$$

$$\boxed{\text{Vibrio} \longrightarrow \text{Comma-shaped}}$$

$$\boxed{\text{Spirillum} \longrightarrow \text{Spiral-shaped}}$$

Step 2: Compare the given options.

Option (A) is incorrect because coccus is spherical.
Option (B) is incorrect because bacillus is rod-shaped.
Option (C) correctly states that spirillum is spiral-shaped.
Option (D) is incorrect because vibrio is comma-shaped.

Step 3: Choose the correct option.

Thus,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Remember the common bacterial shapes:

$$\boxed{\text{Coccus} \longrightarrow \text{Spherical}}$$

$$\boxed{\text{Bacillus} \longrightarrow \text{Rod-shaped}}$$

$$\boxed{\text{Vibrio} \longrightarrow \text{Comma-shaped}}$$

$$\boxed{\text{Spirillum} \longrightarrow \text{Spiral-shaped}}$$

These four bacterial shapes are frequently asked in biology examinations.

---

13. Which of the following vertebrate classes is jawless?

(A) Chondrichthyes

(B) Osteichthyes

(C) Trygon & Aves

(D) Cyclostomata

Correct Answer: (D)

Solution:

Concept:

Vertebrates are classified into different classes based on the presence or absence of jaws, type of skeleton, and other anatomical features.

Cyclostomata are the only living jawless vertebrates.

Examples include:

$$\boxed{\text{Petromyzon (Lamprey), Myxine (Hagfish)}}$$

Step 1: Understand the characteristics of Cyclostomata.

Cyclostomata possess:

- Circular sucking mouth.
- Absence of jaws.
- Cartilaginous cranium.
- Elongated eel-like body.

Hence, they are called jawless fishes.

Step 2: Analyse the remaining options.

- Chondrichthyes possess jaws and cartilaginous skeleton.
- Osteichthyes possess jaws and bony skeleton.
- Trygon (stingray) and birds also possess jaws.

Therefore, none of these groups are jawless.

Step 3: Choose the correct option.

Only Cyclostomata are jawless vertebrates.

Therefore,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\text{Cyclostomata} \rightarrow \text{Jawless vertebrates}}$$

Examples:

$$\boxed{\text{Petromyzon and Myxine}}$$

All other classes of fishes possess true jaws.

---

14. Under the Kingdom Protista, which organisms, often called 'golden algae', are placed along with diatoms?

(A) Dinoflagellates

(B) Desmids

(C) Slime moulds

(D) Euglena

Correct Answer: (B)

Solution:

Concept:

According to the NCERT classification, Kingdom Protista includes chrysophytes, dinoflagellates, euglenoids, slime moulds and protozoans.

Chrysophytes include:

$$\boxed{\text{Diatoms and Golden algae (Desmids).}}$$

These organisms are mostly found in freshwater and are microscopic photosynthetic protists.

Step 1: Understand Chrysophytes.

Chrysophytes are photosynthetic protists that include:

- Diatoms.
- Golden algae (Desmids).

They possess siliceous cell walls and occur abundantly in aquatic habitats.

Step 2: Analyse the given options.

- Dinoflagellates are a separate group of Protista.
- Desmids are golden algae grouped with diatoms.
- Slime moulds are saprophytic protists.
- Euglena belongs to Euglenoids.

Hence, only Desmids satisfy the given condition.

Step 3: Choose the correct option.

Therefore,

$$\boxed{\textbf{Option (B)}}$$

is the correct answer.

Quick Tip: Remember the important Protista groups:

$$\boxed{\text{Chrysophytes} \longrightarrow \text{Diatoms} + \text{Desmids (Golden algae)}}$$

$$\boxed{\text{Euglenoids} \longrightarrow \textit{Euglena}}$$

$$\boxed{\text{Dinoflagellates} \longrightarrow \text{Red tides}}$$

Golden algae are commonly referred to as desmids in NCERT.

15. What is the major difference between Hippocampus and Trygon?

(A) Hippocampus lived in sea water while Trygon in fresh water

(B) Trygon swims continuously, whereas Hippocampus does not

(C) Hippocampus is an Osteichthyes fish, while Trygon is a Chondrichthyes fish

(D) B & C both correct

Correct Answer: (D)

Solution:

Concept:

Hippocampus (Seahorse) and Trygon (Stingray) belong to different classes of fishes.

- Hippocampus belongs to Osteichthyes (bony fishes).
- Trygon belongs to Chondrichthyes (cartilaginous fishes).

They also differ in their swimming habits.

Step 1: Identify the classification of both fishes.

Hippocampus possesses a bony endoskeleton.

Therefore,

$$\boxed{\text{Hippocampus} \longrightarrow \text{Osteichthyes}}$$

Trygon possesses a cartilaginous endoskeleton.

Hence,

$$\boxed{\text{Trygon} \longrightarrow \text{Chondrichthyes}}$$

Thus, Statement (C) is correct.

Step 2: Compare their mode of locomotion.

Trygon lacks a swim bladder and therefore must swim continuously to maintain movement.

Hippocampus possesses a swim bladder and can remain almost stationary in water.

Thus,

$$\boxed{\text{Statement (B) is also correct.}}$$

Step 3: Choose the correct option.

Since both Statements (B) and (C) are correct,

$$\boxed{\textbf{Option (D)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\text{Hippocampus} \rightarrow \text{Osteichthyes (Bony fish)}}$$

$$\boxed{\text{Trygon} \rightarrow \text{Chondrichthyes (Cartilaginous fish)}}$$

Bony fishes possess a swim bladder, whereas cartilaginous fishes do not.

---

16. Which of the following is a primary function of the limbic system?

(A) Regulation of blood pressure, cardiovascular and respiration

(B) Control of body temperature, hunger and thirst

(C) Regulation of emotions, behaviour, and memory

(D) Coordination of voluntary movements

Correct Answer: (C)

Solution:

Concept:

The limbic system is a group of interconnected structures present in the forebrain.

It is mainly associated with:

- Emotions.
- Behaviour.

- Learning.
- Memory.

Major components include the hippocampus, amygdala and parts of the hypothalamus.

Step 1: Understand the function of the limbic system.

The limbic system plays an important role in:

$$\boxed{\text{Emotions, behaviour, learning and memory.}}$$

It is often referred to as the "emotional brain."

Step 2: Analyse the remaining options.

- Blood pressure and respiration are mainly regulated by the medulla oblongata.
- Body temperature, hunger and thirst are regulated by the hypothalamus.
- Voluntary movement is coordinated by the cerebellum.

Therefore, these options are incorrect.

Step 3: Choose the correct option.

The primary function of the limbic system is the regulation of emotions, behaviour and memory. Hence,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Remember the functions of major brain regions:

$$\boxed{\text{Limbic System} \rightarrow \text{Emotions, Behaviour, Memory}}$$

$$\boxed{\text{Hypothalamus} \rightarrow \text{Hunger, Thirst, Temperature}}$$

$$\boxed{\text{Medulla} \rightarrow \text{Respiration and Heartbeat}}$$

$$\boxed{\text{Cerebellum} \rightarrow \text{Balance and Coordination}}$$

---

17. Pellicle is a flexible, protein-rich layer found in:

(A) Slime mould

(B) Chrysophytes

(C) Euglenoid / Euglena

(D) Sporozoa

Correct Answer: (C)

Solution:

Concept:

Euglenoids are unicellular protists that lack a cellulose cell wall.

Instead, they possess a flexible, protein-rich covering called the **pellicle**, which provides protection as well as flexibility.

The most common example of a euglenoid is:

$$\boxed{\textit{Euglena}}$$

Step 1: Understand the structure of Euglenoids.

Unlike plant cells, Euglenoids do not possess a rigid cell wall.

Their outer covering is

$$\boxed{\text{Pellicle}}$$

which is composed mainly of proteins.

This enables the organism to change its shape while moving.

Step 2: Analyse the given options.

- Slime moulds do not possess a pellicle.
- Chrysophytes possess cell walls rather than a pellicle.
- Euglenoids possess a flexible pellicle.
- Sporozoans are parasitic protozoans without a pellicle.

Thus, only Euglenoids have this characteristic covering.

Step 3: Choose the correct option.

Hence,

$$\boxed{\textbf{Option (C)}}$$

is the correct answer.

Quick Tip: Remember:

$$\boxed{\text{Euglenoids} \longrightarrow \text{Flexible pellicle}}$$

They are photosynthetic in the presence of light but become heterotrophic in the absence of light, making them mixotrophic organisms.

---

18. The major pigment responsible for photosynthesis in plants is:

(A) Chlorophyll A

(B) Chlorophyll B

(C) Carotenoids

(D) Phycobilins

Correct Answer: (A)

Solution:

Concept:
Photosynthetic pigments absorb light energy and convert it into chemical energy during photosynthesis.
Among all pigments present in higher plants, chlorophyll **a** is the primary pigment directly involved in the conversion of light energy.
Accessory pigments assist chlorophyll **a** by absorbing light of different wavelengths.
Step 1: Identify the primary photosynthetic pigment.

The chief pigment responsible for photosynthesis is

$$\boxed{\text{Chlorophyll a}}$$

It is present in the reaction centres of both Photosystem I and Photosystem II.
Step 2: Understand the role of accessory pigments.

Other pigments include:

- Chlorophyll b
- Carotenoids
- Xanthophylls

These pigments absorb additional wavelengths of light and transfer the absorbed energy to chlorophyll **a**.
Step 3: Analyse the options.

- Chlorophyll a is the primary pigment.
- Chlorophyll b is an accessory pigment.
- Carotenoids are accessory pigments.
- Phycobilins occur mainly in cyanobacteria and red algae.

Therefore,

$$\boxed{\textbf{Option (A)}}$$

is the correct answer.

Quick Tip: Remember the important pigments:

$$\boxed{\text{Primary pigment} \rightarrow \text{Chlorophyll a}}$$

$$\boxed{\text{Accessory pigments} \rightarrow \text{Chlorophyll b, Carotenoids, Xanthophylls}}$$

Only chlorophyll **a** directly participates in the photochemical reactions of photosynthesis.

---

19. IgA immunity provided to a baby at birth is called:

(A) Active immunity

(B) Passive immunity

(C) Artificial immunity

(D) Innate immunity

Correct Answer: (B)

Solution:

Concept:

Immunity can be classified based on how it is acquired:

- **Active immunity** – Body produces its own antibodies.
- **Passive immunity** – Ready-made antibodies are transferred from another source.

A newborn baby receives antibodies (including IgA) from the mother through breast milk and placenta.

Step 1: Understand IgA transfer.

IgA antibodies are mainly present in colostrum and breast milk.

These antibodies provide immediate protection to the newborn.

$$\boxed{\text{Maternal antibodies transferred to baby}}$$

Step 2: Identify type of immunity.

Since the baby does not produce these antibodies itself, but receives them externally:

$$\boxed{\text{It is Passive immunity}}$$

Step 3: Select correct option.

Hence,

$$\boxed{\textbf{Option (B)}}$$

is correct.

Quick Tip:

$$\boxed{\text{Mother} \rightarrow \text{Baby antibodies} = \text{Passive immunity}}$$

IgA in colostrum provides temporary protection to newborns.

---

20. Which of the following is not a product of anaerobic respiration?

(A) Ethanol + CO_2

(B) Lactic acid

(C) Acetyl CoA

(D) None of the above

Correct Answer: (C)

Solution:

Concept:

Anaerobic respiration occurs in the absence of oxygen and produces different end products depending on the organism.

Common end products are:

- In yeast: Ethanol + CO_2
- In muscle cells: Lactic acid

Step 1: Identify anaerobic products.

Typical anaerobic respiration products include:

$$\boxed{\text{Ethanol} + CO_2}$$

$$\boxed{\text{Lactic acid}}$$

Step 2: Check Acetyl CoA.

Acetyl CoA is formed during aerobic respiration (link reaction) in mitochondria.

It is not a product of anaerobic respiration.

$$\boxed{\text{Acetyl CoA is NOT an anaerobic product}}$$

Step 3: Select correct option.

Hence,

$$\boxed{\textbf{Option (C)}}$$

is correct.

Quick Tip:

$$\boxed{\text{Anaerobic respiration products: ethanol or lactic acid}}$$

$$\boxed{\text{Acetyl CoA} \rightarrow \text{aerobic respiration}}$$

---

21. Which is the major difference between interkinesis and interphase?

(A) Only (I) and (II)

(B) Only (II) and (III)

(C) Only (I) and (III)

(D) (I), (II) and (III)

Correct Answer: (D)

Solution:

Concept:

Interphase is the long preparatory phase between two cell divisions, whereas interkinesis is a short resting phase between meiosis I and meiosis II.

Step 1: Understand interphase.

Interphase includes G1, S and G2 phases where DNA replication and cell growth occur.

$$\boxed{\text{Interphase} \rightarrow \text{DNA replication + growth + organelle duplication}}$$

Step 2: Understand interkinesis.

Interkinesis occurs after meiosis I and before meiosis II.

$$\boxed{\text{Interkinesis} \rightarrow \text{No DNA replication}}$$

Step 3: Key differences.

- DNA replication occurs in interphase but not in interkinesis.
- Interphase is long and active; interkinesis is short and inactive.
- Interphase occurs before mitosis/meiosis; interkinesis occurs only in meiosis.

Hence all statements (I), (II), and (III) are correct.

$$\boxed{\textbf{Option (D)}}$$

Quick Tip:

$$\boxed{\text{Interphase} = \text{growth} + \text{DNA replication}}$$

$$\boxed{\text{Interkinesis} = \text{no DNA replication}}$$

---

22. Which of the following structures in an anther develops into a pollen sac?

(A) Sporogenous tissue

(B) Microspore

(C) Tapetum

(D) Microsporangium

Correct Answer: (D)

Solution:

Concept:

The anther consists of four microsporangia. Each microsporangium develops into a pollen sac.

Step 1: Understand structure of anther.

An anther is bilobed and each lobe contains two pollen sacs.

$$\boxed{\text{Microsporangium} = \text{pollen sac}}$$

Step 2: Development process.

Microsporangium matures and forms pollen sac containing microspores.

Step 3: Evaluate options.

Only microsporangium directly develops into pollen sac.

$$\boxed{\textbf{Option (D)}}$$

Quick Tip:

$$\boxed{\text{Microsporangium} \rightarrow \text{Pollen sac} \rightarrow \text{Pollen grains}}$$

23. Choose the right option based on the diagram: 1) Stomatal aperture, 2) Guard cells, 3) Subsidiary cells, 4) Chloroplast

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

(B) A-2, B-3, C-1

(C) A-3, B-1, C-2

(D) A-2, B-1, C-3

Correct Answer: (A)

Solution:

Concept:

A stomatal apparatus consists of guard cells, stomatal pore, subsidiary cells, and chloroplasts.

Step 1: Identify components.

$$\boxed{\text{Stomatal aperture} \rightarrow \text{pore}}$$

$$\boxed{\text{Guard cells} \rightarrow \text{regulate opening/closing}}$$

$$\boxed{\text{Subsidiary cells} \rightarrow \text{support cells}}$$

$$\boxed{\text{Chloroplast} \rightarrow \text{present in guard cells}}$$

Step 2: Match correctly.

Correct identification gives:

$$A \rightarrow 1, \quad B \rightarrow 2, \quad C \rightarrow 3, \quad D \rightarrow 4$$

Step 3: Select option.

$$\boxed{\text{Option (A)}}$$

Quick Tip:

$$\boxed{\text{Guard cells are kidney-shaped and contain chloroplasts}}$$

---

24. What is Oviparity?

(A) Animals that give birth to live young ones

(B) They lay eggs, and the embryo develops outside the mother's body

(C) Development inside uterus until birth

(D) Asexual reproduction

Correct Answer: (B)

Solution:

Concept:

Oviparity is a mode of reproduction in which animals lay eggs.

Step 1: Understand oviparity.

In oviparous animals:

$$\boxed{\text{Eggs are laid outside the body}}$$

$$\boxed{\text{Embryo develops outside maternal body}}$$

Examples include birds, reptiles, and many fish.

Step 2: Compare options.

- (A) describes viviparity.
- (B) correctly defines oviparity.
- (C) also describes viviparity.

- (D) is incorrect.

Step 3: Final answer.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip:

$$\boxed{\text{Oviparity} \rightarrow \text{Egg laying} \rightarrow \text{external development}}$$

$$\boxed{\text{Viviparity} \rightarrow \text{Live birth} \rightarrow \text{internal development}}$$

---

25. Match the type of chromosome (Column I) with the position of its centromere (Column II):
Column I: A. Metacentric, B. Sub-metacentric, C. Acrocentric, D. Telocentric
Column II: i. One extremely short arm and one very long arm ii. Terminal centromere iii. One short arm and one long arm iv. Two equal arms

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

Correct Answer: (A)

Solution:

Concept:
Chromosomes are classified based on the position of the centromere:

- Metacentric → centromere in middle
- Sub-metacentric → slightly off-centre
- Acrocentric → near one end
- Telocentric → terminal position

Step 1: Identify matching pairs.

$$\boxed{\text{Metacentric} \rightarrow \text{IV}}$$

$$\boxed{\text{Sub-metacentric} \rightarrow \text{III}}$$

$$\boxed{\text{Acrocentric} \rightarrow \text{I}}$$

$$\boxed{\text{Telocentric} \rightarrow \text{II}}$$

Step 2: Select correct option.

Thus,

$$\boxed{\textbf{Option (A)}}$$

Quick Tip:

$\boxed{\text{Metacentric} \rightarrow \text{equal arms}}$ $\boxed{\text{Sub-metacentric} \rightarrow \text{unequal arms}}$

$\boxed{\text{Acrocentric} \rightarrow \text{one very short arm}}$ $\boxed{\text{Telocentric} \rightarrow \text{single arm}}$

---

26. Which of the following is not considered a primary limiting factor for the rate of photosynthesis?

(A) Light intensity

(B) Temperature

(C) Carbon dioxide concentration

(D) Oxygen concentration

Correct Answer: (D)

Solution:

Concept:

The rate of photosynthesis is controlled by several limiting factors such as light, CO_2, and temperature.

Oxygen is not a limiting factor; instead, it can act as an inhibitor due to photorespiration.

Step 1: Identify limiting factors.

Primary limiting factors include:

$$\boxed{\text{Light intensity, } CO_2 \text{ concentration, temperature}}$$

Step 2: Check oxygen role.

Oxygen does not directly limit photosynthesis rate. Instead, high oxygen may increase photorespiration.

$$\boxed{\text{Oxygen is NOT a primary limiting factor}}$$

Step 3: Select correct option.

Hence,

$$\boxed{\textbf{Option (D)}}$$

Quick Tip:

$$\boxed{\text{Limiting factors} \rightarrow \text{Light, } CO_2, \text{Temperature}}$$

$$\boxed{O_2 \rightarrow \text{photorespiration, not limiting factor}}$$

---

27. Which of the following statements are correct?

I) Homologous organs have the same structure but show different functions.

II) Homologous organs have common ancestors.

III) Analogous organs show divergent evolution.

IV) Wings of butterfly and birds are homologous.

(A) I, II and IV are correct

(B) I and II are correct

(C) II, III and IV are correct

(D) Only I and IV are correct

Correct Answer: (B)

Solution:

Concept:

Homologous organs share common ancestry but perform different functions, while analogous organs perform similar functions but have different origins.

Step 1: Check statements.

- I $\rightarrow$ Correct (same origin, different function)
- II $\rightarrow$ Correct (common ancestry)
- III $\rightarrow$ Incorrect (analogous organs show convergent evolution, not divergent)
- IV $\rightarrow$ Incorrect (bird and butterfly wings are analogous)

Step 2: Select correct combination.

Only I and II are correct.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip:

$$\boxed{\text{Homologous} \rightarrow \text{same origin, different function}}$$

$$\boxed{\text{Analogous} \rightarrow \text{different origin, same function}}$$

---

28. Choose the correct option based on the diagram: 1) Hypothalamus, 2) Anterior pituitary, 3) Posterior pituitary, 4) Hypothalamic neuron

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

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

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

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

Correct Answer: (C)

Solution:

Concept:

The hypothalamus controls the pituitary gland through hormones and nerve connections.

Step 1: Identify structures.

$$\boxed{\text{Hypothalamus} \rightarrow \text{master control center}}$$

$$\boxed{\text{Anterior pituitary} \rightarrow \text{hormone secretion via blood}}$$

$$\boxed{\text{Posterior pituitary} \rightarrow \text{releases stored hormones}}$$

$$\boxed{\text{Hypothalamic neuron} \rightarrow \text{connects hypothalamus to pituitary}}$$

Step 2: Match logically.

$$A \rightarrow 1, \quad B \rightarrow 3, \quad C \rightarrow 2, \quad D \rightarrow 4$$

Step 3: Final answer.

$$\boxed{\textbf{Option (C)}}$$

Quick Tip:

$$\boxed{\text{Hypothalamus controls pituitary via hormones + neurons}}$$

$$\boxed{\text{Anterior pituitary = endocrine control}} \quad \boxed{\text{Posterior pituitary = neurosecretion}}$$

29. Which one is the structure of Uracil in RNA?

(A) It is a purine base with a double ring

(B) It is similar to thymine (5-methyl uracil), but lacks the methyl group

(C) It only binds with deoxyribose sugar

(D) It forms hydrogen bonds with guanine

Correct Answer: (B)

Solution:

Concept:

Uracil is a pyrimidine base found in RNA. It replaces thymine in DNA.

Step 1: Understand structure.

Uracil is a single-ring pyrimidine base and is structurally similar to thymine.

$$\boxed{\text{Uracil} = \text{Thymine without CH}_3 \text{ group}}$$

Step 2: Check pairing rules.

Uracil pairs with adenine in RNA through hydrogen bonding.

Step 3: Evaluate options.

- (A) Incorrect → purine is double ring.
- (B) Correct → uracil is like thymine without methyl group.
- (C) Incorrect → RNA uses ribose sugar, not deoxyribose.
- (D) Incorrect → uracil pairs with adenine, not guanine.

Thus,

$$\boxed{\textbf{Option (B)}}$$

Quick Tip:

$$\boxed{\text{Uracil (RNA)} \;\; \text{Adenine pairing}}$$

$$\boxed{\text{Thymine (DNA)} = \text{Uracil} + CH_3}$$

GENERAL KNOWLEDGE

1. What is the capital of Israel?

(A) Tel Aviv

(B) Jerusalem

(C) Haifa

(D) Gaza

Correct Answer: (B)

Solution:

Concept:

A capital city is the official administrative and political center of a country.

Step 1: Recall the capital of Israel.

The internationally recognized capital of Israel is Jerusalem.

$$\boxed{\text{Jerusalem is the capital of Israel}}$$

Step 2: Check options.

Only option (B) matches the correct capital.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip: Jerusalem is the administrative capital of Israel.

2. What is the official currency of Japan?

(A) Yuan

(B) Yen

(C) Won

(D) Dollar

Correct Answer: (B)

Solution:

Concept:

Each country has its own official currency used for financial transactions.

Step 1: Identify Japan's currency.

Japan uses the Yen as its official currency.

$$\boxed{1\ \text{Japan} = \text{Yen}}$$

Step 2: Compare options.

Only option (B) matches.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip: Japan → Yen, China → Yuan, Korea → Won

---

3. Which number is wrong in the sequence 6, 12, 24, 48, 96, 244?

(A) 96

(B) 244

(C) 12

(D) 48

Correct Answer: (B)

Solution:

Concept:

A sequence pattern is observed to identify incorrect terms.

Step 1: Check pattern.

Each term is multiplied by 2:

$$6 \to 12 \to 24 \to 48 \to 96 \to 192$$

Step 2: Compare given sequence.

The last term should be 192, not 244.

$$\boxed{244 \text{ is incorrect}}$$

Step 3: Final answer.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip: Check multiplication or difference pattern in number series carefully.

---

4. Which is the main and official national language of China?

(A) Cantonese

(B) Mandarin / Putonghua

(C) Uyghur

(D) Tibetan

Correct Answer: (B)

Solution:

Concept:

China has multiple dialects, but the official standard language is Mandarin (Putonghua).

Step 1: Identify official language.

Mandarin Chinese (Putonghua) is the official language of China.

$$\boxed{\text{Mandarin} = \text{Official language of China}}$$

Step 2: Compare options.

Only option (B) is correct.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip: Mandarin = China's official language; Cantonese = regional dialect.

---

5. What is a member of the Lok Sabha mainly called?

(A) MLA

(B) MP

(C) Councillor

(D) Governor

Correct Answer: (B)

Solution:

Concept:

Lok Sabha is the lower house of the Parliament of India.

Members of Lok Sabha are called Members of Parliament (MPs).

Step 1: Understand Lok Sabha membership.

Each elected representative in Lok Sabha is an MP.

$$\boxed{\text{Lok Sabha member} = \text{MP}}$$

Step 2: Check options.

Only option (B) is correct.

$$\boxed{\textbf{Option (B)}}$$

Quick Tip: Lok Sabha → MP, Vidhan Sabha → MLA

---

6. Who is the current Union Minister of Agriculture and Farmers Welfare of India?

(A) Narendra Singh Tomar

(B) Arjun Munda

(C) Shivraj Singh Chouhan

(D) Rajnath Singh

Correct Answer: (C)

Solution:

Concept:

The Union Minister of Agriculture and Farmers Welfare is a key cabinet position in India.

Step 1: Recall current minister.

As per the latest government structure, Shivraj Singh Chouhan holds this position.

$$\boxed{\text{Shivraj Singh Chouhan} \rightarrow \text{Agriculture Minister}}$$

Step 2: Compare options.

Only option (C) matches.

$$\boxed{\textbf{Option (C)}}$$

Quick Tip: Ministers may change after cabinet reshuffles, so always verify current updates.

---

7. Lakshmi is Priya's mother, and Jatin is Priya's brother. Shia is Jatin's daughter. How is Lakshmi related to Shia?

(A) Grandmother

(B) Mother

(C) Aunt

(D) Sister-in-law

Correct Answer: (A)

Solution:

Concept:

Use family relationship logic step by step.

Step 1: Understand relations.

Priya's mother is Lakshmi.

Jatin is Priya's brother, so he is also Lakshmi's son.

$$\boxed{\text{Lakshmi is mother of Priya and Jatin}}$$

Step 2: Identify Shia's relation.

Shia is Jatin's daughter.

So Shia is Lakshmi's granddaughter.

$$\boxed{\text{Lakshmi} \rightarrow \text{Grandmother of Shia}}$$

Step 3: Final answer.

$$\boxed{\textbf{Option (A)}}$$

Quick Tip: Mother of parent = Grandmother.
