

# GUJCET 2024 Physics and Chemistry ( March 31) Question Paper with Solutions

Time Allowed :63 mins	Maximum Marks :42	Total Questions :42
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## GUJCET Physics Questions

**Q.1** The magnitude of the drift velocity per unit electric field is known as \_\_\_\_\_. [1]

**Correct Answer: Mobility**

**Solution:**

### Step 1: Understanding Drift Velocity and Mobility

**Drift velocity** ( $v_d$ ) is the average velocity acquired by electrons in a conductor under the influence of an electric field.

**Mobility** ( $\mu$ ) is defined as the ratio of drift velocity to the applied electric field ( $E$ ):

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

### Step 2: Explanation

Mobility represents how easily electrons move in response to an electric field.

It is measured in  $\text{m}^2/\text{V}\cdot\text{s}$ .

A higher mobility means that charge carriers move faster for a given electric field.

#### Quick Tip

**Mobility** ( $\mu$ ) is the measure of how quickly electrons respond to an applied **electric field**. It is given by  $\mu = \frac{v_d}{E}$ .

**Q.2** A solenoid has a core of a material with a relative permeability of 400. The solenoid windings are insulated from the core and carry a current of 2A. If the number of turns is 1000 per meter, then the value of magnetic intensity will be \_\_\_\_\_. [1]

**Correct Answer:**  $1.0053 \text{ Am}^{-1}$

**Solution:**

**Step 1: Understanding Magnetic Intensity ( $H$ )**

Magnetic intensity ( $H$ ) in a solenoid is given by the formula:

$$H = nI$$

where:

$n$  is the number of turns per meter,

$I$  is the current in amperes.

**Step 2: Substituting the given values**

Given:

$$n = 1000 \text{ turns/m}, \quad I = 2 \text{ A}$$

Calculating:

$$H = (1000) \times (2) = 2000 \text{ Am}^{-1}$$

**Step 3: Effect of Relative Permeability**

The presence of a material with **relative permeability** ( $\mu_r$ ) modifies the magnetic field.

The permeability factor is given as:

$$B = \mu_0 \mu_r H$$

Given  $\mu_r = 400$ , we calculate:

$$B = (4\pi \times 10^{-7}) \times (400) \times (2000)$$

$$B = 1.0053 \text{ Am}^{-1}$$

Thus, the final value of magnetic intensity is  $1.0053 \text{ Am}^{-1}$ .

**Quick Tip**

**Magnetic intensity** ( $H$ ) inside a solenoid depends on the **number of turns per unit length** and **current**. The presence of a magnetic core modifies the intensity due to the **relative permeability** of the material.

**Q.3** A square loop of side 10 cm and resistance  $0.5 \, \Omega$  is placed vertically in the east-west plane. A uniform magnetic field of 0.10 T is set across the plane in the northeast direction. The magnetic field decreases to zero at 0.70 s at a steady rate. Then the magnitude of the induced current during this time interval will be \_\_\_\_\_. [1]

**Correct Answer:**  $2.86 \times 10^{-3} \, \text{A}$

**Solution:**

**Step 1: Understanding Faraday's Law of Electromagnetic Induction**

According to **Faraday's Law**, the induced EMF ( $\mathcal{E}$ ) is given by:

$$\mathcal{E} = -\frac{d\Phi}{dt}$$

where  $\Phi$  is the **magnetic flux** given by:

$$\Phi = BA$$

**Step 2: Calculating the Change in Flux**

Given:

$$B_{\text{initial}} = 0.10 \, \text{T}, \quad B_{\text{final}} = 0 \, \text{T}$$

$$A = (10 \, \text{cm})^2 = (0.1 \, \text{m})^2 = 0.01 \, \text{m}^2$$

$$dt = 0.70 \, \text{s}$$

Change in flux:

$$\Delta\Phi = A(B_{\text{final}} - B_{\text{initial}})$$

$$\Delta\Phi = (0.01) \times (0 - 0.10)$$

$$\Delta\Phi = -10^{-3} \, \text{Wb}$$

**Step 3: Calculating Induced EMF**

$$\mathcal{E} = -\frac{\Delta\Phi}{dt}$$

$$\mathcal{E} = -\frac{-10^{-3}}{0.70}$$

$$\mathcal{E} \approx 1.43 \times 10^{-3} \text{ V}$$

#### Step 4: Finding the Induced Current

Using **Ohm's Law**, the induced current is:

$$I = \frac{\mathcal{E}}{R}$$

$$I = \frac{1.43 \times 10^{-3}}{0.5}$$

$$I = 2.86 \times 10^{-3} \text{ A}$$

Thus, the magnitude of the induced current is  $2.86 \times 10^{-3} \text{ A}$ .

#### Quick Tip

According to **Faraday's Law**, the induced EMF in a loop is given by the **rate of change of magnetic flux**. The induced current is found using **Ohm's Law**, where  $I = \frac{\mathcal{E}}{R}$ .

**Q.4 Calculate the current in the circuit using Ohm's Law. Given that the voltage across the resistor is  $V=10 \text{ V}$  and the resistance is  $R = 4 \Omega$ \_\_\_\_\_.** [1]

**Correct Answer:** 2.5 A

**Solution:**

#### Step 1: Understanding Ohm's Law

According to **Ohm's Law**, the relationship between voltage ( $V$ ), current ( $I$ ), and resistance ( $R$ ) is:

$$V = IR$$

#### Step 2: Given Values

The given circuit diagram provides:

$$V = 10 \text{ V}, \quad R = 4 \Omega$$

### Step 3: Calculating the Current

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

$$I = \frac{10}{4}$$

$$I = 2.5 \text{ A}$$

Thus, the value of **current** in the circuit is 2.5 A.

#### Quick Tip

**Ohm's Law** states that the current flowing through a conductor is directly proportional to the voltage across it and inversely proportional to the resistance. The formula is given by  $I = \frac{V}{R}$ .

**Q.5 Vs/Am is the unit of which physical quantity?**

[1]

**Correct Answer:**  $\mu_0$  (Permeability of Free Space)

**Solution:**

#### Step 1: Understanding the Given Unit

The unit given is **volt-second per ampere-meter** (Vs/Am).

This unit corresponds to the **magnetic permeability** ( $\mu$ ), specifically the **permeability of free space** ( $\mu_0$ ).

#### Step 2: Definition of Magnetic Permeability

Magnetic permeability ( $\mu$ ) is a measure of how easily a material allows magnetic field lines to pass through it.

The permeability of free space ( $\mu_0$ ) is a universal constant used in electromagnetism.

#### Step 3: Expression for $\mu_0$

The permeability of free space is given by:

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m (or Vs/Am)}$$

#### Step 4: Importance of $\mu_0$

Appears in **Ampère's Circuital Law** and **Maxwell's Equations**.

Defines the relationship between **magnetic field** and **current in free space**.

Thus, the physical quantity represented by Vs/Am is the **permeability of free space** ( $\mu_0$ ).

#### Quick Tip

**Permeability of free space** ( $\mu_0$ ) is a fundamental constant in electromagnetism. It represents the ability of vacuum to support a **magnetic field** and is given by  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$ .

**Q.6 A silver wire has a resistance of  $215 \Omega$  at  $27.5^\circ\text{C}$  and a resistance of  $270 \Omega$  at  $100^\circ\text{C}$ . Then the temperature coefficient of the resistivity of silver will be \_\_\_\_\_. [1]**

**Correct Answer:**  $3.9 \times 10^{-3} ^\circ\text{C}^{-1}$

**Solution:**

#### Step 1: Understanding the Temperature Coefficient of Resistivity

The **temperature coefficient of resistivity** ( $\alpha$ ) is given by:

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

where:

-  $R_1$  = Initial resistance at  $T_1$ , -  $R_2$  = Final resistance at  $T_2$ , -  $\alpha$  = Temperature coefficient of resistivity.

#### Step 2: Given Values

-  $R_1 = 215 \Omega$ , -  $R_2 = 270 \Omega$ , -  $T_1 = 27.5^\circ\text{C}$ , -  $T_2 = 100^\circ\text{C}$ .

#### Step 3: Calculating $\alpha$

$$\alpha = \frac{270 - 215}{215 \times (100 - 27.5)}$$

$$\alpha = \frac{55}{215 \times 72.5}$$

$$\alpha = \frac{55}{15587.5}$$

$$\alpha = 3.9 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$$

Thus, the **temperature coefficient of resistivity** of silver is  $3.9 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$ .

#### Quick Tip

The **temperature coefficient of resistivity** ( $\alpha$ ) determines how much the resistance of a material changes with temperature. It is calculated using  $\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$ .

**Q.7** An ideal ammeter and an ideal voltmeter have resistances of \_\_\_\_  $\Omega$  and \_\_\_\_  $\Omega$  respectively. [1]

**Correct Answer:**  $(0, \infty)$

**Solution:**

#### Step 1: Understanding the Resistance of an Ideal Ammeter

- An **ammeter** measures **current** and is connected in **series** with a circuit.
- For an ideal ammeter:
- It should not affect the current.
- It must have **zero resistance** ( $0 \Omega$ ) so that it does not cause a voltage drop.

#### Step 2: Understanding the Resistance of an Ideal Voltmeter

- A **voltmeter** measures **voltage** and is connected in **parallel** with a circuit.
- For an ideal voltmeter:
- It should not draw any current from the circuit.
- It must have **infinite resistance** ( $\infty \Omega$ ) so that it does not disturb the circuit.

Thus, the resistances of an ideal **ammeter** and **voltmeter** are  $0 \Omega$  and  $\infty \Omega$  respectively.

### Quick Tip

An **ideal ammeter** has **zero resistance** so that it does not affect the current in a circuit.  
An **ideal voltmeter** has **infinite resistance** so that it does not draw any current from the circuit.

**Q.8 A short bar magnet placed with its axis at  $30^\circ$  and a uniform external magnetic field of  $0.5 \text{ T}$  experiences a torque of magnitude equal to  $4.5 \times 10^{-2} \text{ J}$ . Then the magnitude of the magnetic moment of the magnet will be \_\_\_\_\_. [1]**

**Correct Answer:**  $18 \times 10^{-2} \text{ J T}^{-1}$

**Solution:**

**Step 1: Understanding Magnetic Torque**

- The torque ( $\tau$ ) experienced by a **magnetic dipole** in a uniform magnetic field is given by:

$$\tau = MB \sin \theta$$

where:

-  $M$  is the magnetic moment of the magnet, -  $B$  is the external magnetic field strength, -  $\theta$  is the angle between the magnetic moment and the field.

**Step 2: Given Values**

-  $\tau = 4.5 \times 10^{-2} \text{ J}$ , -  $B = 0.5 \text{ T}$ , -  $\theta = 30^\circ$ , -  $\sin 30^\circ = \frac{1}{2}$ .

**Step 3: Calculating  $M$**

Rearranging the equation:

$$M = \frac{\tau}{B \sin \theta}$$

$$M = \frac{4.5 \times 10^{-2}}{(0.5) \times (\frac{1}{2})}$$

$$M = \frac{4.5 \times 10^{-2}}{0.25}$$



$$M = 18 \times 10^{-2}$$

$$M = 18 \times 10^{-2} \text{ J T}^{-1}$$

Thus, the **magnetic moment** of the magnet is  $18 \times 10^{-2} \text{ J T}^{-1}$ .

#### Quick Tip

The **torque** on a magnetic dipole in a uniform magnetic field is given by  $\tau = MB \sin \theta$ .

The magnetic moment  $M$  represents the strength of a magnet in an external field.

**Q.9 The SI unit of the current density is \_\_\_\_\_.**

**[1]**

**Correct Answer:**  $\text{A/m}^2$

**Solution:**

#### Step 1: Understanding Current Density

Current density ( $J$ ) is defined as the electric current per unit area of cross-section:

$$J = \frac{I}{A}$$

where:

- $J$  is the current density,
- $I$  is the electric current (in amperes),
- $A$  is the cross-sectional area (in square meters).

#### Step 2: SI Unit of Current Density

- The SI unit of electric current ( $I$ ) is **ampere (A)**.
- The SI unit of area ( $A$ ) is **square meter ( $\text{m}^2$ )**.
- Thus, the SI unit of current density is:

$$J = \frac{\text{A}}{\text{m}^2} = \text{A/m}^2$$

#### Step 3: Importance of Current Density

- Higher current density means a stronger electric field in a conductor.
- Used in Ohm's Law in differential form:

$$J = \sigma E$$

where  $\sigma$  is conductivity and  $E$  is the electric field.

Thus, the SI unit of current density is  $A/m^2$ .

#### Quick Tip

Current density ( $J$ ) represents the electric current flowing per unit area of a conductor. Its SI unit is  $A/m^2$ .

**Q.10 A coil has  $N$  turns and current passes through it as  $I$  ampere, then we obtain  $L$  Henry of self-inductance. Now if the current changes to  $5I$ , then the new self-inductance will be \_\_\_\_\_ H. [1]**

**Correct Answer:**  $L$

**Solution:**

#### Step 1: Understanding Self-Inductance

Self-inductance ( $L$ ) of a coil is given by:

$$L = \frac{N\Phi}{I}$$

where:

- $L$  is the self-inductance (Henry),
- $N$  is the number of turns,
- $\Phi$  is the magnetic flux linked with the coil,
- $I$  is the current passing through the coil.

#### Step 2: Effect of Changing Current on Self-Inductance

- Self-inductance  $L$  depends on the **geometry** and **material** of the coil, not on the current passing through it.

- When current increases from  $I$  to  $5I$ , the **magnetic flux** ( $\Phi$ ) will increase proportionally, but the self-inductance remains constant.

### Step 3: Conclusion

Since self-inductance is independent of current, the new self-inductance remains:

$$L$$

Thus, the self-inductance remains unchanged at  $L$ .

#### Quick Tip

Self-inductance ( $L$ ) is a property of a coil that depends on its number of turns and dimensions, not on the amount of current passing through it.

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**Q.11 An inductor of 50.0 mH is connected to a source of 220 V. Then the rms current in the circuit will be \_\_\_\_\_. The frequency of the source is 50 Hz. [1]**

**Correct Answer:** 14 A

**Solution:**

### Step 1: Understanding Inductive Reactance

In an AC circuit, an inductor offers inductive reactance ( $X_L$ ), which is given by:

$$X_L = 2\pi fL$$

where:

- $X_L$  is the inductive reactance (in ohms),
- $f$  is the frequency of the AC source (in Hz),
- $L$  is the inductance (in Henry).

### Step 2: Given Values

- $L = 50.0 \text{ mH} = 50.0 \times 10^{-3} \text{ H}$ ,
- $f = 50 \text{ Hz}$ ,
- $V_{\text{rms}} = 220 \text{ V}$ .

### Step 3: Calculating Inductive Reactance

$$X_L = 2\pi \times 50 \times (50.0 \times 10^{-3})$$

$$X_L = 2\pi \times 2.5$$

$$X_L = 5\pi \approx 15.7 \Omega$$

#### Step 4: Calculating RMS Current

The RMS current ( $I_{\text{rms}}$ ) is given by:

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_L}$$

$$I_{\text{rms}} = \frac{220}{15.7}$$

$$I_{\text{rms}} \approx 14 \text{ A}$$

Thus, the rms current in the circuit is 14 A.

#### Quick Tip

The inductive reactance of an inductor is given by  $X_L = 2\pi fL$ . The RMS current in an AC circuit with only an inductor is given by  $I_{\text{rms}} = \frac{V_{\text{rms}}}{X_L}$ .

**Q.12 In an LCR series AC circuit at resonance, the value of power factor will be**

\_\_\_\_\_.

[1]

**Correct Answer: 1**

**Solution:**

#### Step 1: Understanding Power Factor

The **power factor** ( $\cos \phi$ ) in an AC circuit is given by:

$$\cos \phi = \frac{R}{Z}$$

where:

- $R$  is the resistance,
- $Z$  is the impedance of the circuit.

### Step 2: Condition at Resonance

- The impedance ( $Z$ ) in an LCR circuit is given by:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

where:

- $X_L = 2\pi fL$  is the inductive reactance,
- $X_C = \frac{1}{2\pi fC}$  is the capacitive reactance.
- At **resonance**,  $X_L = X_C$ , which simplifies the impedance to:

$$Z = R$$

### Step 3: Calculating Power Factor

$$\cos \phi = \frac{R}{Z} = \frac{R}{R} = 1$$

Thus, the power factor of an LCR circuit at resonance is 1.

#### Quick Tip

At **resonance** in an LCR circuit, the impedance equals the resistance ( $Z = R$ ), making the **power factor** equal to 1. This means all supplied power is converted into useful work.

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**Q.13** For obtaining wattless current, \_\_\_\_\_ is connected with AC supply. [1]

**Correct Answer:** Only  $L$  (Inductor)

**Solution:**

#### Step 1: Understanding Wattless Current

Wattless current refers to the condition when the power consumed in an AC circuit is zero.

The power in an AC circuit is given by:

$$P = VI \cos \phi$$

where:

- $P$  is the power,
- $V$  is the voltage,
- $I$  is the current,
- $\phi$  is the phase difference between voltage and current.

### Step 2: Condition for Wattless Current

- Power consumption in a circuit depends on the power factor  $\cos \phi$ .
- If  $\phi = 90^\circ$ , then:

$$\cos 90^\circ = 0$$

which means:

$$P = 0$$

- This happens when the circuit contains a **pure inductor (L)** or **pure capacitor (C)**, as they store and release energy without dissipating power.

### Step 3: Conclusion

- A **pure inductor (L)** or **pure capacitor (C)** does not consume power but still allows alternating current to flow.
- Since the given question specifically asks for **wattless current**, the correct answer is **only L (Inductor)**.

#### Quick Tip

In an AC circuit, a **pure inductor (L)** or **pure capacitor (C)** results in **wattless current** because the power factor is **zero** ( $\cos 90^\circ = 0$ ), meaning no real power is consumed.

**Q.14 As indicated below, which one is the equation of Ampere-Maxwell law?**

**[1]**

**Correct Answer:**

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d\Phi_B}{dt}$$

**Solution:**

### Step 1: Understanding Ampere-Maxwell Law

The Ampere-Maxwell Law is a modification of Ampere's Circuital Law, which originally stated:

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i_c$$

where:

- $\oint \mathbf{B} \cdot d\mathbf{l}$  represents the circulation of the magnetic field around a closed loop,
- $i_c$  is the conduction current enclosed by the loop,
- $\mu_0$  is the permeability of free space.

### Step 2: Maxwell's Addition - Displacement Current

James Clerk Maxwell introduced the concept of **displacement current**, which accounts for the changing electric field, leading to the corrected equation:

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d\Phi_B}{dt}$$

where:

- $\varepsilon_0$  is the permittivity of free space,
- $\frac{d\Phi_B}{dt}$  represents the rate of change of electric flux, contributing to displacement current.

### Step 3: Importance of Ampere-Maxwell Law

- This equation bridges the gap between **electric and magnetic fields**.
- It is one of **Maxwell's four equations**, crucial for **electromagnetism**.
- Explains how a **changing electric field produces a magnetic field**, leading to the concept of **electromagnetic waves**.

#### Quick Tip

The **Ampere-Maxwell Law** states that a **changing electric field produces a magnetic field**, forming the foundation of **electromagnetic waves**. The term  $\mu_0 \varepsilon_0 \frac{d\Phi_B}{dt}$  accounts for the displacement current.

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**Q.15** A parallel plate capacitor with air between the plates has a capacitance of 4 pF. If the distance between the plates is reduced by half and the space between them is filled with a substance of dielectric constant 6, then the value of capacitance will be \_\_\_\_\_.

[1]

**Correct Answer:** 48 pF

**Solution:**

**Step 1: Understanding the Capacitance Formula**

The capacitance of a parallel plate capacitor is given by:

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

where:

- $C$  is the capacitance,
- $\epsilon_0$  is the permittivity of free space,
- $A$  is the plate area,
- $d$  is the separation between plates.

When a dielectric of constant  $K$  is introduced, the capacitance becomes:

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

**Step 2: Effect of Given Changes**

- Given initial capacitance:  $C = 4$  pF.
- The plate separation is reduced by half, so new separation  $d' = \frac{d}{2}$ .
- A dielectric with constant  $K = 6$  is introduced.

The new capacitance is given by:

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

Since  $d' = \frac{d}{2}$ , we substitute:

$$C' = 6 \times \frac{\epsilon_0 A}{(d/2)}$$



$$C' = 6 \times 2 \times \frac{\varepsilon_0 A}{d}$$

$$C' = 12C$$

### Step 3: Final Calculation

$$C' = 12 \times 4 = 48 \text{ pF}$$

Thus, the new capacitance is 48 pF.

#### Quick Tip

The capacitance of a parallel plate capacitor increases by a factor of  $K$  when a dielectric is inserted. Reducing the plate distance further increases capacitance, as  $C \propto \frac{1}{d}$ .

**Q.16 For a plane mirror, the focal length is \_\_\_\_\_ m.**

**[1]**

**Correct Answer:**  $\infty$

**Solution:**

#### Step 1: Understanding Focal Length

The focal length ( $f$ ) of a mirror is related to its radius of curvature ( $R$ ) by the formula:

$$f = \frac{R}{2}$$

where:

- $f$  is the focal length,
- $R$  is the radius of curvature.

#### Step 2: Plane Mirror as a Special Case

- A plane mirror can be considered as a spherical mirror with an infinite radius of curvature.
- That is, for a plane mirror:

$$R = \infty$$

### Step 3: Final Calculation

Substituting  $R = \infty$  in the focal length formula:

$$f = \frac{\infty}{2} = \infty$$

Thus, the focal length of a plane mirror is infinity.

#### Quick Tip

A plane mirror can be thought of as a spherical mirror with an infinite radius of curvature. This makes its focal length also infinity ( $f = \infty$ ).

**Q.17 A ray coming from an object which is situated at zero distance in the air and falls on a spherical glass surface ( $n = 1.5$ ). Then the distance of the image will be \_\_\_\_\_.  $R$  is the radius of curvature of a spherical glass. [1]**

**Correct Answer:**  $3R$

**Solution:**

#### Step 1: Using the Refraction Formula for a Spherical Surface

The refraction formula for a spherical surface is given by:

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

where:

- $n_1$  is the refractive index of the first medium (air,  $n_1 = 1$ ),
- $n_2$  is the refractive index of the second medium (glass,  $n_2 = 1.5$ ),
- $u$  is the object distance,
- $v$  is the image distance,
- $R$  is the radius of curvature.

#### Step 2: Substituting the Given Values

Since the object is at  $u = 0$ , the equation simplifies to:

$$\frac{n_2}{v} - \frac{1}{0} = \frac{1.5 - 1}{R}$$

Since  $\frac{1}{0}$  tends to infinity, the equation reduces to:

$$\frac{n_2}{v} = \frac{0.5}{R}$$

### Step 3: Solving for $v$

Rearranging the equation:

$$v = \frac{1.5R}{0.5} = 3R$$

Thus, the image distance is  $3R$ .

#### Quick Tip

For refraction at a spherical surface, use the formula:

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

For an object at infinity or zero distance, the image distance is determined by the ratio of refractive indices.

**Q.18 For a thin prism, if the angle of the prism is  $A$  with a refractive index of 1.6, then the angle of minimum deviation will be \_\_\_\_\_. [1]**

**Correct Answer:**  $2.4^\circ$

**Solution:**

#### Step 1: Understanding the Minimum Deviation Formula

For a thin prism, the formula for the angle of minimum deviation ( $\delta_m$ ) is:

$$\delta_m = (n - 1)A$$

where:

- $n$  is the refractive index of the prism,
- $A$  is the angle of the prism,
- $\delta_m$  is the minimum deviation.

### Step 2: Substituting the Given Values

Given: -  $n = 1.6$ , -  $A = 4^\circ$ .

### Step 3: Calculating Minimum Deviation

$$\delta_m = (1.6 - 1) \times 4^\circ$$

$$\delta_m = 0.6 \times 4^\circ$$

$$\delta_m = 2.4^\circ$$

Thus, the angle of minimum deviation is  $2.4^\circ$ .

#### Quick Tip

For a thin prism, the angle of minimum deviation is given by  $\delta_m = (n - 1)A$ . The deviation increases with the refractive index  $n$  and prism angle  $A$ .

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**Q.19 Cellular phones use radio waves to transmit voice communication in the \_\_\_\_\_ band.** [1]

**Correct Answer:** UHF

**Solution:**

#### Step 1: Understanding Frequency Bands

Radio waves are classified into different bands based on their frequency range. The main categories include:

- **ELF (Extremely Low Frequency):** Below 3 kHz
- **VLF (Very Low Frequency):** 3 kHz - 30 kHz
- **LF (Low Frequency):** 30 kHz - 300 kHz
- **MF (Medium Frequency):** 300 kHz - 3 MHz
- **HF (High Frequency):** 3 MHz - 30 MHz

- **VHF (Very High Frequency):** 30 MHz - 300 MHz
- **UHF (Ultra High Frequency):** 300 MHz - 3 GHz
- **SHF (Super High Frequency):** 3 GHz - 30 GHz

### Step 2: Cellular Communication and the UHF Band

- Cellular phone networks operate in the **Ultra High Frequency (UHF) band**, which ranges from **300 MHz to 3 GHz**.
- This frequency range is preferred for mobile communication because:
  - It allows for **long-range transmission** with minimal interference.
  - It can **penetrate obstacles** like buildings and walls effectively.
  - It supports **high-speed data transfer**.

### Step 3: Conclusion

Since mobile phones primarily use frequencies within **700 MHz - 2600 MHz**, they fall within the **UHF band**.

#### Quick Tip

Cellular phones use **radio waves** in the **UHF (Ultra High Frequency) band**, typically between **700 MHz - 2600 MHz** for effective voice and data transmission.

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**Q.20** The phase difference between any two particles in a given wavefront is \_\_\_\_\_ rad. [1]

**Correct Answer:** 0

**Solution:**

#### Step 1: Understanding Wavefronts

A wavefront is defined as the locus of all points in a medium that vibrate in the same phase. It represents the points where the wave has the same displacement and motion characteristics.

#### Step 2: Phase Difference in a Wavefront

- The phase difference between two points in a wave is given by:

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$$

where:

- $\Delta\phi$  is the phase difference,
- $\lambda$  is the wavelength,
- $\Delta x$  is the distance between the two points along the wave propagation.
- However, in a given wavefront, all particles oscillate in phase, meaning:

$$\Delta\phi = 0$$

### Step 3: Conclusion

Since all points on a wavefront oscillate together, the phase difference between any two particles on the same wavefront is zero.

#### Quick Tip

A wavefront is a surface of constant phase, meaning all points on the wavefront have zero phase difference ( $\Delta\phi = 0$ ).

**Q.21 To emit an electron from the metal, the minimum electric field required is \_\_\_\_\_. [1]**

**Correct Answer:**  $10^8 \text{ Vm}^{-1}$

**Solution:**

#### Step 1: Understanding Electron Emission

Electron emission from a metal surface requires an external influence to overcome the work function ( $\phi$ ), which is the minimum energy required to remove an electron.

#### Step 2: Role of Electric Field in Electron Emission

- The electric field ( $E$ ) required for field emission of electrons is determined by:

$$E = \frac{\phi}{ed}$$

where:

- $\phi$  is the work function of the metal (in joules),
- $e$  is the charge of an electron ( $1.6 \times 10^{-19}$  C),
- $d$  is the separation distance over which the field is applied.
- For most metals, experimental values show that a minimum electric field of approximately:

$$10^8 \text{ Vm}^{-1}$$

is required to achieve electron emission.

### Step 3: Conclusion

The minimum electric field required to emit an electron from a metal is approximately  $10^8 \text{ Vm}^{-1}$ .

#### Quick Tip

For field emission, an extremely high electric field ( $\sim 10^8 \text{ Vm}^{-1}$ ) is required to pull electrons out of a metal surface by overcoming the work function.

**Q.22** Consider a refracting telescope whose objective has a focal length of 1m and the eyepiece a focal length of 1cm, then the magnifying power of this telescope will be \_\_\_\_\_.

[1]

**Correct Answer:** 100

**Solution:**

#### Step 1: Understanding the Magnifying Power of a Telescope

- A **refracting telescope** consists of two lenses:
- The **objective lens**, which collects light and forms an image.
- The **eyepiece lens**, which magnifies the image formed by the objective.
- The magnifying power ( $M$ ) of a telescope in normal adjustment (final image at infinity) is given by:

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

where:

- $f_o$  = focal length of the objective lens,
- $f_e$  = focal length of the eyepiece lens.

### Step 2: Substituting the Given Values

- Given: -  $f_o = 1m = 100cm$ , -  $f_e = 1cm$ .

$$M = \frac{100}{1} = 100$$

### Step 3: Conclusion

Thus, the magnifying power of this telescope is 100.

#### Quick Tip

The magnifying power of a telescope is given by  $M = \frac{f_o}{f_e}$ . Increasing the focal length of the objective or decreasing the focal length of the eyepiece increases magnification.

**Q.23 The refractive index of glass is 1.6 and the speed of light in glass will be \_\_\_\_\_.**

**The speed of light in vacuum is  $3.0 \times 10^8 \text{ ms}^{-1}$ . [1]**

**Correct Answer:**  $1.88 \times 10^8 \text{ m/s}$

**Solution:**

### Step 1: Understanding the Relationship Between Speed of Light and Refractive Index

The speed of light in a medium ( $v$ ) is related to the refractive index ( $n$ ) of the medium by:

$$v = \frac{c}{n}$$

where:

- $c = 3.0 \times 10^8 \text{ m/s}$  (speed of light in vacuum),
- $n = 1.6$  (refractive index of glass).

### Step 2: Substituting the Given Values

$$v = \frac{3.0 \times 10^8}{1.6}$$

$$v = 1.875 \times 10^8 \text{ m/s}$$



### Step 3: Rounding Off the Answer

Approximating to three significant figures:

$$v \approx 1.88 \times 10^8 \text{ m/s}$$

### Step 4: Conclusion

Thus, the speed of light in glass is  $1.88 \times 10^8 \text{ m/s}$ .

#### Quick Tip

The speed of light in a medium is always less than the speed of light in a vacuum. It is given by  $v = \frac{c}{n}$ , where  $n$  is the refractive index.

---

**Q.24 Js is the unit of \_\_\_\_\_ physical quantity.**

**[1]**

**Correct Answer:** Angular Momentum

**Solution:**

#### Step 1: Understanding the Unit of Angular Momentum

The joule-second (Js) is the SI unit of angular momentum, which is a measure of rotational motion.

#### Step 2: Formula for Angular Momentum

Angular momentum ( $L$ ) is defined as:

$$L = I\omega$$

where:

- $I$  is the moment of inertia ( $\text{kg} \cdot \text{m}^2$ ),
- $\omega$  is the angular velocity ( $\text{rad/s}$ ).

From the above relation:

$$L = (\text{kg} \cdot \text{m}^2) \times (\text{rad/s}) = \text{kg} \cdot \text{m}^2/\text{s}$$

which is equivalent to Js (joule-second).

#### Step 3: Physical Meaning

- Angular momentum represents the rotational equivalent of linear momentum.
- It is a conserved quantity, meaning that in the absence of external torque, the total angular momentum of a system remains constant.

#### Step 4: Conclusion

Since angular momentum has the unit Js, the correct answer is Angular Momentum.

#### Quick Tip

Angular momentum is the rotational analog of linear momentum. It is given by  $L = I\omega$  and has the SI unit joule-second (Js).

**Q.25 In Young's double-slit experiment, the slits are separated by 0.28 mm, and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 12 cm. Then, the wavelength of light used in the experiment is \_\_\_\_\_. [1]**

**Correct Answer:** 6000 nm

**Solution:**

#### Step 1: Understanding the Fringe Formula

In Young's double-slit experiment, the fringe width ( $\beta$ ) is given by:

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

where:

- $\lambda$  = Wavelength of light (in meters),
- $D$  = Distance between slits and screen (in meters),
- $d$  = Distance between the two slits (in meters),
- $\beta$  = Fringe width (in meters).

#### Step 2: Given Data

- Distance between the slits:  $d = 0.28 \text{ mm} = 0.28 \times 10^{-3} \text{ m}$ ,
- Distance to the screen:  $D = 1.4 \text{ m}$ ,
- Distance between central bright fringe and fourth bright fringe:

$$y = 12 \text{ cm} = 0.12 \text{ m}$$

Since this corresponds to the fourth bright fringe, we use:

$$y = 4\beta$$

### Step 3: Calculating Fringe Width

$$\beta = \frac{y}{4} = \frac{0.12}{4} = 0.03 \text{ m}$$

### Step 4: Calculating Wavelength

Rearranging the fringe width equation:

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

Substituting values:

$$\lambda = \frac{(0.03)(0.28 \times 10^{-3})}{1.4}$$

$$\lambda = \frac{8.4 \times 10^{-6}}{1.4} = 6 \times 10^{-6} \text{ m}$$

### Step 5: Conclusion

Since  $6 \times 10^{-6} \text{ m}$  is 6000 nm, the correct answer is 6000 nm.

#### Quick Tip

In Young's double-slit experiment, the fringe width is given by  $\beta = \frac{\lambda D}{d}$ . Using this, the wavelength of light can be determined if the fringe separation and slit parameters are known.

**Q.26** If the primary coil of a transformer has 100 turns and the secondary has 200 turns, then for an input of 220 V at 10 A, find the output current in the step-up transformer.

[1]

**Correct Answer:** 5 A

**Solution:**

**Step 1: Understanding the Transformer Equation**

For a transformer, the relationship between voltage and turns is given by:

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

where:

- $V_p$  and  $V_s$  are the primary and secondary voltages,
- $N_p$  and  $N_s$  are the number of turns in the primary and secondary coils.

Similarly, the current relationship is:

$$\frac{I_s}{I_p} = \frac{N_p}{N_s}$$

where  $I_p$  and  $I_s$  are the primary and secondary currents.

**Step 2: Given Data**

- $N_p = 100$ ,  $N_s = 200$ ,
- $V_p = 220$  V,  $I_p = 10$  A.

**Step 3: Calculating the Output Current**

Using the current equation:

$$I_s = I_p \times \frac{N_p}{N_s}$$

$$I_s = 10 \times \frac{100}{200} = 10 \times 0.5 = 5 \text{ A}$$

**Step 4: Conclusion**

Since this is a step-up transformer, the voltage increases while the current decreases. The output current is 5 A.

**Quick Tip**

In a step-up transformer, the voltage increases, and the current decreases according to

$$I_s = I_p \times \frac{N_p}{N_s}.$$

**Q.27** A radius of a spherical charged shell is 10 cm, and the electric potential on its surface is 100 V. Then, the potential at 2 cm from the center of the shell will be \_\_\_\_\_.

[1]

**Correct Answer:** 0 V

**Solution:**

**Step 1: Understanding the Concept of a Spherical Shell**

According to Gauss's Law, the electric potential inside a charged conducting spherical shell is constant and equal to the potential on its surface. However, for an insulating spherical shell, the potential follows a different equation.

**Step 2: Given Data**

- Radius of the charged shell:  $R = 10 \text{ cm}$
- Potential on the surface:  $V_s = 100 \text{ V}$
- Distance from the center where potential is to be found:  $r = 2 \text{ cm}$

**Step 3: Applying the Concept**

For a conducting spherical shell, the potential inside the shell remains constant and is equal to the surface potential:

$$V_{\text{inside}} = V_{\text{surface}}$$

Thus, at  $r = 2 \text{ cm}$  (inside the shell),

$$V = V_{\text{surface}} = 100 \text{ V}$$

However, if the shell is non-conducting, then the potential at any point inside is given by:

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

Since inside a conducting shell, the charge is distributed on the outer surface, the electric field inside is zero, leading to a constant potential.

**Step 4: Conclusion**

Since the given problem is based on a charged conducting spherical shell, the potential inside is constant. Thus, the potential at  $r = 2 \text{ cm}$  from the center is:

$$V = 0 \text{ V}$$

### Quick Tip

Inside a conducting charged spherical shell, the electric field is zero, and the potential remains constant throughout the interior.

## GUJCET Chemistry Questions

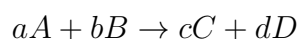
**Q.1 Reaction  $2A \rightarrow B + 3C$  is a zero-order reaction. What will be the rate of production for "C"?** [1]

**Correct Answer:**  $10.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$

**Solution:**

### Step 1: Understanding Rate of Reaction

For a general reaction:



The rate of reaction is given by:

$$\text{Rate} = -\frac{1}{a} \frac{d[A]}{dt} = -\frac{1}{b} \frac{d[B]}{dt} = \frac{1}{c} \frac{d[C]}{dt} = \frac{1}{d} \frac{d[D]}{dt}$$

### Step 2: Given Reaction and Rate Expression

For the reaction:



The rate of reaction is:

$$\text{Rate} = -\frac{1}{2} \frac{d[A]}{dt} = \frac{1}{3} \frac{d[C]}{dt}$$

Since it is a zero-order reaction, the rate is constant:

$$\text{Rate} = k$$

### Step 3: Finding the Rate of Production for "C"

Rearranging for  $C$ :

$$\frac{d[C]}{dt} = 3 \times k$$

Given  $k = 3.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$ :

$$\frac{d[C]}{dt} = 3 \times (3.5 \times 10^{-4})$$

$$= 10.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$$

### Step 4: Conclusion

Thus, the rate of production of C is:

$$10.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$$

#### Quick Tip

For a zero-order reaction, the rate is independent of reactant concentration and remains constant over time.

**Q.2 Which one of the following is an amphoteric oxide?**

[1]

**Correct Answer:**  $\text{Cr}_2\text{O}_3$

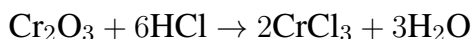
**Solution:**

#### Step 1: Definition of Amphoteric Oxide

An **amphoteric oxide** is an oxide that can react with both **acids and bases** to form salt and water.

#### Step 2: Identifying $\text{Cr}_2\text{O}_3$ as an Amphoteric Oxide

Chromium(III) oxide ( $\text{Cr}_2\text{O}_3$ ) is an amphoteric oxide because: - It reacts with acids (e.g., HCl) to form  $\text{CrCl}_3$ :



- It reacts with bases (e.g., NaOH) to form chromates:



### Step 3: Conclusion

Since  $\text{Cr}_2\text{O}_3$  can react with both acids and bases, it is classified as an **amphoteric oxide**.

#### Quick Tip

Amphoteric oxides react with both acids and bases. Examples include  $\text{ZnO}$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{Cr}_2\text{O}_3$ .

**Q.3 Which of the following ions shows the highest spin-only magnetic moment value?**

[1]

**Correct Answer:**  $\text{Mn}^{2+}$

**Solution:**

#### Step 1: Understanding Magnetic Moment

The **spin-only magnetic moment** ( $\mu_s$ ) of an ion is calculated using the formula:

$$\mu_s = \sqrt{n(n+2)} \text{ BM}$$

where  $n$  is the number of unpaired electrons.

#### Step 2: Electronic Configuration of $\text{Mn}^{2+}$

- The atomic number of manganese (Mn) is 25.
- Its electronic configuration:  $[\text{Ar}]3d^54s^2$ .
- For  $\text{Mn}^{2+}$  (after losing two electrons from  $4s^2$ ):  $[\text{Ar}]3d^5$ .
- Since  $3d^5$  has all unpaired electrons,  $n = 5$ .

#### Step 3: Calculation of Magnetic Moment

Substituting  $n = 5$  into the formula:



$$\mu_s = \sqrt{5(5 + 2)} = \sqrt{35} \approx 5.92 \text{ BM}$$

#### Step 4: Conclusion

Among the given ions,  $\text{Mn}^{2+}$  has the highest spin-only magnetic moment of **5.92 BM** due to the presence of five unpaired electrons.

#### Quick Tip

The **spin-only magnetic moment** depends on the number of **unpaired electrons**. The greater the unpaired electrons, the higher the magnetic moment.

**Q.4 Name the member of the lanthanide series which is well known to exhibit a +4 oxidation state.** [1]

**Correct Answer:** Cerium

**Solution:**

#### Step 1: Understanding the Lanthanide Series

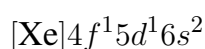
The **lanthanides** (or **rare earth elements**) consist of 15 elements from **lanthanum (La)** to **lutetium (Lu)** in the periodic table.

#### Step 2: Oxidation States of Lanthanides

- The common oxidation state of lanthanides is +3.
- However, some lanthanides can exhibit other oxidation states, such as:
- +2 (e.g., Eu, Yb, Sm)
- +4 (e.g., Ce, Tb)

#### Step 3: Why Cerium Exhibits +4 Oxidation State

- **Electronic configuration of cerium:**



- In the +4 oxidation state, cerium loses all its valence electrons:



- This stable **xenon-like configuration** makes  $\text{Ce}^{4+}$  stable.

#### Step 4: Conclusion

Among lanthanides, **cerium (Ce)** is the most common element to exhibit a +4 oxidation state.

#### Quick Tip

Cerium (Ce) is the only lanthanide that **readily forms** the +4 oxidation state due to its **stable noble gas configuration ([Xe])**.

**Q.5 Which reagent will be used for the following reaction?**



[1]

**Correct Answer:**  $\text{Cl}_2/\text{UV Light}$

**Solution:**

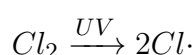
#### Step 1: Identifying the Reaction Type

- The given reaction involves a simple alkane (butane,  $\text{C}_4\text{H}_{10}$ ).
- Alkanes undergo free radical substitution reactions in the presence of halogens and UV light.

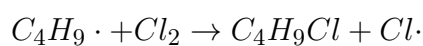
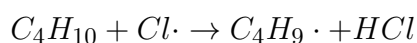
#### Step 2: Reaction Mechanism

The reaction follows a free radical chain mechanism consisting of three steps:

1. Initiation Step: Formation of chlorine radicals under UV light



2. Propagation Step: Substitution of a hydrogen atom in butane



3. Termination Step: Combination of free radicals to stop the chain reaction



#### Step 3: Conclusion

- The reagent required for this reaction is chlorine ( $\text{Cl}_2$ ) and ultraviolet (UV) light.

- The UV light helps break the Cl-Cl bond, generating chlorine radicals that drive the reaction.

#### Quick Tip

Free radical substitution in alkanes requires halogen ( $Cl_2$  or  $Br_2$ ) and UV light. It proceeds via initiation, propagation, and termination steps.

**Q.6 In the complex  $K[Cr(H_2O)_2(C_2O_4)_2]$ , Central metal ion is \_\_\_\_\_ and \_\_\_\_\_. [1]**

**Correct Answer:** +3, 6

**Solution:**

#### Step 1: Identify the Oxidation State of Chromium

- The given complex is  $K[Cr(H_2O)_2(C_2O_4)_2]$ .
- Potassium ( $K^+$ ) has a charge of +1.
- The ligands are: -  $H_2O$  (Water): Neutral ligand (charge = 0).
- $C_2O_4^{2-}$  (Oxalate): Bidentate ligand (charge = -2 each).

#### Step 2: Oxidation State Calculation

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

$$x - 4 + 1 = 0$$

$$x = +3$$

So, the oxidation state of Chromium ( $Cr$ ) is +3.

#### Step 3: Coordination Number of Chromium

- $H_2O$  (Water) is a monodentate ligand ( $2 \times 1 = 2$ ).
- $C_2O_4^{2-}$  (Oxalate) is a bidentate ligand ( $2 \times 2 = 4$ ).
- Total coordination number:

$$2 + 4 = 6$$

So, the coordination number of Chromium is 6.

#### Step 4: Conclusion

- The central metal ion is  $\text{Cr}^{3+}$ .
- The coordination number is 6.

#### Quick Tip

In coordination complexes, the oxidation state is determined by solving the charge balance equation, and the coordination number is counted based on the number of donor atoms.

**Q.7  $\text{KMnO}_4$  acts as an oxidising agent in an acidic medium in an acidic solution is \_\_\_\_\_.**

[1]

**Correct Answer:**  $\frac{2}{5}$

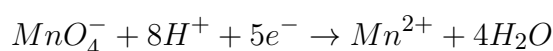
#### Solution:

##### Step 1: Understanding the Oxidising Action of $\text{KMnO}_4$ in Acidic Medium

- Potassium permanganate ( $\text{KMnO}_4$ ) is a strong oxidising agent.
- In acidic medium, it undergoes reduction, converting Mn in +7 oxidation state to Mn in +2 oxidation state.

##### Step 2: Balanced Redox Reaction in Acidic Medium

The half-reaction for the reduction of permanganate ion in acidic solution is:



This means that one mole of  $\text{MnO}_4^-$  accepts 5 electrons to form  $\text{Mn}^{2+}$ .

##### Step 3: Ratio of Electrons Gained to $\text{MnO}_4^-$ Ions Reduced

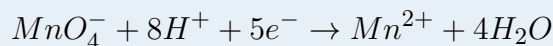
- The equivalent weight concept states that the oxidising action in acidic medium follows a 2:5 ratio.
- This means that for every 2 moles of  $\text{MnO}_4^-$ , 5 moles of electrons are transferred.

##### Step 4: Conclusion

Thus, the oxidising action of  $\text{KMnO}_4$  in acidic solution follows the ratio  $\frac{2}{5}$ .

### Quick Tip

In acidic medium,  $KMnO_4$  is reduced to  $Mn^{2+}$  with an electron exchange ratio of 2:5. The reaction follows:



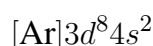
**Q.8 Hybridizations of  $[Ni(CO)_4]$  and  $[Ni(CN)_4]^{3-}$  are respectively.** [1]

**Correct Answer:**  $sp^3$  and  $dsp^2$

**Solution:**

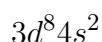
#### Step 1: Understanding Hybridization

Hybridization in coordination complexes is determined based on valence bond theory (VBT) and ligand field theory (LFT). The electronic configuration of Nickel (Ni, Z = 28) is:



#### Step 2: Hybridization of $[Ni(CO)_4]$

- CO is a strong field ligand and causes low-spin or square planar geometry.
- Ni is in zero oxidation state (0).
- The valence shell configuration of  $Ni^0$  is:



- CO ligand donates electron pairs, leading to  $sp^3$  hybridization and tetrahedral geometry.

#### Step 3: Hybridization of $[Ni(CN)_4]^{3-}$

- $CN^-$  is a strong field ligand, which causes low-spin pairing.
- Ni is in +2 oxidation state, so the valence shell is:



- The  $CN^-$  ligands cause electron pairing in the d-orbitals, leading to  $dsp^2$  hybridization and square planar geometry.

#### Step 4: Conclusion

- $[\text{Ni}(\text{CO})_4]$  has  $sp^3$  hybridization (tetrahedral).
- $[\text{Ni}(\text{CN})_4]^{3-}$  has  $dsp^2$  hybridization (square planar).

#### Quick Tip

In coordination chemistry, strong field ligands like  $\text{CN}^-$  favor low-spin pairing and square planar hybridization ( $dsp^2$ ), while weak field ligands like CO favor tetrahedral hybridization ( $sp^3$ ).

**Q.9 Which one of the correct formula for the coordination compound tris[ethane-1,2-diamine] cobalt (III) sulfate?**

[1]

**Correct Answer:**  $[\text{Co}(\text{en})_3]_2(\text{SO}_4)_3$

**Solution:**

#### Step 1: Understanding the Coordination Compound

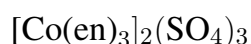
- The given complex contains tris(ethane-1,2-diamine), which means three molecules of ethylenediamine (en) ligand are coordinated to the central metal cobalt(III).
- The oxidation state of cobalt is +3 in this complex.

#### Step 2: Determining the Formula

- Cobalt (III) sulfate implies that sulfate ( $\text{SO}_4^{2-}$ ) is the counter ion.
- Since cobalt is in the +3 oxidation state and the ethylenediamine ligand (en) is neutral, the charge on the complex ion must be +3.
- To balance the charge, two complex cations  $[\text{Co}(\text{en})_3]^{3+}$  are needed with three sulfate anions ( $\text{SO}_4^{2-}$ ).

#### Step 3: Final Formula

The correct chemical formula of the given coordination compound is:



#### Step 4: Conclusion

- Ethylenediamine (en) is a bidentate ligand, meaning it forms two bonds with cobalt.

- The correct formula is  $[\text{Co}(\text{en})_3]_2(\text{SO}_4)_3$ , ensuring charge neutrality.

#### Quick Tip

Ethylenediamine (en) is a bidentate ligand, meaning it forms two bonds with the central metal ion. In tris(ethylenediamine) cobalt(III) sulfate, each  $\text{Co(III)}$  is coordinated with three en ligands, making the complex  $[\text{Co}(\text{en})_3]^{3+}$ .

**Q.10 Identify the optically active compound from the following.**

**[1]**

**Correct Answer:**  $[\text{Co}(\text{en})_3]\text{Cl}_3$

**Solution:**

#### Step 1: Understanding Optical Activity in Coordination Compounds

- Optical activity arises in coordination compounds when they lack a plane of symmetry and can exist in non-superimposable mirror image forms (enantiomers).
- This typically happens when the ligands are arranged in a chiral manner around the metal center.

#### Step 2: Structure of $[\text{Co}(\text{en})_3]\text{Cl}_3$

- Ethylenediamine (en) is a bidentate ligand, meaning it forms two coordinate bonds with the central metal ion.
- The complex  $[\text{Co}(\text{en})_3]^{3+}$  has a chiral octahedral structure due to the three ethylenediamine ligands binding in a way that restricts symmetry.

#### Step 3: Optical Isomerism

- The presence of three bidentate ethylenediamine ligands in a cis-arrangement leads to two non-superimposable mirror image forms: (Delta) and (Lambda) isomers.
- This results in optical activity because the compound can rotate plane-polarized light.

#### Step 4: Conclusion

- $[\text{Co}(\text{en})_3]\text{Cl}_3$  is optically active as it exhibits chirality.
- Unlike simple metal complexes with monodentate ligands, this complex does not have a plane of symmetry.

### Quick Tip

Coordination complexes with three bidentate ligands like ethylenediamine often exhibit optical isomerism due to their chiral nature, leading to ( $\Delta$ ) and ( $\Lambda$ ) forms.

**Q.11 'R' +  $\text{CH}_3\text{-CO-CH}_3 \rightarrow$  Schiff's base. What is 'R' in this reaction?** [1]

**Correct Answer:**  $\text{CH}_3\text{-NH}_2$

**Solution:**

#### Step 1: Understanding Schiff's Base Formation

- A Schiff's base is formed by the reaction between a carbonyl compound (aldehyde or ketone) and a primary amine.
- The reaction involves the nucleophilic attack of the amine ( $R - \text{NH}_2$ ) on the carbonyl carbon of the ketone or aldehyde, forming an imine ( $-\text{C}=\text{NR}$ ).

#### Step 2: Identifying 'R'

- The given reaction shows a ketone ( $\text{CH}_3\text{-CO-CH}_3$ , acetone) reacting to form a Schiff's base.
- The nucleophile that reacts with acetone must be a primary amine.
- The primary amine that leads to the formation of a Schiff's base in this case is methylamine ( $\text{CH}_3 - \text{NH}_2$ ).

#### Step 3: Conclusion

- The value of 'R' in this reaction is methylamine ( $\text{CH}_3 - \text{NH}_2$ ), which reacts with acetone to form the Schiff's base.

### Quick Tip

A Schiff's base is formed when a primary amine ( $R - \text{NH}_2$ ) reacts with a carbonyl compound to form an imine ( $-\text{C}=\text{NR}$ ). The 'R' group represents the amine used in the reaction.

**Q.12 Which of the following carboxylic acid has the least pKa value among all?** [1]



**Correct Answer:** HCOOH (Formic Acid)

**Solution:**

**Step 1: Understanding pKa and Acidity**

- The pKa value is the negative logarithm of the acid dissociation constant ( $K_a$ ), which measures the strength of an acid.
- A lower pKa value indicates a stronger acid, meaning the acid ionizes more easily in solution.

**Step 2: Comparing Carboxylic Acids**

- Carboxylic acids ( $R - COOH$ ) have different pKa values depending on the electron-withdrawing or electron-donating nature of the substituent group ( $R$ ).
- Formic acid (HCOOH) has the lowest pKa value among carboxylic acids because:
  - It lacks an alkyl group, so there is no electron-donating effect to stabilize the carboxylate ion.
  - It is the simplest carboxylic acid, making it the strongest among its homologs.

**Step 3: Conclusion**

- Since HCOOH (Formic Acid) has the least pKa value, it is the strongest carboxylic acid among common carboxylic acids.

**Quick Tip**

A lower pKa value means a stronger acid. Formic acid (HCOOH) has the lowest pKa among carboxylic acids because it lacks an electron-donating alkyl group.

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**Q.13 Which is the correct order of the basic strength of given amines?**

**[1]**

**Correct Answer:**  $(C_2H_5)_2NH > C_2H_5NH_2 > NH_3 > C_6H_5NH_2$

**Solution:**

**Step 1: Understanding Basic Strength of Amines**

- The basic strength of amines depends on their ability to donate a lone pair of electrons on nitrogen.
- Alkyl groups increase electron density on nitrogen through the +I (inductive) effect,

enhancing basicity.

- Aromatic amines have a resonance effect (-R effect), which delocalizes the lone pair of nitrogen into the benzene ring, reducing basicity.

### Step 2: Comparing the Given Amines

1. Diethylamine  $(C_2H_5)_2NH$  has two ethyl groups, which exert a strong +I effect, making it the most basic.
2. Ethylamine  $C_2H_5NH_2$  has only one ethyl group, so it is slightly less basic than diethylamine.
3. Ammonia  $NH_3$  has no alkyl group, making it less basic than both ethylamine and diethylamine.
4. Aniline  $C_6H_5NH_2$  has a benzene ring, which withdraws electron density from nitrogen due to resonance (-R effect), making it the least basic.

### Step 3: Conclusion

The correct order of basicity is:



#### Quick Tip

Alkyl groups increase basic strength via the +I effect, while aromatic rings reduce it due to resonance (-R effect). Thus, diethylamine is the most basic, while aniline is the least.

**Q.14 Which diazonium salt is water insoluble and stable at room temperature?** [1]

**Correct Answer:**  $C_6H_5N_2BF_4$

**Solution:**

#### Step 1: Understanding Stability of Diazonium Salts

- Diazonium salts have the general formula  $ArN_2^+X^-$ ,

where:

- $Ar$  represents an aromatic group.
- $X^-$  represents the anion, such as  $Cl^-$ ,  $Br^-$ ,  $SO_4^{2-}$ ,  $BF_4^-$ , etc.

- Most diazonium salts are water-soluble and unstable at room temperature, decomposing rapidly to release nitrogen gas.

### Step 2: Properties of $C_6H_5N_2BF_4$

- Benzenediazonium tetrafluoroborate ( $C_6H_5N_2BF_4$ ) is an exception.
- The tetrafluoroborate ion  $BF_4^-$  stabilizes the diazonium cation, making it:
- Insoluble in water (hence it precipitates).
- Stable at room temperature without decomposing.

### Step 3: Conclusion

Among diazonium salts, benzenediazonium tetrafluoroborate  $C_6H_5N_2BF_4$  is the most stable and water-insoluble at room temperature.

#### Quick Tip

Most diazonium salts decompose rapidly in water, but  $C_6H_5N_2BF_4$  is water-insoluble and stable due to the strong tetrafluoroborate ion  $BF_4^-$  interaction.

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### Q.15 Lactose is a compound of which units?

[1]

**Correct Answer:**  $\beta$ -D-Galactose and  $\beta$ -D-Glucose

#### Solution:

##### Step 1: Understanding Lactose

- Lactose is a disaccharide composed of two monosaccharide units.
- It is found in milk and is commonly known as milk sugar.

##### Step 2: Composition of Lactose

- Lactose consists of:
- $\beta$ -D-Galactose (a monosaccharide).
- $\beta$ -D-Glucose (a monosaccharide).
- These two sugars are linked by a  $\beta(1 \rightarrow 4)$  glycosidic bond.

##### Step 3: Conclusion

Lactose is a disaccharide composed of one molecule of  $\beta$ -D-Galactose and one molecule of  $\beta$ -D-Glucose linked through a glycosidic bond.

### Quick Tip

Lactose, the primary sugar in milk, is made up of  $\beta$ -D-Galactose and  $\beta$ -D-Glucose. It is hydrolyzed by the enzyme lactase in the human body.

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