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

Time Allowed :63 mins	Maximum Marks :42	Total Questions :42

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 (μ) 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 $m^2/V{\cdot}s$.

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

> Quick Tip
>
> **Mobility** (μ) 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** (μ_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 Ω 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: 2.86×10^{-3} 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 Φ 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 2.86×10^{-3} 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 V and the resistance is R = 4 Ω_______. **[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: μ_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** (μ), specifically the **permeability of free space** (μ_0).

Step 2: Definition of Magnetic Permeability

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

The permeability of free space (μ_0) is a universal constant used in electromagnetism.

Step 3: Expression for μ_0

The permeability of free space is given by:

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

Step 4: Importance of μ_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** (μ_0).

> Quick Tip
>
> **Permeability of free space** (μ_0) is a fundamental constant in electromagnetism. It represents the ability of vacuum to support a **magnetic field** and is given by $\mu_0 = 4\pi \times 10^{-7}$ H/m.

Q.6 A silver wire has a resistance of 215 Ω at 27.5°C and a resistance of 270 Ω at 100°C. Then the temperature coefficient of the resistivity of silver will be _______. [1]

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

Solution:

Step 1: Understanding the Temperature Coefficient of Resistivity

The **temperature coefficient of resistivity** (α) 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, - α = Temperature coefficient of resistivity.

Step 2: Given Values

- $R_1 = 215\,\Omega$, - $R_2 = 270\,\Omega$, - $T_1 = 27.5°C$, - $T_2 = 100°C$.

Step 3: Calculating α

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

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

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

$$\alpha = 3.9 \times 10^{-3}\,°C^{-1}$$

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

Quick Tip

The **temperature coefficient of resistivity** (α) 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 _____ Ω and _____ Ω 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° and a uniform external magnetic field of 0.5 T experiences a torque of magnitude equal to 4.5×10^{-2} J. Then the magnitude of the magnetic moment of the magnet will be _______. [1]

Correct Answer: 18×10^{-2} J T^{-1}

Solution:

Step 1: Understanding Magnetic Torque

- The torque (τ) 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, - θ is the angle between the magnetic moment and the field.

Step 2: Given Values

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

Step 3: Calculating M

Rearranging the equation:

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

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

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

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

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

Thus, the **magnetic moment** of the magnet is 18×10^{-2} **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: 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 (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 σ 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,
- Φ 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** (Φ) 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.

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:

$$X_L = 2\pi f L$$

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

- $L = 50.0$ mH = 50.0×10^{-3} H,
- $f = 50$ Hz,
- $V_{\text{rms}} = 220$ 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_{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 $X_L = 2\pi f L$. 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:

- $X_L = 2\pi f L$ is the inductive reactance,

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

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,

- ϕ 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,

- μ_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:

- ε_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.

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:

$$C = \frac{\varepsilon_0 A}{d}$$

where:

- C is the capacitance,

- ε_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:

$$C' = K\frac{\varepsilon_0 A}{d}$$

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:

$$C' = K\frac{\varepsilon_0 A}{d'}$$

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

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

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

$$C' = 12C$$

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: ∞

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: $2.4°$

Solution:

Step 1: Understanding the Minimum Deviation Formula

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

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

where:

- n is the refractive index of the prism,

- A is the angle of the prism,

- δ_m is the minimum deviation.

Step 2: Substituting the Given Values

Given: - $n = 1.6$, - $A = 4°$.

Step 3: Calculating Minimum Deviation

$$\delta_m = (1.6 - 1) \times 4°$$

$$\delta_m = 0.6 \times 4°$$

$$\delta_m = 2.4°$$

Thus, the angle of minimum deviation is $2.4°$.

> **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.

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.

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,

- λ is the wavelength,

- Δx 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 (ϕ), 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:

- ϕ is the work function of the metal (in joules),

- e is the charge of an electron (1.6×10^{-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 Vm^{-1}.

Quick Tip

For field emission, an extremely high electric field ($\sim 10^8$ 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 3.0×10^8 ms^{-1}. **[1]**

Correct Answer: 1.88×10^8 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:

- $c = 3.0 \times 10^8$ 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 1.88×10^8 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 ($kg \cdot m^2$),

- ω is the angular velocity (rad/s).

From the above relation:

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

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 (β) is given by:

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

where:

- λ = Wavelength of light (in meters),

- D = Distance between slits and screen (in meters),

- d = Distance between the two slits (in meters),

- β = Fringe width (in meters).

Step 2: Given Data

- Distance between the slits: $d = 0.28$ mm $= 0.28 \times 10^{-3}$ m,

- Distance to the screen: $D = 1.4$ 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 6×10^{-6} 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: $R = 10$ cm
- Potential on the surface: $V_s = 100$ V
- Distance from the center where potential is to be found: $r = 2$ 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 $r = 2$ 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 $r = 2$ 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: 10.5×10^{-4} mol L^{-1} s^{-1}

Solution:

Step 1: Understanding Rate of Reaction

For a general reaction:

$$aA + bB \rightarrow cC + dD$$

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:

$$2A \rightarrow B + 3C$$

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 $k = 3.5 \times 10^{-4}$ mol L^{-1} 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: Cr_2O_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 Cr_2O_3 as an Amphoteric Oxide

Chromium(III) oxide (Cr_2O_3) is an amphoteric oxide because: - It reacts with acids (e.g., HCl) to form $CrCl_3$:

$$Cr_2O_3 + 6HCl \rightarrow 2CrCl_3 + 3H_2O$$

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

$$Cr_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaCr(OH)_4$$

Step 3: Conclusion

Since Cr_2O_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 ZnO, Al_2O_3, and Cr_2O_3.

Q.3 Which of the following ions shows the highest spin-only magnetic moment value? [1]

Correct Answer: Mn^{2+}

Solution:

Step 1: Understanding Magnetic Moment

The **spin-only magnetic moment** (μ_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 Mn^{2+}

- The atomic number of manganese (Mn) is 25.
- Its electronic configuration: $[\text{Ar}]3d^5 4s^2$.
- For 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, 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:**

$$[\text{Xe}]4f^1 5d^1 6s^2$$

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

$$[\text{Xe}]$$

- This stable **xenon-like configuration** makes 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?

$CH_3CH_2CH_2CH_3 \rightarrow$ **[1]**

Correct Answer: Cl_2/UV Light

Solution:

Step 1: Identifying the Reaction Type

- The given reaction involves a simple alkane (butane, C_4H_{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

$$Cl_2 \xrightarrow{UV} 2Cl\cdot$$

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

$$C_4H_{10} + Cl\cdot \rightarrow C_4H_9 \cdot + HCl$$

$$C_4H_9 \cdot + Cl_2 \rightarrow C_4H_9Cl + Cl\cdot$$

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

$$Cl \cdot + Cl\cdot \rightarrow Cl_2$$

Step 3: Conclusion

- The reagent required for this reaction is chlorine (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 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 $KMnO_4$ 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 $KMnO_4$ in Acidic Medium

- Potassium permanganate $(KMnO_4)$ 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:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

This means that one mole of MnO_4^- accepts 5 electrons to form Mn^{2+}.

Step 3: Ratio of Electrons Gained to 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 MnO_4^-, 5 moles of electrons are transferred.

Step 4: Conclusion

Thus, the oxidising action of $KMnO_4$ 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:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Q.8 Hybridizations of $[\text{Ni(CO)}_4]$ and $[\text{Ni(CN)}_4]^{3-}$ 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:

$$[\text{Ar}]3d^8 4s^2$$

Step 2: Hybridization of $[\text{Ni(CO)}_4]$

- 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:

$$3d^8 4s^2$$

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

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

- CN^- is a strong field ligand, which causes low-spin pairing.

- Ni is in $+2$ oxidation state, so the valence shell is:

$$3d^8$$

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

Step 4: Conclusion

- $[Ni(CO)_4]$ has sp^3 hybridization (tetrahedral).

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

Quick Tip

In coordination chemistry, strong field ligands like 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: $[Co(en)_3]_2(SO_4)_3$

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 (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 $[Co(en)_3]^{3+}$ are needed with three sulfate anions (SO_4^{2-}).

Step 3: Final Formula

The correct chemical formula of the given coordination compound is:

$$[Co(en)_3]_2(SO_4)_3$$

Step 4: Conclusion

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

- The correct formula is $[Co(en)_3]_2(SO_4)_3$, 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 Co(III) is coordinated with three en ligands, making the complex $[Co(en)_3]^{3+}$.

Q.10 Identify the optically active compound from the following. [1]

Correct Answer: $[Co(en)_3]Cl_3$

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 $[Co(en)_3]Cl_3$

- Ethylenediamine (en) is a bidentate ligand, meaning it forms two coordinate bonds with the central metal ion.

- The complex $[Co(en)_3]^{3+}$ 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

- $[Co(en)_3]Cl_3$ 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' + CH_3-CO-CH_3 → Schiff's base. What is 'R' in this reaction? [1]

Correct Answer: CH_3-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 ($R - NH_2$) on the carbonyl carbon of the ketone or aldehyde, forming an imine (-C=NR).

Step 2: Identifying 'R'

- The given reaction shows a ketone (CH_3-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 ($CH_3 - NH_2$).

Step 3: Conclusion

- The value of 'R' in this reaction is methylamine ($CH_3 - NH_2$), which reacts with acetone to form the Schiff's base.

Quick Tip

A Schiff's base is formed when a primary amine ($R - NH_2$) reacts with a carbonyl compound to form an imine (-C=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.

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:

$$(C_2H_5)_2NH > C_2H_5NH_2 > NH_3 > C_6H_5NH_2$$

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.

Q.15 Lactose is a compound of which units? [1]

Correct Answer: β-D-Galactose and β-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:

- β-D-Galactose (a monosaccharide).

- β-D-Glucose (a monosaccharide).

- These two sugars are linked by a $\beta(1 \to 4)$ glycosidic bond.

Step 3: Conclusion

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

Quick Tip

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