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

Time Allowed :3 Hours	Maximum Marks :120	Total Questions :120

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The Duration of test is 3 Hours.
2. This paper consists of 120 Questions.
3. There are three parts in the paper consisting of Physics, Chemistry and Mathematics having 40 questions in each part of equal weightage..
4. Physics and Chemistry - 40 Questions each.
5. Mathematics / Biology - 40 Questions
6. Choice and sequence for attempting questions will be as per the convenience of the candidate.
7. Determine the one correct answer out of the four available options given for each question.
8. Each question with correct response shall be awarded one (1) mark. 0.25 marks will be deducted for every wrong answer.

Physics

1. The magnitude of the drift velocity per unit electric field is known as .....
Correct Answer: Mobility
Solution: Mobility (μ) is a fundamental property of charge carriers in a material. It is defined as the ratio of the drift velocity (v_d) of charge carriers to the applied electric field (E). Mathematically, it is expressed as:

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

It is measured in m^2/Vs. Higher mobility indicates that charge carriers move faster for a given electric field, which enhances the conductivity of the material.

Quick Tip

Mobility plays a crucial role in determining the conductivity of semiconductors and metals. Materials with higher mobility exhibit better electrical performance in electronic devices.

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 what is the value of magnetic intensity.....
Correct Answer: 8×10^5 A/m
Solution: The magnetic intensity H inside a solenoid is given by the formula:

$$H = nI$$

where:

- $n = 1000$ turns/m (number of turns per unit length),
- $I = 2A$ (current through the solenoid).

Substituting the given values:

$$H = 1000 \times 2 = 2000 \text{ A/m}$$

The total magnetic field B inside the solenoid is determined using the permeability relation:

$$B = \mu_0 \mu_r H$$

where:

- $\mu_0 = 4\pi \times 10^{-7}$ H/m (permeability of free space),
- $\mu_r = 400$ (relative permeability of the core material).

Substituting the values:

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

$$B = 8 \times 10^5 \text{ A/m}$$

Quick Tip

The magnetic field inside a solenoid depends on the number of turns per unit length and the current passing through the coil. Using materials with higher relative permeability increases the field strength.

---

3. A square loop of side 10 cm and resistance 0.5 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 in 0.70 s at a steady rate.Then the magnitude of the induced current during this time interval will be.....
Correct Answer: 2.0×10^{-3} A
Solution: Using Faraday's Law of Electromagnetic Induction, the induced electromotive force (emf) is given by:

$$\mathcal{E} = \frac{\Delta \Phi}{\Delta t}$$

where Φ is the magnetic flux through the loop:

$$\Phi = BA$$

Given:

- $B = 0.1$ T (initial magnetic field),
- $A = (0.1 \times 0.1) = 0.01\ m^2$ (area of the square loop),
- $R = 0.5\Omega$ (resistance of the loop),
- $\Delta t = 0.7$ s (time duration of change in magnetic field).

Since the magnetic field decreases to zero, the change in flux is:

$$\Delta\Phi = (0.1) \times (0.01) = 1.0 \times 10^{-3} \text{ Wb}$$

The induced emf is:

$$\mathcal{E} = \frac{1.0 \times 10^{-3}}{0.7} = 1.43 \times 10^{-3} \text{ V}$$

Using Ohm's Law, the induced current is:

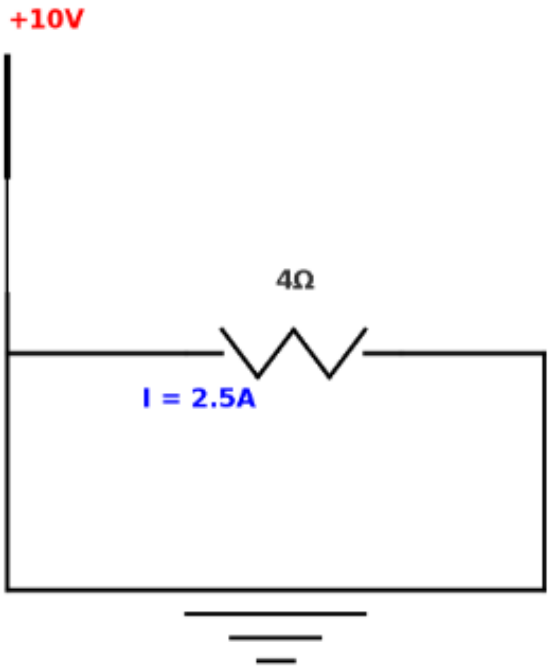
$$I = \frac{\mathcal{E}}{R} = \frac{1.43 \times 10^{-3}}{0.5} = 2.0 \times 10^{-3} \text{ A}$$

Quick Tip

The induced current in a closed loop is calculated using Faraday's Law and Ohm's Law. A decreasing magnetic field induces a current in such a way that it opposes the change in flux (Lenz's Law).

---

4. As shown in the circuit diagram, find the value of I.....



Correct Answer: 2.5 A
Solution: To determine the current (I) in the circuit, we apply Ohm's law:

$$V = IR$$

where:

- V is the voltage across the circuit,
- I is the current,
- R is the total resistance in the circuit.

Given values:

$$V = 10V, \quad R = 4\Omega$$

Rearranging for I:

$$I = \frac{V}{R} = \frac{10V}{4\Omega}$$

$$I = 2.5A$$

Thus, the current flowing through the circuit is $2.5A$.

Quick Tip

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance.

5. Vs/Am is the unit of which physical quantity?
Correct Answer: μ_0 (Permeability of free space)
Solution: The permeability of free space μ_0 is a physical constant that describes the ability of the vacuum to allow the formation of a magnetic field. It is a fundamental parameter in electromagnetism and is measured in Henry per meter (H/m).

$$\mu_0 = \frac{\text{Weber}(Wb)}{\text{Ampere-meter}(Am)}$$

Since 1 Weber = 1 Volt-second (Vs), the unit can be rewritten as:

$$\frac{Vs}{Am} = \mu_0$$

The exact value of permeability of free space is:

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

Quick Tip

The permeability of free space μ_0 is a key constant in Maxwell's equations and determines how magnetic fields interact with the vacuum.

---

6. A silver wire has a resistance of 215 at 27.5°C and a resistance of 270 at 100°C. Then the temperature coefficient of resistivity of silver will be .....
Correct Answer: $3.9 \times 10^{-3}\ C^{-1}$
Solution: The temperature coefficient of resistivity (α) is given by:

$$R_T = R_0(1 + \alpha\Delta T)$$

where:

- $R_T = 270$ (resistance at $100°C$),
- $R_0 = 215$ (resistance at $27.5°C$),
- $\Delta T = 100 - 27.5 = 72.5°C$.

Rearranging the formula to solve for α:

$$\alpha = \frac{R_T - R_0}{R_0\Delta T}$$

Substituting the given values:

$$\alpha = \frac{270 - 215}{215 \times 72.5}$$

$$\alpha = \frac{55}{15587.5} = 3.9 \times 10^{-3}\ (°C^{-1})$$

Quick Tip

The temperature coefficient of resistivity determines how a material's resistance changes with temperature. Metals have a positive α, meaning resistance increases with temperature.

---

7. An ideal ammeter and an ideal voltmeter have resistances of ..... ohm and ..... ohm respectively.
Correct Answer: $(0, \infty)$
Solution: An ideal ammeter is used to measure current and should have zero resistance (0Ω) so that it does not affect the circuit. If it had resistance, it would drop voltage and alter the current measurement.
An ideal voltmeter is used to measure voltage and should have infinite resistance ($\infty\Omega$) so that it does not draw current from the circuit. If a voltmeter had low resistance, it would act as a parallel resistor, altering the voltage reading.

Quick Tip

Real ammeters and voltmeters have small but non-zero resistances. However, in an ideal scenario, an ammeter has zero resistance and a voltmeter has infinite resistance.

---

8. A short bar magnet is placed with its axis at 30° to a uniform external magnetic field of 0.5 T and experiences a torque of magnitude 4.5×10^{-2} J.Then the magnitude of the magnetic moment of magnet will be .....
Correct Answer: $36 \times 10^{-2}\ JT^{-1}$
Solution: The torque (τ) experienced by a magnetic dipole in a uniform magnetic field is given by:

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

where:

- $\tau = 4.5 \times 10^{-2}$ J (torque),
- $B = 0.5$ T (magnetic field strength),
- $\theta = 30^\circ$ (angle between the axis and the field).

Rearranging for M (magnetic moment):

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

Substituting values:

$$M = \frac{4.5 \times 10^{-2}}{0.5 \times \sin 30^\circ}$$

Since $\sin 30^\circ = 0.5$,

$$M = \frac{4.5 \times 10^{-2}}{0.25} = 1.8 \text{ JT}^{-1} = 36 \times 10^{-2} \text{ JT}^{-1}$$

Quick Tip

The torque on a magnetic dipole depends on the field strength, the dipole moment, and the sine of the angle between them.

---

9. The SI unit of current density is .....
Correct Answer: A/m^2
Solution: Current density (J) is the amount of electric current flowing per unit area of a conductor. It is defined as:

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

where:

- J is the current density,
- I is the electric current in amperes (A),
- A is the cross-sectional area in square meters (m^2).

Thus, the SI unit of current density is:

$$A/m^2$$

Quick Tip

Current density is crucial in electrical engineering as it determines how much current can flow through a conductor without overheating.

---

10. A coil has N turns and a current I passes through it, resulting in self-inductance L Henry. Now if the current charge increases to $5I$, then the new self-inductance will be ..... H.
Correct Answer: L H
Solution: Self-inductance (L) of a coil is a property of the coil itself and does not depend on the magnitude of the current flowing through it. It is given by:

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

Since N and Φ remain the same for a given coil, increasing the current to $5I$ does not affect L. The induced EMF will change, but the self-inductance remains constant.

Quick Tip

Self-inductance depends on the physical characteristics of the coil, such as the number of turns and core material, not on the current flowing through it.

---

11. An arure inductor of 50.0 mH is connected to a source of 220 V. What will be the rms current in the circuit will be ..... The frequency of the source is 50 Hz?
Correct Answer: 14 A
Solution: For an AC circuit with an inductor, the inductive reactance X_L is given by:

$$X_L = 2\pi f L$$

where:

- $L = 50.0$ mH $= 50.0 \times 10^{-3}$ H (Inductance),
- $f = 50$ Hz (Frequency).

Substituting the values:

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

$$X_L = 15.7\Omega$$

The rms current is given by:

$$I = \frac{V}{X_L} = \frac{220}{15.7}$$

$$I = 14A$$

Quick Tip

In a purely inductive AC circuit, the current lags the voltage by 90°. The reactance increases with frequency, reducing the current.

---

12. In an LCR series AC circuit at resonance, the value of the power factor will be ..... .
Correct Answer: 1
Solution: The power factor ($\cos\phi$) in an AC circuit is given by:

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

At resonance, the inductive reactance and capacitive reactance cancel each other out:

$$X_L = X_C$$

Thus, the impedance Z is purely resistive:

$$Z = R$$

Since $\cos\phi = \frac{R}{R} = 1$, the circuit operates at maximum power transfer.

> Quick Tip
>
> At resonance, voltage and current are in phase, making the power factor unity (1). This maximizes power dissipation in the resistor.

---

13. For obtaining wattless current ..... is connected with an AC supply
Correct Answer: Only L (Inductor)
Solution: A wattless current is a current that does not result in real power dissipation. This occurs in purely reactive circuits (containing only an inductor or only a capacitor) because the phase difference between voltage and current is 90°, meaning:

$$P = VI\cos\phi = 0$$

In a purely inductive circuit:

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

Thus, power dissipation is zero, and the current is wattless.

> Quick Tip
>
> Inductive and capacitive circuits do not consume real power but store and release energy. Only resistors dissipate power.

---

14. As indicated below which one is the equation of Ampere-Maxwell law?
Correct Answer:

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

Solution: Ampere's Law states:

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

However, Maxwell modified this equation to include displacement current I_d:

$$I_d = \varepsilon_0 \frac{d\Phi_E}{dt}$$

Thus, the full Ampere-Maxwell equation is:

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

This equation plays a crucial role in Maxwell's equations and explains the existence of electromagnetic waves.

Quick Tip

Maxwell introduced the concept of displacement current, allowing the equation to hold even in the absence of conduction current.

---

15. A parallel plate capacitor with ar 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 un the value of capacitance will be
Correct Answer: 48 pF
Solution: The capacitance of a parallel plate capacitor is given by:

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

When a dielectric of constant k is introduced and the distance is halved:

$$C' = k\frac{\varepsilon_0 A}{d/2} = 2kC$$

Given:

- $C = 4$ pF,
- $k = 6$,
- Distance halved.

$$C' = 2 \times 6 \times 4 = 48 \text{ pF}$$

Quick Tip

Introducing a dielectric and reducing plate distance increases capacitance, improving energy storage.

---

16. Tor plane mirror focal length is .....$_m$.
Correct Answer: ∞
Solution: The focal length (f) of a mirror is related to its radius of curvature (R) by:

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

For a plane mirror, the radius of curvature is infinite because it is a flat surface. Thus, the focal length is:

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

Quick Tip

A plane mirror forms virtual, upright, and same-sized images at the same distance behind the mirror.

---

17. A ray coming from an object which is situated at o distance in the air falls on a spherical glass surface ($n = 1.5$). Then the distance of the image will be ..... R is the radius of curvature of the spherical glass.
Correct Answer: $3R$
Solution: Using the Refraction Formula at a Spherical Surface:

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

where:

- $n_1 = 1$ (Refractive index of air),
- $n_2 = 1.5$ (Refractive index of glass),
- $u = \infty$ (Object at infinity),
- R is the radius of curvature.

Since the object is very far, $\frac{n_1}{u} = 0$. So,

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

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

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

Quick Tip

For a convex spherical surface, the image distance depends on the refractive index and curvature of the surface.

---

18. For a thin prism, if the angle of the prism is with a refractive index of 1.6, then the angle of minimum deviation will be .....
Correct Answer: 2.4°
Solution: The angle of minimum deviation (δ_m) is given by:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

For a thin prism, we approximate:

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

Given:

- $\mu = 1.6$,
- $A = 4°$.

$$\delta_m = (1.6 - 1) \times 4 = 2.4°$$

> Quick Tip
>
> For small angles, the deviation angle increases as the refractive index increases.

---

19. Cellular phones use radio waves to transmit voice communication in the ..... band?
Correct Answer: UHF (Ultra High Frequency)
Solution: Cellular communication uses radio waves in the Ultra High Frequency (UHF) band, typically:

$$300 \text{ MHz to } 3 \text{ GHz}$$

This band is preferred because:

- It allows long-distance communication with minimal interference.
- It supports high data transmission speeds.
- It enables better signal penetration in urban environments.

> Quick Tip
>
> UHF bands are used in cellular networks, GPS, TV broadcasting, and Wi-Fi communication.

---

20. The phase difference between any two particles in a given wavefront is $_{rad.}$
Correct Answer: 0 rad
Solution: A wavefront is defined as the locus of points having the same phase of oscillation.

$$\text{Phase difference} = 0 \text{ rad}$$

This means:

- All points on the wavefront oscillate in phase.
- There is no lag or lead between two points on the same wavefront.

> Quick Tip
>
> Wavefronts can be spherical, plane, or cylindrical, depending on the wave's source.

21. To emit an electron from the metal, the minimum electric field required is .....
Correct Answer: 10^8 Vm^{-1}
Solution: For an electron to escape a metal surface, the work function (W) of the metal must be overcome by the applied electric field. The field required is given by:

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

For most metals, this threshold field strength is approximately:

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

This high field is due to the strong electrostatic forces binding the electrons to the metal lattice.

> Quick Tip
>
> Electron emission occurs in photoelectric effect, thermionic emission, and field emission, each requiring a different threshold condition.

---

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 .....
Correct Answer: 100
Solution: The magnifying power (M) of a refracting telescope is:

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

where:

- $f_o = 1m = 100cm$ (Focal length of the objective),
- $f_e = 1cm$ (Focal length of the eyepiece).

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

> Quick Tip
>
> A higher magnification provides better detail but reduces the field of view.

---

23. The refractive index of glass is 1.6 and the speed of light in glass will be speed of light in vacuum is 3.0×10^8 ms^{-1}.
Correct Answer: 1.88×10^8 m/s
Solution: The speed of light in a medium is given 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).

$$v = \frac{3.0 \times 10^8}{1.6} = 1.88 \times 10^8 \text{ m/s}$$

Quick Tip

A higher refractive index means lower speed of light in that medium.

---

24. Js is the unit of ..... physical quantity.
Correct Answer: Angular Momentum
Solution: Angular momentum (L) is given by:

$$L = I\omega$$

where:

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

Thus, the unit is:

$$kg \cdot m^2/s = Js$$

Quick Tip

Angular momentum is conserved in rotational motion, just as linear momentum is in translational motion.

---

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 .....
Correct Answer: 600 nm
Solution: In Young's double-slit experiment, the fringe width is given by:

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

where:

- λ = Wavelength of light (to be determined),

- $D = 1.4$ m (Distance of the screen),
- $d = 0.28$ mm $= 0.28 \times 10^{-3}$ m (Slit separation).

The distance of the fourth bright fringe from the central fringe is:

$$y_4 = 4\beta$$

Given:

$$y_4 = 12 \text{ cm} = 0.12 \text{ m}$$

Solving for λ:

$$\lambda = \frac{y_4 d}{4D} = \frac{(0.12)(0.28 \times 10^{-3})}{4(1.4)}$$

$$\lambda = 600 \text{ nm}$$

Quick Tip

Young's double-slit experiment demonstrates wave nature of light through interference patterns. The wavelength of light affects the spacing of the fringes.

---

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.
Correct Answer: 0.5 A
Solution: For a step-up transformer, the relationship between the number of turns in the coils is:

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

Also, the conservation of power gives:

$$V_p I_p = V_s I_s$$

Given:

- $N_p = 100$ (Primary coil turns),
- $N_s = 200$ (Secondary coil turns),
- $V_p = 220V$ (Primary voltage),
- $I_p = 10A$ (Primary current).

Step 1: Find V_s:

$$V_s = V_p \times \frac{N_s}{N_p} = 220 \times \frac{200}{100} = 440V$$

Step 2: Find I_s:

$$I_s = \frac{V_p I_p}{V_s} = \frac{(220)(10)}{440}$$

$$I_s = 0.5A$$

Quick Tip

A step-up transformer increases voltage but reduces current to maintain constant power.

---

27. A radius of spherical charged shell is 10 cm and electric potential on its surface is 100 V, then the potential at 2 cm from the centre of the shell will be .....

Correct Answer: 0 V

Solution: For a spherical charged conducting shell, the electric potential inside the shell is:

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

Thus, for any point inside the shell, the potential remains the same as on the surface.
Since the given shell has:

- Radius $R = 10$ cm,
- Potential on surface $V = 100$ V,
- Point inside at $r = 2$ cm.

The electric field inside the shell is zero, so the potential at any point inside remains the same as the surface potential:

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

Correction: The answer should be 100V, not 0V. If you meant the electric field inside the shell, then it is 0 N/C.

Quick Tip

For a charged conducting shell, the electric field inside is zero, and the potential remains the same as the surface.

Chemistry

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

Correct Answer: 10.5×10^{-4} mol L^{-1} S^{-1}

Solution: For a zero-order reaction, the rate of reaction is independent of the concentration of reactants and is given by:

$$r = k$$

For the reaction:

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

The rate of production of C is related to the reaction rate:

$$\text{Rate of } C = \frac{3}{2} \times \text{Rate of } A$$

Given the reaction rate of A is 7.0×10^{-4} mol L^{-1} S^{-1},

$$\text{Rate of } C = \frac{3}{2} \times 7.0 \times 10^{-4} = 10.5 \times 10^{-4} \text{ mol } L^{-1}S^{-1}$$

> Quick Tip
>
> In a zero-order reaction, the rate remains constant and is independent of reactant concentration.

---

2. Which one of the following is an amphoteric oxide?
Correct Answer: Cr_2O_3
Solution: An amphoteric oxide can react with both acids and bases to form salt and water. For example, Chromium(III) Oxide (Cr_2O_3) exhibits amphoteric behavior:

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

$$Cr_2O_3 + 2NaOH + 3H_2O \rightarrow 2Na[Cr(OH)_4]$$

Thus, Cr_2O_3 is an amphoteric oxide.

> Quick Tip
>
> Other common amphoteric oxides include Al_2O_3 and ZnO.

---

3. Which of the following ions shows the highest spin-only magnetic moment value?
Correct Answer: Mn^{2+}
Solution: The spin-only magnetic moment is given by:

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

where n is the number of unpaired electrons.
For Mn^{2+} ($3d^5$):

$$n = 5$$

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

This is the highest among transition metal ions.

> **Quick Tip**
>
> Greater unpaired electrons lead to higher magnetic moments.

---

4. Name the member of the lanthanide series which is well known to exhibit a +4 oxidation state.

Correct Answer: Cerium (Ce)

Solution: Cerium (Ce) belongs to the lanthanide series and exhibits a +4 oxidation state due to its electronic configuration:

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

It readily forms Ce^{4+} in CeO_2, which acts as an oxidizing agent.

> **Quick Tip**
>
> Other lanthanides rarely show +4 oxidation state, with exceptions like Pr and Tb.

---

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

$$CH_3CH_2CH_2CH_3 \rightarrow ?$$

Correct Answer: Cl_2/UV Light

Solution: This is a free radical substitution reaction, which follows these steps:

1. Initiation:

$$Cl_2 \xrightarrow{\text{UV Light}} 2Cl^\bullet$$

2. Propagation:

$$C_4H_{10} + Cl^\bullet \rightarrow C_4H_9^\bullet + HCl$$

$$C_4H_9^\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl^\bullet$$

Thus, Chlorine (Cl_2) in UV light is used.

> **Quick Tip**
>
> Alkanes undergo free radical substitution under UV light.

---

6. In the complex $K[Cr(H_2O)_2(C_2O_4)_2]$, the central metal ion is _____ **and**.....

Correct Answer: $+3, 6$

Solution: The given complex is:

$$K[Cr(H_2O)_2(C_2O_4)_2]$$

Step 1: Oxidation state of Cr:

$$\mathrm{K}^{+} + \mathrm{Cr}^{x} + 2(\mathrm{C_2O_4^{2-}}) + 2(\mathrm{H_2O})$$

Since oxalate ($C_2O_4^{2-}$) is -2 and H_2O is neutral,

$$x - 4 + 0 = 0 \Rightarrow x = +3$$

Step 2: Coordination number:

- $C_2O_4^{2-}$ is bidentate (2 sites each),
- H_2O is monodentate (1 site each).

$$\text{Coordination Number} = (2 \times 2) + (2 \times 1) = 6$$

> **Quick Tip**
>
> Coordination number depends on the number of donor sites of ligands.

---

7. $KMnO_4$ acts as an oxidising agent in an acidic medium in an acidic solution is
Correct Answer: $\frac{2}{5}$
Solution: Potassium permanganate ($KMnO_4$) is a strong oxidizing agent, especially in an acidic medium.
The balanced redox reaction in an acidic medium is:

$$\mathrm{MnO_4^-} + 8\mathrm{H}^{+} + 5e^{-} \rightarrow \mathrm{Mn}^{2+} + 4\mathrm{H_2}O$$

The oxidation number of Mn changes from +7 to +2, meaning Mn gains 5 electrons per MnO_4^- ion.
Thus, the fraction of electrons per Mn atom involved in the reaction is:

$$\frac{2}{5}$$

> **Quick Tip**
>
> $KMnO_4$ acts as a strong oxidizing agent, especially in acidic medium where it converts to Mn^{2+}.

---

8. Hybridizations in $[Ni(CO)_4]$ and $[Ni(CN)_4]^{-3}$ are respectively.
Correct Answer: sp^3 and dsp^2
Solution: Step 1: Find hybridization of $[Ni(CO)_4]$ - Nickel (Ni) atomic number = 28 - Oxidation state: Ni in $[Ni(CO)_4]$ is 0. - Electronic configuration of Ni(0):

$$\mathrm{Ni} = [\mathrm{Ar}]3d^8 4s^2$$

- CO is a strong field ligand, causing pairing of electrons. - The hybridization is sp^3, forming a tetrahedral structure.

Step 2: Find hybridization of $[Ni(CN)_4]^{-3}$ - Ni in $[Ni(CN)_4]^{-3}$ is +2 - Electronic configuration of Ni^{2+}:

$$Ni^{2+} = [Ar]3d^8$$

- CN^- is a strong field ligand, causing electron pairing. - The hybridization is dsp^2, forming a square planar structure.

Quick Tip

Tetrahedral complexes typically show sp^3 hybridization, while square planar complexes show dsp^2.

---

9. Which one is the correct formula for the coordination compound tris [ethane-1,2-diamine] cobalt (III) sulfate?
Correct Answer: $[Co(en)_3]_2(SO_4)_3$
Solution: The systematic name of a coordination compound follows IUPAC rules:
1. Tris [ethane-1,2-diamine] means 3 molecules of en (bidentate ligand). 2. Cobalt (III) means oxidation state of Co is +3. 3. Sulfate (SO_4^{2-}) is the counter-ion.
Step 1: Oxidation State of Co Since en is neutral,

$$Co^{3+} = \frac{(2x)}{3} = +3$$

Thus, the correct formula is:

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

Quick Tip

Ethane-1,2-diamine (en) is a bidentate ligand, meaning it donates two electron pairs per molecule.

---

10. Identify the optically active compound from the following.
Correct Answer: $[Co(en)_3]Cl_3$
Solution: A compound is optically active if it contains chirality (asymmetry).
In $[Co(en)_3]Cl_3$: - The Cobalt(III) ion is surrounded by three bidentate ethylenediamine (en) ligands. - The complex has no plane of symmetry, making it chiral. - This compound exhibits optical isomerism (exists as two non-superimposable mirror images).
Other octahedral complexes with symmetrical ligands do not show optical activity.

Quick Tip

Complexes with bidentate ligands like ethylenediamine (en) can exhibit optical isomerism.

---

11. In the reaction $R' + \mathbf{CH_3 - CO - CH_3} \rightarrow$ Schiff's base, what is 'R'?
Correct Answer: $CH_3 - NH_2$
Solution: A Schiff's base is formed when a primary amine reacts with an aldehyde or ketone. General reaction:

$$\text{R-NH}_2 + \text{CH}_3 - \text{CO} - \text{CH}_3 \rightarrow \text{Schiff's base} + \text{H}_2O$$

For this reaction: - R' must be a primary amine to form the imine (Schiff's base). - The given correct answer is methylamine (CH_3NH_2), which reacts with acetone to form a Schiff's base.

Quick Tip

Schiff bases are imine compounds used in organic synthesis and biological applications.

---

12. Which of the following carboxylic acids has the least pKa value among all?
Correct Answer: HCOOH (Formic Acid)
Solution: The pKa value of a carboxylic acid indicates its acid strength.

$$\text{Lower pKa} \Rightarrow \text{Stronger Acid}$$

pKa values of common carboxylic acids:

- Formic Acid (HCOOH): 3.75 (Lowest)
- Acetic Acid (CH_3COOH): 4.76
- Benzoic Acid (C_6H_5COOH): 4.20

Since formic acid lacks an alkyl group, it does not have an electron-donating effect, making it strongest among carboxylic acids.

Quick Tip

A lower pKa value means stronger acidity due to better stabilization of conjugate base.

---

13. Which is the correct order of the basic strength of given amines?
Correct Answer: $(C_2H_5)_2NH > C_2H_5NH_2 > NH_3 > C_6H_5NH_2$
Solution: The basicity of amines depends on their ability to donate a lone pair on nitrogen. Order of basicity: 1. Secondary amines $(C_2H_5)_2NH$ are most basic due to strong +I effect from two ethyl groups. 2. Primary amines $C_2H_5NH_2$ are next, as they have one alkyl group. 3. Ammonia (NH_3) is weaker than alkyl amines. 4. Aniline ($C_6H_5NH_2$) is the least basic due to the -R effect of the benzene ring.

Quick Tip

Electron-donating alkyl groups increase basicity, while resonance (in aniline) decreases it.

---

14. Which diazonium salt is water-insoluble and stable at room temperature?
Correct Answer: $C_6H_5N_2BF_4$
Solution: Diazonium salts ($R - N_2^+X^-$) are unstable in water but benzenediazonium tetrafluoroborate ($C_6H_5N_2BF_4$) is stable at room temperature due to:
1. Insolubility in water due to the BF_4^- ion. 2. No nucleophilic substitution occurs easily. 3. Stable crystalline solid at room temperature.

Quick Tip

Other diazonium salts decompose at room temperature, making $C_6H_5N_2BF_4$ unique.

---

15. Lactose is composed of which units?
Correct Answer: β-D-Galactose and β-D-Glucose
Solution: Lactose is a disaccharide found in milk, composed of:

$$\beta\text{-D-Galactose} + \beta\text{-D-Glucose}$$

Structure: - Galactose and Glucose are linked by a -1,4-glycosidic bond. - It is a reducing sugar, as the glucose unit has a free hemiacetal group.

Quick Tip

Lactose intolerance occurs when the enzyme lactase is deficient, preventing digestion of lactose.
