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Chapters: Ch 1, Ch 2, Ch 3 (Chemistry Unit)

Format: CBSE Step-by-Step Rubrics

SECTION A: OBJECTIVE & MULTI-CONCEPT MCQS (10 MARKS)

1 Mark for each correct option with detailed conceptual rationale

Ans 1. (a) $X = \text{NO}_2$, $Y = \text{O}_2$, $Z = \text{Reddish-brown (hot), Yellow (cold)}$

[1 Mark]

Rationale: Heating lead nitrate decomposes as: $2\text{Pb}(\text{NO}_3)_2(\text{s}) \rightarrow 2\text{PbO}(\text{s}) + 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$. Brown fumes are nitrogen dioxide (NO_2); oxygen (O_2) supports burning. Lead monoxide (PbO) residue is reddish-brown while hot and turns yellow upon cooling.

Ans 2. (a) HCl is oxidized and MnO_2 is the oxidizing agent

[1 Mark]

Rationale: In $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$, HCl loses hydrogen / chlorine increases oxidation state from -1 to 0 (oxidation). MnO_2 supplies oxygen / manganese decreases oxidation state from $+4$ to $+2$ (reduced), acting as the oxidizing agent.

Ans 3. (c) Exothermic combination reaction forming a basic solution

[1 Mark]

Rationale: Quicklime (CaO) combines with water releasing massive heat (exothermic). The resulting product $\text{Ca}(\text{OH})_2$ produces hydroxide ions (OH^-), making it alkaline/basic.

Ans 4. (d) Hydrochloric acid

[1 Mark]

Rationale: A solution turning red litmus blue is basic. Adding excess strong acid (HCl) neutralizes the base and makes the solution acidic, which turns blue litmus paper back to red.

Ans 5. (b) Metal is Fe ; Single displacement redox reaction

[1 Mark]

Rationale: $\text{Fe}(\text{s}) + \text{CuSO}_4(\text{aq}) [\text{blue}] \rightarrow \text{FeSO}_4(\text{aq}) [\text{light green}] + \text{Cu}(\text{s}) [\text{red-brown deposit}]$. Iron is more reactive than copper and displaces it.

Ans 6. (b) $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ and $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

[1 Mark]

Rationale: Plaster of Paris is calcium sulphate hemihydrate ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$). Gypsum is calcium sulphate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).

Ans 7. (c) Kerosene oil, to shield from moisture and O_2

[1 Mark]

Rationale: Element 'A' is Sodium (Na) or Potassium (K). Highly electropositive alkali metals react violently with air and water, catching fire due to liberated H_2 . They are safely submerged in kerosene.

Ans 8. (c) Al_2O_3

[1 Mark]

Rationale: Aluminium oxide (Al_2O_3) and Zinc oxide (ZnO) are amphoteric oxides; they react with both mineral acids (HCl) and strong alkalis (NaOH) to form salts and water.

Ans 9. (b) Polyvinyl chloride (PVC)

[1 Mark]

Rationale: PVC is a poor conductor of electricity, flexible, and chemically stable, making it the standard insulating polymer for live copper wires.

Ans 10. (b) $X = \text{Ca}(\text{OH})_2$, $Y = \text{CaCO}_3$

[1 Mark]

Rationale: Slaked lime $[\text{Ca}(\text{OH})_2]$ is applied on walls. It slowly reacts with atmospheric carbon dioxide: $\text{Ca}(\text{OH})_2(\text{aq}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{l})$, depositing a glistening white layer of calcium carbonate.

SECTION B: ASSERTION & REASONING (4 MARKS)

Marking: 1 Mark for correct option selection with justification

Ans 11. (a) Both A and R are true, and R is the correct explanation of A.

[1 Mark]

Justification: HNO_3 is a strong oxidizing acid. The nascent hydrogen liberated during metal-acid contact is oxidized to water, while nitrogen gets reduced into NO_2 , NO , or N_2O .

Ans 12. (a) Both A and R are true, and R is the correct explanation of A.

[1 Mark]

Justification: Covalent HCl gas does not contain free ions. Only in aqueous media does HCl ionize into H_3O^+ and Cl^- ; free hydronium ions are essential to turn blue litmus paper red.

Ans 13. (c) A is true, but R is false.

[1 Mark]

Justification: Acid dilution is extremely *exothermic* (not endothermic). Adding water directly to concentrated acid produces sudden localized boiling, splashing hot corrosive acid outward and shattering glass apparatus.

Ans 14. (a) Both A and R are true, and R is the correct explanation of A.

[1 Mark]

Justification: The electrostatic Coulombic attraction between oppositely charged cations and anions across the giant 3D lattice requires extensive heat energy to overcome.

SECTION C: SHORT ANSWER QUESTIONS (12 MARKS)

2 Marks each with step-wise mark distribution

Ans 15.

[2 Marks]

1. White silver chloride turns **grey** due to the formation of metallic silver. | [0.5 mark]

Balanced Equation: $2\text{AgCl}(\text{s}) \xrightarrow{\text{sunlight}} 2\text{Ag}(\text{s}) + \text{Cl}_2(\text{g})$ | [0.5 mark]

2. Reaction type: **Photochemical decomposition reaction**. | [0.5 mark]

Application: Extensively used in **black and white photography**. | [0.5 mark]

Ans 16.

[2 Marks]

1. Compound 'P' is **Sodium sulfate** (Na_2SO_4); 'Q' is **Barium sulfate** (BaSO_4). | [0.5 mark]

Balanced Equation: $\text{Na}_2\text{SO}_4(\text{aq}) + \text{BaCl}_2(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})\downarrow + 2\text{NaCl}(\text{aq})$ | [0.5 mark]

2. **Double displacement reaction / Precipitation reaction**. | [0.5 mark]

Justification: There is a mutual exchange of ions between the two reactant salts to form an insoluble precipitate (BaSO_4).

| [0.5 mark]

Ans 17.

[2 Marks]

1. Phenomenon: **Corrosion / Rusting of iron**. Organic acids (such as citric acid) present in fruit juices supply H^+ ions, accelerating the electrochemical oxidation of iron. | [1 mark]

2. Industrial prevention methods:

- **Galvanization:** Coating iron with a thin protective sacrificial layer of zinc. | [0.5 mark]
- **Alloying:** Mixing iron with chromium and nickel to produce corrosion-resistant Stainless Steel, or electroplating/painting. | [0.5 mark]

Ans 18.

[2 Marks]

1. Iron with red-hot steam: $3\text{Fe(s)} + 4\text{H}_2\text{O(g)} \rightarrow \text{Fe}_3\text{O}_4\text{(s)} + 4\text{H}_2\text{(g)}$ | [1 mark]
2. Thermal decomposition of limestone: $\text{CaCO}_3\text{(s)} \rightarrow [\Delta] \text{CaO(s)} + \text{CO}_2\text{(g)}$ | [1 mark]

Ans 19.

[2 Marks]

1. Compound 'X': **Sodium hydrogen carbonate / Sodium bicarbonate**; Formula: NaHCO_3 . | [1 mark]
2. Thermal decomposition equation: $2\text{NaHCO}_3\text{(s)} \rightarrow [\Delta] \text{Na}_2\text{CO}_3\text{(s)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$ | [1 mark]

Ans 20.

[2 Marks]

Calcination (Carbonate Ores)	Roasting (Sulfide Ores)
Heating the ore strongly in the absence or limited supply of air below its melting point. [0.5 mark]	Heating the ore strongly in the excess presence of air/oxygen below its melting point. [0.5 mark]
$\text{ZnCO}_3\text{(s)} \rightarrow [\Delta] \text{ZnO(s)} + \text{CO}_2\text{(g)}$ [0.5 mark]	$2\text{ZnS(s)} + 3\text{O}_2\text{(g)} \rightarrow [\Delta] 2\text{ZnO(s)} + 2\text{SO}_2\text{(g)}$ [0.5 mark]

SECTION D: SHORT ANSWER & TRICKY REASONING (18 MARKS)

3 Marks each with precise intermediate steps

Ans 21.

[3 Marks]

1. Initial change: Pale green crystals lose water of crystallization turning into **dirty white** anhydrous FeSO_4 . On further strong heating, it decomposes into a **reddish-brown** solid residue (Fe_2O_3). | [1 mark]
2. Balanced thermal decomposition equation:
 $2\text{FeSO}_4\text{(s)} \rightarrow [\Delta] \text{Fe}_2\text{O}_3\text{(s)} + \text{SO}_2\text{(g)} + \text{SO}_3\text{(g)}$ | [1 mark]
3. Gases evolved: **Sulphur dioxide (SO_2)** and **Sulphur trioxide (SO_3)**, exhibiting the characteristic pungent suffocating smell of **burning sulphur**. Since both are non-metallic acidic oxides, they turn **wet blue litmus paper red**. | [1 mark]

Ans 22.

[3 Marks]

1. Identification: **A = NaHCO_3** (Baking soda), **B = Na_2CO_3** (Soda ash), **C = CO_2** gas, **D = $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$** (Washing soda). | [1 mark]
2. Chemical Equations:
 - ° Formation of B: $2\text{NaHCO}_3\text{(s)} \rightarrow [\Delta] \text{Na}_2\text{CO}_3\text{(s)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$ | [0.5 mark]
 - ° Recrystallization to D: $\text{Na}_2\text{CO}_3\text{(s)} + 10\text{H}_2\text{O(l)} \rightarrow \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O(s)}$ | [0.5 mark]
3. Uses of D: (i) In glass, soap, and paper industries. (ii) Removing permanent hardness of water. | [1 mark]

Ans 23.

[3 Marks]

1. Order of reactivity: **$\text{Mg} > \text{Zn} > \text{Fe} > \text{Cu}$** . | [0.5 mark]
Copper (Cu) does not react with dilute **HCl** because its standard reduction potential is higher than hydrogen (it lies below hydrogen in the activity series and cannot displace H^+ ions). | [0.5 mark]
2. Two metals that liberate H_2 with ~1% dilute HNO_3 : **Magnesium (Mg)** and **Manganese (Mn)**. | [1 mark]
3. Balanced equation: $\text{Fe(s)} + 2\text{HCl(aq)} \rightarrow \text{FeCl}_2\text{(aq)} + \text{H}_2\text{(g)}$ (Note: forms FeCl_2 , not FeCl_3). | [1 mark]

Ans 24.**[3 Marks]**

1. Cell configuration:

- (i) Anode: **Thick block of impure copper (blister copper)**. | [0.5 mark]
- (ii) Cathode: **Thin strip/sheet of pure copper**. | [0.5 mark]
- (iii) Electrolyte: **Acidified aqueous Copper(II) sulphate solution (CuSO₄ + dil. H₂SO₄)**. | [0.5 mark]

2. Electrode Reactions:

At Anode (Oxidation): $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ | [0.5 mark]At Cathode (Reduction): $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$ | [0.5 mark]3. **Anode Mud**: Insoluble impurities of less electropositive noble metals that collect directly below the anode. Contains **Gold (Au)**, **Silver (Ag)**, and **Platinum (Pt)**. | [0.5 mark]**Ans 25.****[3 Marks]**

1. Tooth decay begins when oral cavity pH falls below 5.5. Substance: **Calcium hydroxyapatite** (crystalline calcium phosphate), formula: $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$ or $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{Ca}(\text{OH})_2$. | [1 mark]
2. Mechanism: Bacteria break down residual sugars producing organic acids that dissolve enamel hydroxyapatite. Toothpaste is **basic**, neutralizing excess acid and promoting remineralization. | [1 mark]
3. Bee sting injects **methanoic acid (formic acid)** causing intense stinging. It is neutralized by applying a mild base like **baking soda paste (NaHCO₃)**. Wasp stings are alkaline and treated with mild vinegar. | [1 mark]

Ans 26.**[3 Marks]**1. Electronic configurations: **Mg (Z = 12): 2, 8, 2; Cl (Z = 17): 2, 8, 7**. | [0.5 mark]

2. Electron-Dot Representation:

Mg loses 2 valence electrons: $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ [2, 8]Two Cl atoms accept 1 electron each: $2\text{Cl} + 2\text{e}^- \rightarrow 2[\text{:}\ddot{\text{Cl}}\text{:}]^-$ [2, 8, 8]Ionic formula: $[\text{Mg}]^{2+} [\text{:Cl:}]_2^- \rightarrow \text{MgCl}_2$ | [1.5 marks]3. Electrical Conductivity: Solid **MgCl₂** has ions locked in fixed lattice sites by rigid electrostatic bonds (no free mobile ions). In molten or aqueous state, the lattice collapses, releasing free mobile ions that carry electric current. | [1 mark]**SECTION E: COMPETENCY & CASE-BASED QUESTIONS (8 MARKS)**

4 Marks for each case study with direct answer mapping

Ans 27. Case Study 1: The Chlor-Alkali Industry**[4 Marks]**

1. Balanced equation with states: $2\text{NaCl(aq)} + 2\text{H}_2\text{O(l)} \xrightarrow{\text{[electricity]}} 2\text{NaOH(aq)} + \text{Cl}_2(\text{g})\uparrow + \text{H}_2(\text{g})\uparrow$ | [1 mark]
2. Compound: **Bleaching powder / Calcium oxychloride (CaOCl₂)**.
Synthesis: $\text{Ca(OH)}_2(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{CaOCl}_2(\text{s}) + \text{H}_2\text{O(l)}$ | [1 mark]
3. Reason: Bleaching powder reacts slowly with atmospheric carbon dioxide, liberating chlorine gas:
 $\text{CaOCl}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{Cl}_2\uparrow$. | [1 mark]
4. Two uses of **H₂**: (i) Hydrogenation of vegetable oils to form margarine/anaspati ghee. (ii) Synthesis of ammonia (NH₃) for nitrogenous fertilizers / clean fuel. | [1 mark]

Ans 28. Case Study 2: Thermite Railway Welding**[4 Marks]**

- Reactants in thermite mixture: **Iron(III) oxide (Fe_2O_3)** and **Aluminium powder (Al)** (in ~3:1 ratio). | **[1 mark]**
- Equation: $\text{Fe}_2\text{O}_3(\text{s}) + 2\text{Al}(\text{s}) \rightarrow 2\text{Fe}(\text{l}) + \text{Al}_2\text{O}_3(\text{s}) + \text{Enormous Heat}$.
Iron is produced in molten form because the enthalpy of reaction releases enormous energy, elevating temperatures beyond iron's melting point (1538°C). | **[1 mark]**
- Redox Identification: **Al is oxidized** (gains oxygen to form Al_2O_3); **Fe_2O_3 is reduced** (loses oxygen to form Fe). | **[1 mark]**
- Feasibility of Carbon: **No**. Reduction with carbon requires a continuous external furnace and does not generate immediate localized molten iron on-track to fuse rails seamlessly. | **[1 mark]**

SECTION F: LONG ANSWER SYNTHESIS & EXPERIMENTAL PROVING (10 MARKS)

5 Marks each with rigorous rubric distribution

Ans 29. Complete Metallurgy & Reduction Schemes**[5 Marks]****1. Low Reactivity (Copper from Cu_2S):**Step 1: Partial roasting in air: $2\text{Cu}_2\text{S}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow [\Delta] 2\text{Cu}_2\text{O}(\text{s}) + 2\text{SO}_2(\text{g})$ | **[0.5 mark]**Step 2: Auto-reduction: $2\text{Cu}_2\text{O}(\text{s}) + \text{Cu}_2\text{S}(\text{s}) \rightarrow [\Delta] 6\text{Cu}(\text{s}) + \text{SO}_2(\text{g})$ | **[1 mark]****2. Moderate Reactivity (Zinc Metallurgy):**

- Carbonates and sulfides are converted into oxides because reducing metal oxides using carbon is thermodynamically more favorable and requires less energy than reducing carbonates or sulfides directly. | **[0.5 mark]**
- Calcination of calamine: $\text{ZnCO}_3(\text{s}) \rightarrow [\Delta] \text{ZnO}(\text{s}) + \text{CO}_2(\text{g})$ | **[0.5 mark]**
- Roasting of zinc blende: $2\text{ZnS}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow [\Delta] 2\text{ZnO}(\text{s}) + 2\text{SO}_2(\text{g})$ | **[0.5 mark]**
- Carbon reduction: $\text{ZnO}(\text{s}) + \text{C}(\text{s}) \rightarrow \text{Zn}(\text{s}) + \text{CO}(\text{g})$ | **[0.5 mark]**

3. High Reactivity (Sodium Extraction):Carbon cannot reduce highly reactive metal oxides because alkali metals have far greater affinity for oxygen than carbon does. | **[0.5 mark]**Sodium is isolated via **electrolytic reduction of molten (fused) NaCl** (Downs Process). Aqueous NaCl cannot be used because H^+ discharges preferentially as H_2 .Cathode: $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}(\text{l})$ | Anode: $2\text{Cl}^- \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$. | **[1 mark]****Ans 30. Multi-Part Deductive Inorganic Analysis****[5 Marks]****1. Identification:**

- P = $\text{Pb}(\text{NO}_3)_2$** [Lead(II) nitrate] | **[0.5 mark]**
- Q = NO_2** [Nitrogen dioxide brown gas] | **[0.5 mark]**
- R = O_2** [Oxygen gas] | **[0.5 mark]**
- S = PbO** [Lead(II) oxide residue] | **[0.5 mark]**

Decomposition Equation: $2\text{Pb}(\text{NO}_3)_2(\text{s}) \rightarrow [\Delta] 2\text{PbO}(\text{s}) + 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$ | **[0.5 mark]****2. Precipitation of 'T':**Precipitate 'T' is **Lead(II) iodide (PbI_2)**. | **[0.5 mark]**Balanced Equation: $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{KI}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) \downarrow [\text{yellow}] + 2\text{KNO}_3(\text{aq})$ | **[0.5 mark]**Classification: **Double displacement and precipitation reaction**. | **[0.5 mark]****3. Acid & Gas Chemistry:**Organic acid 'M' in sour milk: **Lactic acid**. | **[0.5 mark]**Gas evolved with vinegar and baking soda: **Carbon dioxide (CO_2)**.Lime water test: Bubbling CO_2 through clear lime water turns it milky due to CaCO_3 formation. Passing excess CO_2 clears milkiness due to soluble calcium hydrogen carbonate $[\text{Ca}(\text{HCO}_3)_2]$. | **[0.5 mark]**

