EDUVISTA MASTER INTERACTIVE INFOGRAPHIC & PYQ COMPENDIUM

CLASS 11 NCERT CHEMISTRY — CHAPTER 7: REDOX REACTIONS
Academic Standard: CBSE Board Exams + JEE Main + NEET Competitive Level
Official Branding: EDUVISTA | Learn • Understand • Achieve

OFFICIAL EDUVISTA INTERACTIVE LEARNING SYSTEM

EDUVISTA INTERACTIVE SMART NOTES: REDOX REACTIONS

Class 11 NCERT Chemistry | Code: `kech201` | 100% Concept & Exam Mastery

✔ Interactive Decision Trees ✔ Self-Testing PYQ Practice ✔ Hyperlinked Jump Grid

✔ Step-by-Step Balancing Workbench

INTERACTIVE JUMP MATRIX — QUICK SECTION NAVIGATOR

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1. CLASSICAL & ELECTRONIC CONCEPTS OF REDOX

Redox reactions (Reduction-Oxidation) involve simultaneous electron transfer between reacting chemical species.

Oxidation (OIL = Oxidation Is Loss of Electrons)

- **Classical View:** Addition of Oxygen or Electronegative element; Removal of Hydrogen or Electropositive element.
- **Electronic View:** Loss of one or more electrons (Increases Oxidation Number).
- **Example:** $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ | $Mg \rightarrow Mg^{2+} + 2e^-$

Reduction (RIG = Reduction Is Gain of Electrons)

- **Classical View:** Removal of Oxygen or Electronegative element; Addition of Hydrogen or Electropositive element.
- **Electronic View:** Gain of one or more electrons (Decreases Oxidation Number).
- **Example:** $2HgO(s) \rightarrow 2Hg(l) + O_2(g)$ (Δ) | $Hg^{2+} + 2e^- \rightarrow Hg$

Oxidising Agent vs Reducing Agent

- **Oxidising Agent (Oxidant):** Accepts electrons → Gets reduced itself → Oxidation state decreases.
- **Reducing Agent (Reductant):** Donates electrons → Gets oxidised itself → Oxidation state increases.

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2. COMPETITIVE ELECTRON TRANSFER & REACTIVITY SERIES

Placing metallic strips in aqueous salt solutions demonstrates relative electron-releasing tendencies.

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|                      COMPETITIVE ELECTRON TRANSFER EXPERIMENTS                  |
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| 1. Zn in CuSO4 sol  : Zn(s) + Cu²⁺(aq) → Zn²⁺(aq) + Cu(s)   [Zn loses e⁻ > Cu]|
| 2. Cu in AgNO3 sol  : Cu(s) + 2Ag⁺(aq) → Cu²⁺(aq) + 2Ag(s)  [Cu loses e⁻ > Ag]|
| 3. Co in NiSO4 sol  : Co(s) + Ni²⁺(aq) ⇌ Co²⁺(aq) + Ni(s)   [Equilibrium]      |
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EDUVISTA MEMORY TRICK (ELECTRON RELEASE POWER):
Zn > Cu > Ag (Zinc displaces Copper; Copper displaces Silver)

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3. OXIDATION NUMBER (O.N.) DECISION TREE & RULES

INTERACTIVE DECISION TREE: HOW TO ASSIGN OXIDATION NUMBERS

1. **Is the element uncombined/free state?** → `O.N. = 0` (e.g. O_2, S∯, P_4, Na, Fe).
2. **Is it a monoatomic ion?** → `O.N. = Net Charge` (e.g. Na^+ = +1, Mg^{2+} = +2, Cl^- = -1).
3. **Is the atom Fluorine?** → `O.N. = -1 ALWAYS` (No exceptions!).
4. **Is the atom Oxygen?**
   - In usual oxides (H_2O, CO_2) → `O.N. = -2`
   - In Peroxides (H_2O_2, Na_2O_2) → `O.N. = -1`
   - In Superoxides (KO_2) → `O.N. = -1/2`
   - In Fluorides (OF_2, O_2F_2) → `O.N. = +2, +1`

5. **Is the atom Hydrogen?**
    - Bonded to Non-Metals (HCl, H_2O) → `O.N. = +1`
    - Bonded to Metals / Hydrides (LiH, NaH, CaH_2) → `O.N. = -1`

Rule #	Element / Group	Standard Oxidation Number	Exceptions & Special Cases
Rule 1	Free / Uncombined Elements	**Always 0**	H_2, O_2, N_2, S_8, P_4, Na, Fe (O.N. = 0)
Rule 2	Monoatomic Ions	**Equal to Ion Charge**	Na^+ (+1), Mg^{2+} (+2), Fe^{3+} (+3), Cl^- (-1)
Rule 3	Fluorine	**Always -1**	Most electronegative element (No exceptions)
Rule 4	Oxygen	**Usually -2**	Peroxides (H_2O_2, Na_2O_2: **-1**); Superoxides (KO_2: **-1/2**); OF_2 (**+2**); O_2F_2 (**+1**)
Rule 5	Hydrogen	**Usually +1**	Binary Metal Hydrides (LiH, NaH, CaH_2: **-1**)
Rule 6	Halogens (Cl, Br, I)	**Usually -1**	Positive (+1, +3, +5, +7) when bonded to O or F
Rule 7	Neutral Molecules / Ions	**Σ O.N. = 0** (Molecule)	**Σ O.N. = Net Charge** (Polyatomic Ion)

Stock Notation:

• **Fe_2O_3** → Iron(III) oxide | **FeO** → Iron(II) oxide | **MnO_2** → Manganese(IV) oxide | **$AuCl_3$** → Gold(III) chloride

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4. STRUCTURAL PARADOXES & EXCEPTIONAL OXIDATION STATES

Certain compounds yield fractional average oxidation numbers from chemical formulas because identical atoms occupy different bonding environments!

1. Caro's Acid (H_2SO_5 — Peroxomonosulphuric Acid)

• *Formula Calculation:* 2(+1) + S + 5(-2) = 0 → S = +8 (IMPOSSIBLE! Max valence of S is 6).

• *Structural Explanation:* Contains 1 Peroxy linkage (-O-O-, O.N. = -1). Structure: H-O-S(=O)$_2$-O-O-H.

• *Correct Calculation:* 2(+1) [H] + S + 3(-2) [Oxo O] + 2(-1) [Peroxy O] = 0 → **S = +6** ( ).

2. Chromium Peroxide (CrO_5 — Butterfly Structure)

• *Formula Calculation:* Cr + 5(-2) = 0 → Cr = +10 (IMPOSSIBLE!).

• *Structural Explanation:* Contains 4 peroxy oxygens (-1) and 1 oxo oxygen (-2).

• *Correct Calculation:* Cr + 1(-2) + 4(-1) = 0 → **Cr = +6** ( ).

3. Fractional Oxidation State Examples

• **Fe_3O_4 (Magnetite):** Mixture of FeO (+2) and Fe_2O_3 (+3) → Average O.N. = **+8/3**.

• **Pb_3O_4 (Red Lead):** Mixture of 2PbO (+2) and PbO_2 (+4) → Average O.N. = **+8/3**.

• **Br_3O_8 (Tribromooctaoxide):** 2 terminal Br = +6; 1 central Br = +4 → Average O.N. = **+16/3**.

• **$S_4O_6^{2-}$ (Tetrathionate Ion):** 2 terminal S = +5; 2 central S = 0 → Average O.N. = **+2.5**.

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5. TYPES OF REDOX REACTIONS & DISPROPORTIONATION

Type of Redox Reaction	General Equation	Classic NCERT Example	Key Feature
Combination	A + B → C	$C(s) + O_2(g) \rightarrow CO_2(g)$	At least one reactant must be in elemental form
Decomposition	C → A + B	$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$	At least one product must be in elemental form
Metal Displacement	X + YZ → XZ + Y	$CuSO_4 + Zn \rightarrow ZnSO_4 + Cu$	More reactive metal displaces less reactive metal
Non-Metal Displacement	X + YZ → XZ + Y	$2Na + 2H_2O \rightarrow 2NaOH + H_2$	Active metal displaces H_2 gas from water/ acid
Disproportionation	A → B + C	$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$	**SAME element is oxidised and reduced simultaneously**

EDUVISTA EXAM ALERT (FLUORINE DISPROPORTIONATION):
Fluorine (F_2) **CANNOT** undergo disproportionation because it is the most electronegative element and exhibits only 0 and -1 oxidation states!

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6. BALANCING REDOX WORKBENCH

STEP-BY-STEP BALANCING WORKBENCH: ACIDIC MEDIUM

Target Reaction: $MnO_4^-(aq) + Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + Fe^{3+}(aq)$

Step 1: Split into Half-Reactions
Oxidation: $Fe^{2+} \rightarrow Fe^{3+}$ | Reduction: $MnO_4^- \rightarrow Mn^{2+}$

Step 2: Balance Oxygen with H_2O
Reduction: $MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

Step 3: Balance Hydrogen with H^+
Reduction: $MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

Step 4: Balance Net Charge with e^-
Oxidation: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (× 5)
Reduction: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (× 1)

Step 5: Add Half-Reactions & Cancel e^-
Final Balanced Equation: $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

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7. REDOX TITRATIONS & INDICATORS

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|                          REDOX TITRATION INDICATOR MECHANISMS                   |
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| 1. SELF-INDICATOR     : KMnO4 (Purple MnO4⁻ → Colourless Mn²⁺; Pink endpoint)  |
| 2. INTERNAL INDICATOR : K2Cr2O7 (Diphenylamine indicator → Intense Blue-Violet)|
| 3. IODOMETRIC TITRATION: I2 + 2S2O3²⁻ → 2I⁻ + S4O6²⁻ (Starch → Blue-Colourless)|
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8. ELECTROCHEMICAL CELLS & DANIELL CELL

A **Galvanic (Electrochemical) Cell** converts chemical energy of a spontaneous redox reaction into electrical energy.

EDUVISTA MEMORY TRICK FOR ANODE: "LOAN"
- **L** — Left side
- **O** — Oxidation occurs
- **A** — Anode electrode
- **N** — Negative polarity

Functions of Salt Bridge:

1. Completes electrical circuit without allowing mixing of half-cell solutions.
2. Maintains electrical neutrality in both half-cell compartments via ion migration (K^+, Cl^-, NO_3^-).

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9. STANDARD ELECTRODE POTENTIAL & ELECTROCHEMICAL SERIES

- **Cell EMF Formula:**
  $$\mathbf{E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = E^\circ_{Right} - E^\circ_{Left}}$$
- **Spontaneity Criterion:** Reaction is spontaneous if $\mathbf{E^\circ_{cell} > 0}$.

ELECTROCHEMICAL SERIES HIGHLIGHTS		
$F_2(g) + 2e^- \rightarrow 2F^-$	$E° = +2.87$ V	Strongest Oxidising Agent
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	$E° = +1.51$ V	Strong Oxidising Agent
$2H^+ + 2e^- \rightarrow H_2(g)$	$E° = 0.00$ V	REFERENCE (SHE)
$Zn^{2+} + 2e^- \rightarrow Zn(s)$	$E° = -0.76$ V	Reducing Agent
$Li^+ + e^- \rightarrow Li(s)$	$E° = -3.05$ V	Strongest Reducing Agent

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10. CBSE BOARD EXAM PREVIOUS YEAR QUESTIONS (SOLVED)

CBSE 2024 [1 MARK]

Q1. Identify the oxidising agent in: $H_2S(g) + Cl_2(g) \rightarrow 2HCl(g) + S(s)$

Click to View Solution & Marking Scheme

Solution: Chlorine (Cl_2) is reduced from oxidation state 0 (in Cl_2) to -1 (in HCl). Therefore, **Cl_2 is the oxidising agent**.

CBSE 2023 [2 MARKS]

Q2. Calculate the oxidation number of the underlined element: (a) $K_3[\underline{Fe}(CN)_6]$ (b) $\underline{Cr}O_5$

Click to View Solution & Marking Scheme

(a) $K_3[Fe(CN)_6]$: 3(+1) + x + 6(-1) = 0 ⇒ 3 + x - 6 = 0 ⇒ **x = +3**.

(b) CrO_5: Structure has 4 peroxy oxygens (-1) and 1 oxo oxygen (-2) ⇒ x + 1(-2) + 4(-1) = 0 ⇒ **x = +6**.

CBSE 2023 [3 MARKS]

Q3. Balance in acidic medium: $MnO_4^-(aq) + Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + Fe^{3+}(aq)$

Click to View Solution & Marking Scheme

Oxidation: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (× 5)

Reduction: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (× 1)

Final Balanced Equation: $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

CBSE 2022 [3 MARKS]

Q4. Balance in basic medium: $MnO_4^-(aq) + I^-(aq) \rightarrow MnO_2(s) + I_2(s)$

Click to View Solution & Marking Scheme

Oxidation: $2I^- \rightarrow I_2 + 2e^-$ (× 3)

Reduction: $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$ (× 2)

Add 8 OH^- to both sides & simplify: **$2MnO_4^- + 6I^- + 4H_2O \rightarrow 2MnO_2 + 3I_2 + 8OH^-$**

CBSE 2020 [5 MARKS]

Q5. Justify why $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ is a disproportionation reaction.

Click to View Solution & Marking Scheme

• Oxygen in H_2O_2 has oxidation number **-1**.

• In H_2O, oxygen decreases to **-2** (Reduction).

• In O_2, oxygen increases to **0** (Oxidation).

Since the **same element (Oxygen) is simultaneously oxidised and reduced**, this is a disproportionation reaction.

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11. JEE MAIN & NEET COMPETITIVE PYQS (SOLVED)

JEE MAIN 2023

Q1. The oxidation state of central sulfur atom in $S_4O_6^{2-}$ and Caro's acid (H_2SO_5) respectively are:

Click to View Solution & Analysis

Correct Answer: (B) or (C) [Terminal S = +5, Central S = 0 in $S_4O_6^{2-}$; S = +6 in H_2SO_5].

In $S_4O_6^{2-}$, the structure is $^-O_3S\text{-}S\text{-}S\text{-}SO_3^-$. Terminal sulfur atoms are +5, central are 0. Caro's acid (H_2SO_5) has 1 peroxy linkage → S = +6.

NEET 2022

Q2. Which halogen does NOT undergo disproportionation in alkaline medium?

Click to View Solution & Analysis

Correct Answer: (D) F_2

Fluorine is the most electronegative element and exhibits only 0 and -1 oxidation states. It cannot exhibit positive oxidation states needed for disproportionation.

JEE MAIN 2022

Q3. For Zn(s) | Zn^{2+}(aq) || Cu^{2+}(aq) | Cu(s), given E°(Zn^{2+}/Zn) = -0.76 V and E°(Cu^{2+}/Cu) = +0.34 V. Calculate E°cell.

Click to View Solution & Analysis

E°cell = E°cathode - E°anode = (+0.34 V) - (-0.76 V) = **+1.10 V** (Spontaneous).

NEET 2021

Q4. Volume of 0.02 M $KMnO_4$ required to oxidise 20 mL of 0.1 M $FeSO_4$ in acidic medium?

Click to View Solution & Analysis

$M_1 \times V_1 \times n_1 = M_2 \times V_2 \times n_2 \Rightarrow 0.02 \times V_1 \times 5 = 0.1 \times 20 \times 1 \Rightarrow 0.1 \times V_1 = 2 \Rightarrow$ **V_1 = 20 mL**.

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12. INTERACTIVE SELF-TEST PRACTICE QUIZ

TEST YOUR KNOWLEDGE (5-MINUTE CHECKPOINT)

Q1: What is the oxidation number of Cr in CrO_5?

Reveal Answer

Answer: +6 (Contains 4 peroxy oxygens of -1 and 1 oxo oxygen of -2).

Q2: Name the indicator used in Iodometric Titrations.

Reveal Answer

Answer: Starch Indicator (Forms deep blue complex with I_2).

Q3: What does the LOAN rule stand for in Galvanic cells?

Reveal Answer

Answer: Left, Oxidation, Anode, Negative.

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