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Oxidation

Oxidation is defined as the addition of oxygen or an electronegative element to a substance, or the

Examples:

- CH□94(g) + 2O□92(g) □12□12□12; CO□92(g) + 2H□92O(l) *(Addition of oxygen)*
- Mg(s) + F□92(g) □12□12□12; MgF□92(s) *(Addition of electronegative element)*
- 2H□92S(g) + O□92(g) □12□12□12; 2S(s) + 2H□92O(l) *(Removal of hydrogen)*
- 2K□94Fe(CN)□94 + H□92O□92 □12□12□12; 2K□93Fe(CN)□93 + 2KOH(aq) *(Removal of electropositive element)*

Reduction

Reduction is defined as the removal of oxygen or an electronegative element from a substance, or

Examples:

- 2HgO(s) □12□12□12; 2Hg(l) + O□92(g) *(Removal of oxygen)*
- 2FeCl□93(aq) + H□92(g) □12□12□12; 2FeCl□92(aq) + 2HCl(aq) *(Removal of electronegative element)*
- CH□92=CH□92(g) + H□92(g) □12□12□12; CH□93□0CH□93(g) *(Addition of hydrogen)*
- 2HgCl□92(aq) + SnCl□92(aq) □12□12□12; Hg□92Cl□92(s) + SnCl□94(aq) *(Addition of electropositive element)*

Redox Reaction

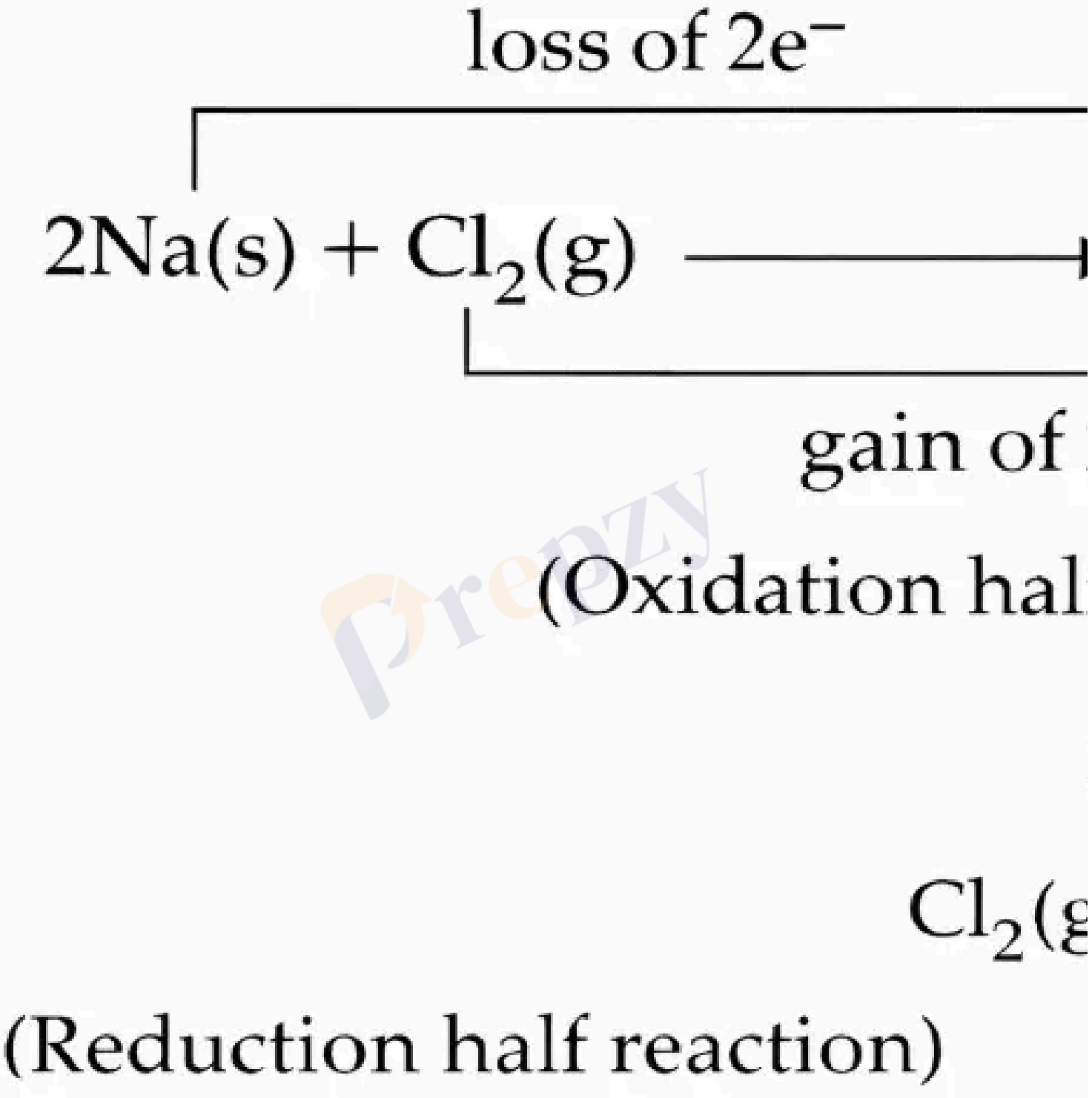
A redox reaction is a chemical reaction that involves both oxidation and reduction processes occur

Redox Reaction in Terms of Electron Transfer

In a redox reaction, one substance loses electrons (oxidation) and another gains electrons (reducti

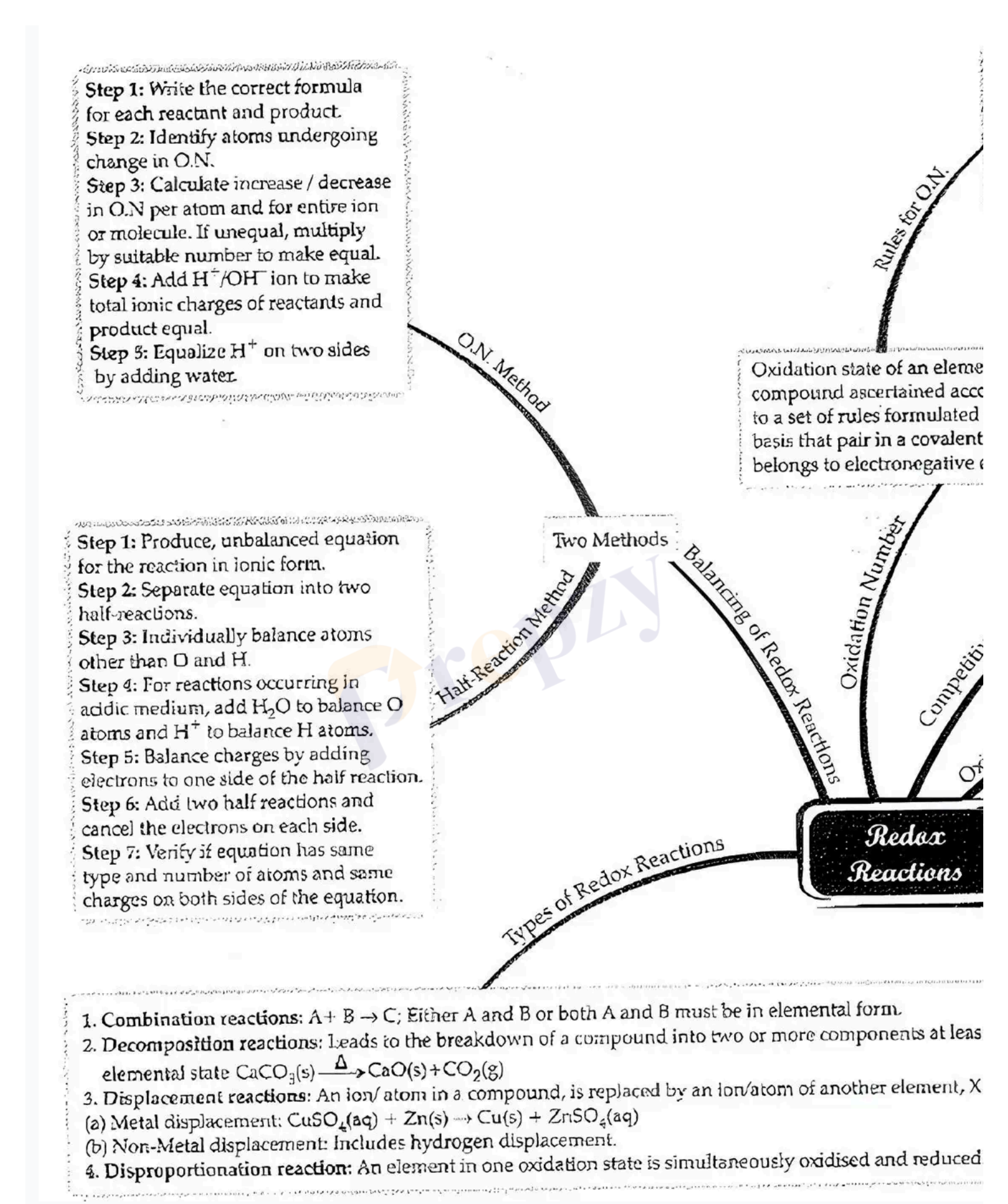
- Sodium (Na) atoms lose electrons to form Na^+ ions (oxidation).

- Chlorine (Cl_2) molecules gain electrons to form Cl^- ions (reduction).
- The transfer of electrons occurs simultaneously, resulting in the formation of sodium chloride (NaCl).



Oxidation and Reduction Half Reactions

The half reaction involving loss of electrons is called the oxidation half reaction, and the half react



Oxidising Agent and Reducing Agent

Oxidising Agent: The species that oxidises another substance and itself gets reduced; it accepts el

Reducing Agent: The species that reduces another substance and itself gets oxidised; it donates e

Oxidation Number

Oxidation number (O.N.) is the charge an atom would have if electrons in bonds were assigned to t

Rules for Oxidation Number:

- Atoms in elemental form have O.N. = 0.
- Oxygen usually has O.N. = -2, except in peroxides (-1), superoxides (-1/2), and when bonded to fluorine (+2 or +1).
- Hydrogen usually has O.N. = +1, except when bonded to metals in binary compounds (-1).
- Fluorine always has O.N. = -1.
- Other halogens usually have O.N. = -1 when in halide ions, but positive O.N. when combined with oxygen.
- The sum of oxidation numbers in a neutral compound is zero.
- The sum of oxidation numbers in a polyatomic ion equals the charge on the ion.

Examples of Oxidation Numbers in Ions:

- Na^{+}: +1
- Mg^{2+}: +2
- Fe^{3+}: +3
- Cl^{-}: -1
- O^{2-}: -2

According to Oxidation Number Concept:

- Oxidation is an increase in oxidation number.
- Reduction is a decrease in oxidation number.
- Oxidising agent increases the oxidation number of an element.
- Reducing agent decreases the oxidation number of an element.
- Redox reactions involve changes in oxidation numbers of species.

Key Terms

Oxidation Number: The charge that an atom appears to have in a compound or ion.

Key Facts

- Electron releasing tendency among Zn, Ag, and Cu is Zn > Cu > Ag.
- Oxidation state is often used interchangeably with oxidation number.
- Stock notation expresses oxidation number using Roman numerals in parentheses after the metal symbol, e.g., $Sn(II)Cl_2$ for stannous

Mnemonics

Concept: Redox reaction

Mnemonic: OiL RiG

Interpretation: Oxidation Is Losing (electrons), Reduction Is Gaining (electrons).

Solved Examples

Example 1: Identify oxidation and reduction in the reaction:

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

Solution:

Oxidation: $Zn \rightarrow Zn^{2+} + 2e^-$ (Zn loses electrons)

Reduction: $Cu^{2+} + 2e^- \rightarrow Cu$ (Cu gains electrons)

Zn is oxidised and Cu^{2+} is reduced.

Example 2: Calculate oxidation number of S in H_2SO_4.

Solution:

Let oxidation number of S = x

H = +1, O = -2

Sum of oxidation numbers = 0

2(+1) + x + 4(-2) = 0

2 + x - 8 = 0

x = +6

Oxidation number of S is +6.

Practice Set

- **Level 1:** Define oxidation and reduction with examples.
- **Level 2:** Explain the role of oxidising and reducing agents in a redox reaction.
- **Level 3:** Calculate the oxidation number of chlorine in ClO_4^- ion.

Answer Key

- **Level 1:** Oxidation is addition of oxygen or removal of hydrogen; reduction is removal of oxygen or addition of hydrogen. Examples: C
- **Level 2:** Oxidising agent accepts electrons and gets reduced; reducing agent donates electrons and gets oxidised.
- **Level 3:** In ClO_4^- ion, sum of oxidation numbers = -1; O = -2; let Cl = x; x + 4(-2) = -1; x - 8 = -1; x = +7.

Types of Redox Reactions Balancing Electrode Processes

Types of Redox Reactions

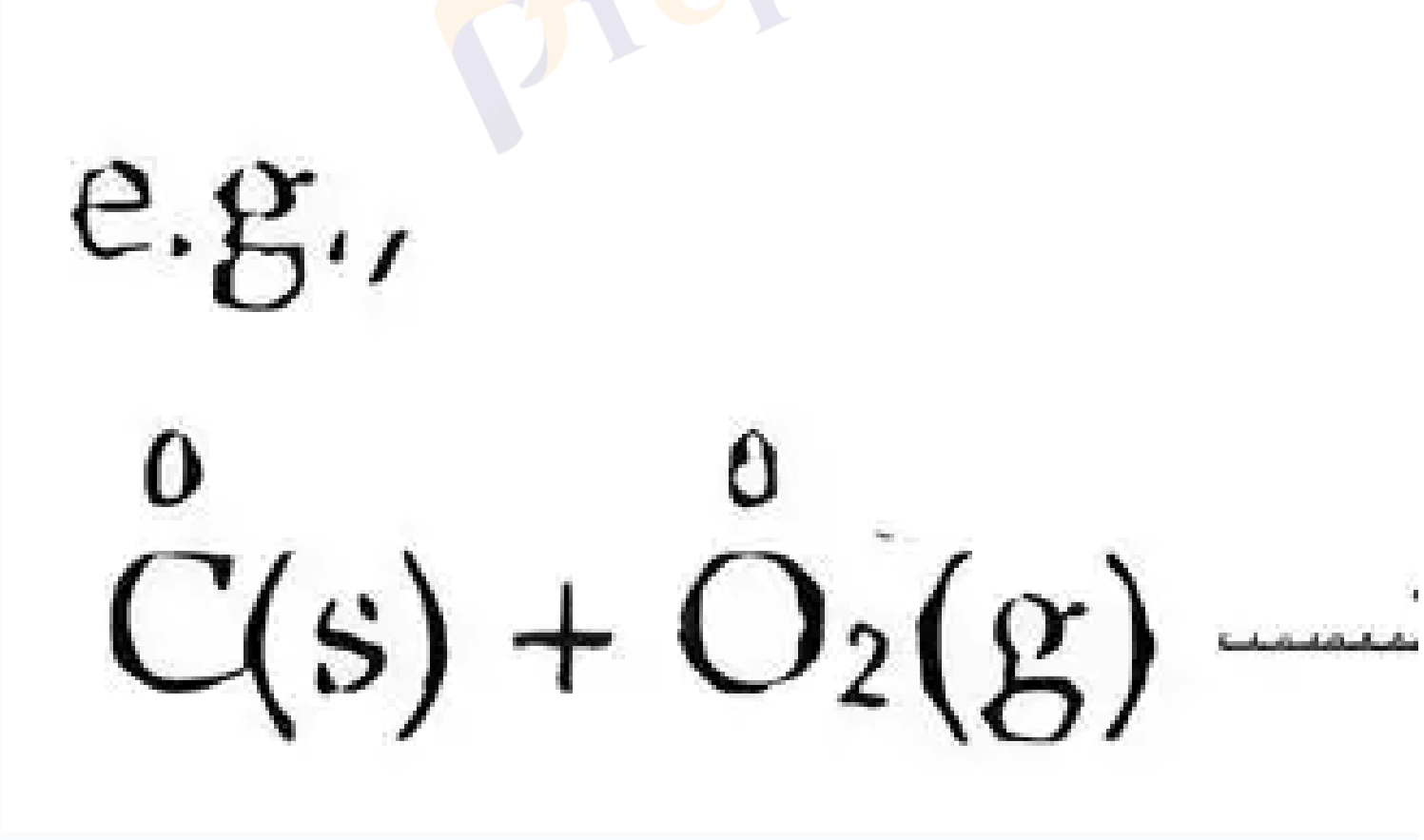
Redox reactions are classified into:

Combination Reactions

These involve two or more substances combining to form a single compound.

Example:

C(s) + O□92(g) □12□12□12; CO□92(g)

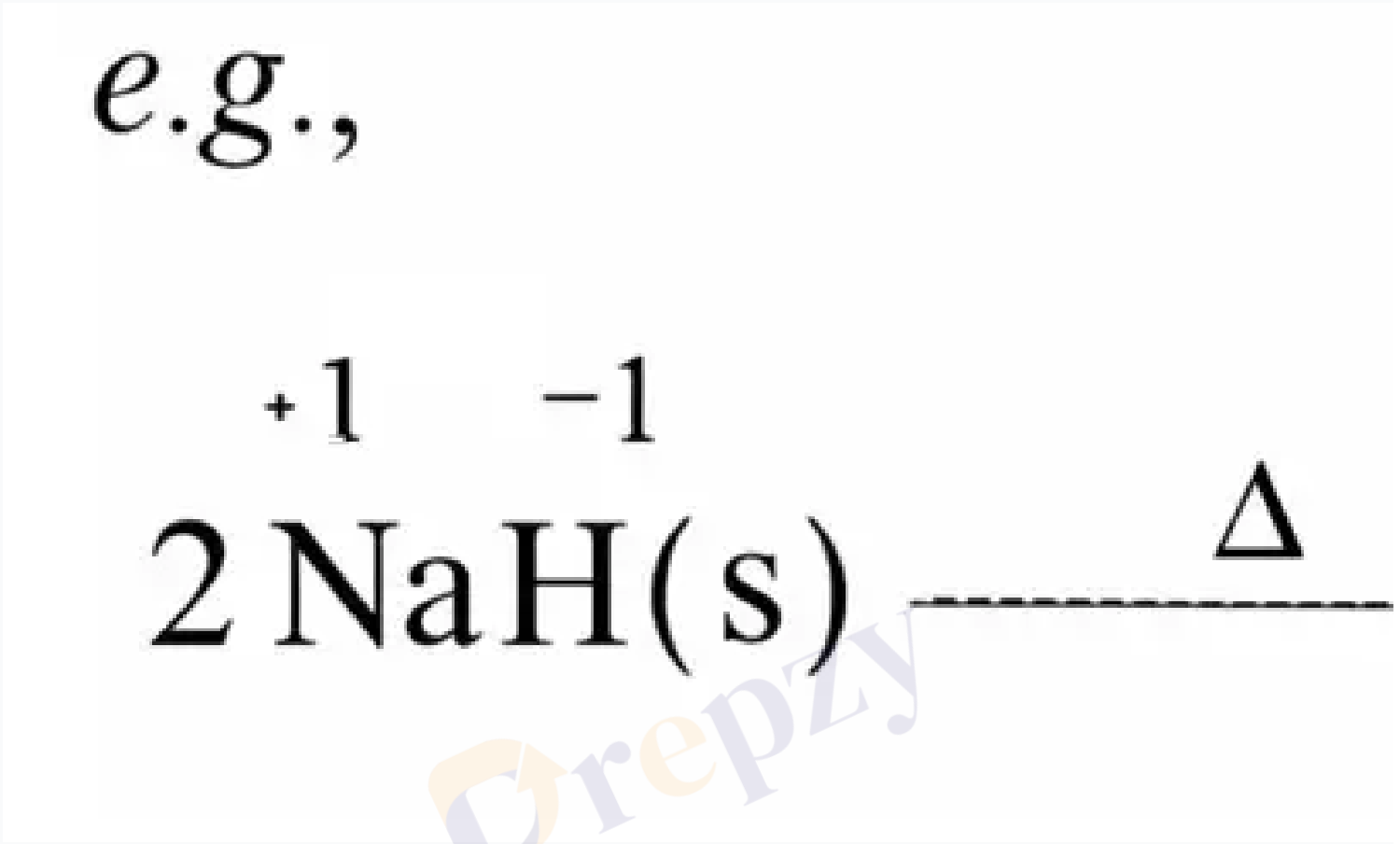


Decomposition Reactions

These involve the breakdown of a compound into two or more components, at least one in element

Example:

2NaH(s) □12□12□12; 2Na(s) + H□92(g)



Displacement Reactions

These involve replacement of an atom or ion by another atom or ion from a compound.

General form:

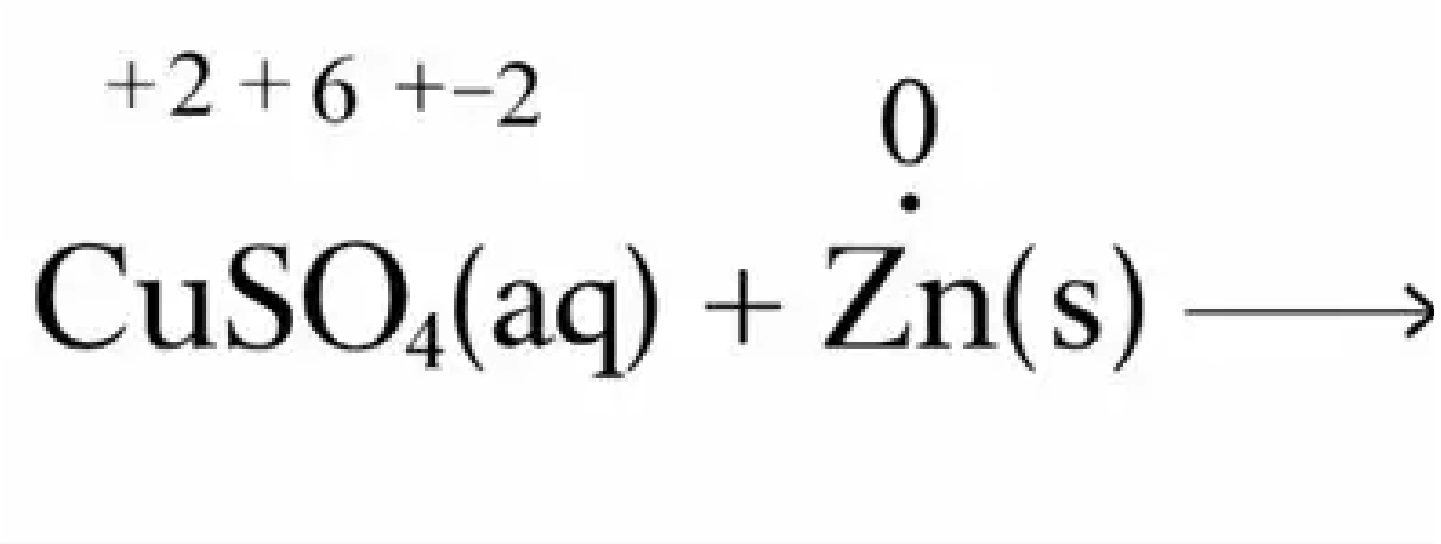
X + YZ □12□12□12; XZ + Y

Metal Displacement Reactions

A metal displaces another metal from its compound if it is more reactive.

Example:

Zn(s) + $CuSO_4$(aq) □12□12□12; $ZnSO_4$(aq) + Cu(s)



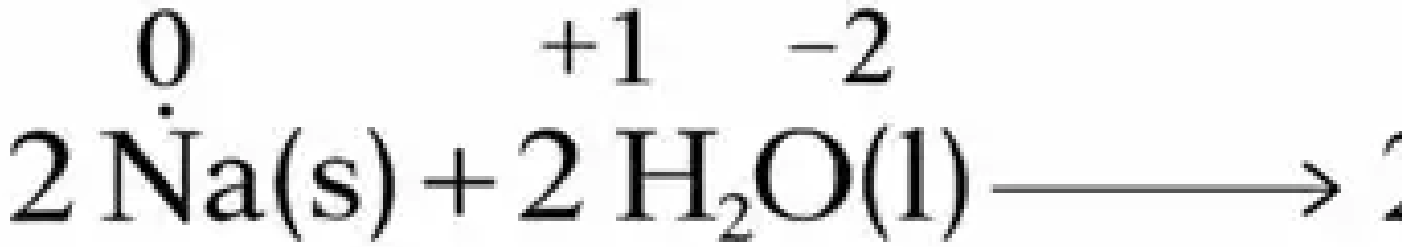
Non-metal Displacement Reactions

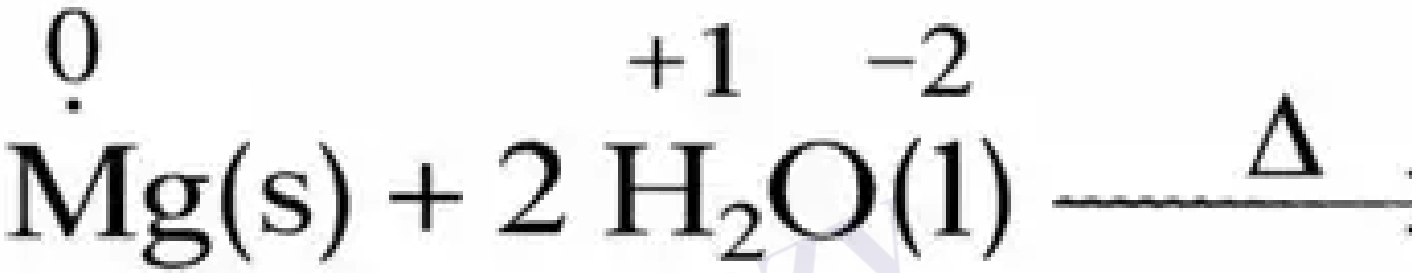
These include displacement of hydrogen from water or acids by metals.

Examples:

2Na(s) + 2H□92O(l) □12□12□12; 2NaOH(aq) + H□92(g)

Mg(s) + 2H□92O(g) □12□12□12; Mg(OH)□92(s) + H□92(g)





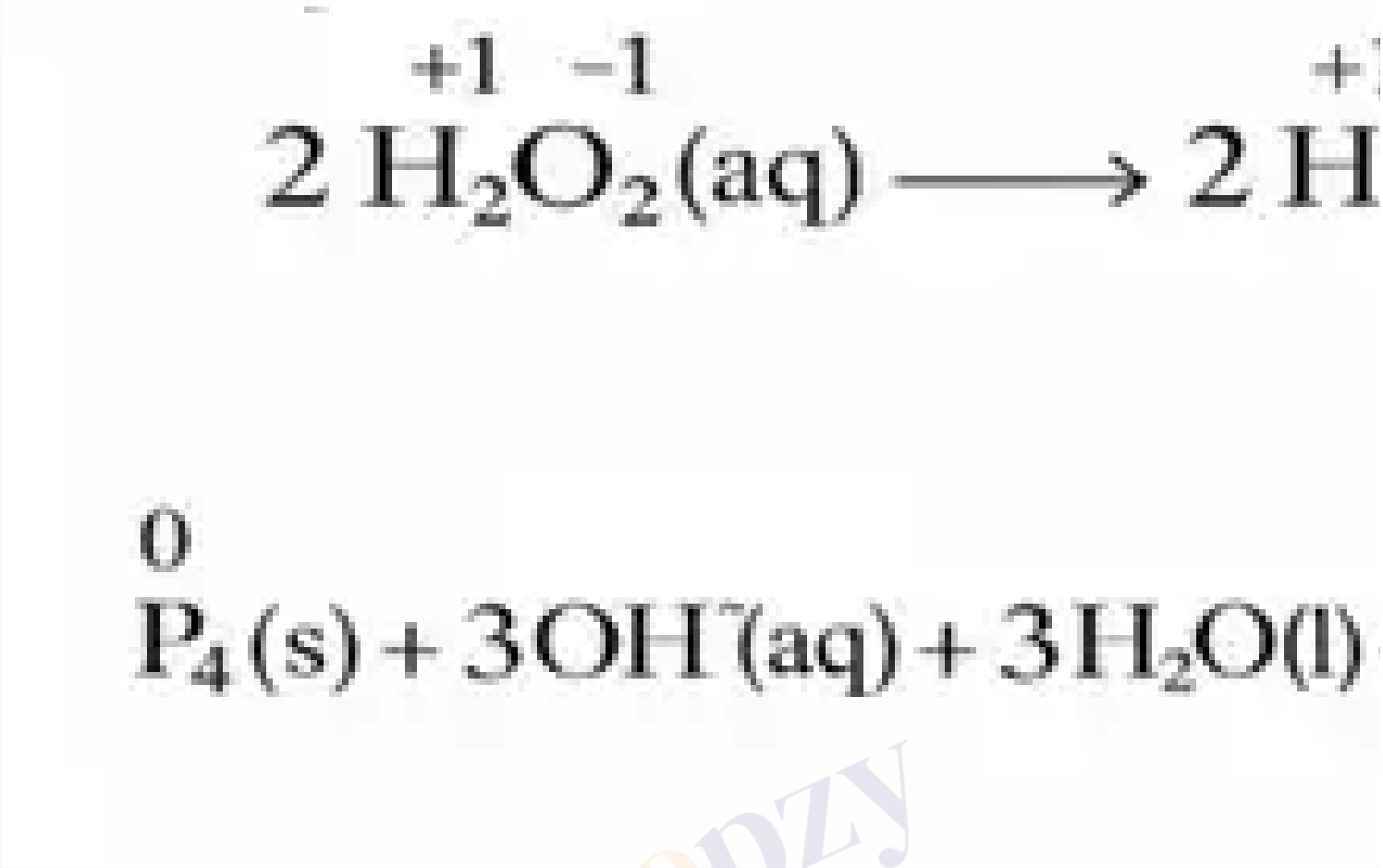
Disproportionation Reactions

In these reactions, an element in one oxidation state is simultaneously oxidised and reduced.

Examples:

2H□92O□92 □12□12□12; 2H□92O + O□92

P□94 + 3OH$^-$ + 3H□92O □12□12□12; PH□93 + 3H□92PO□92$^-$



Balancing Redox Reactions

Oxidation Number Method

- Write correct formulas for reactants and products.
- Assign oxidation numbers and identify changes.
- Balance changes in oxidation numbers by multiplying.
- Add H^+ or OH^- ions to balance charges in acidic or basic medium.
- Add H_2O to balance hydrogen and oxygen atoms.
- Check that atoms and charges are balanced.

Half Reaction Method

- Write ionic equation and separate into oxidation and reduction half reactions.
- Balance atoms other than O and H.
- Balance O by adding H_2O and H by adding H^+ (acidic medium).
- Balance charges by adding electrons.
- Multiply half reactions to equalize electrons and add them.
- For basic medium, add OH^- to both sides to neutralize H^+.

Electrode Processes

Direct Redox Reactions

Oxidation and reduction occur in the same container, e.g., electrolytic cell where Zn is oxidised and

Indirect Redox Reactions

Oxidation and reduction occur in separate containers connected by a salt bridge, e.g., Daniel cell w

Redox Couple

The oxidised and reduced forms of a substance involved in a half reaction.

Electrode

Electrical conductor making contact with non-metallic part of circuit.

Electrode Potential

Potential associated with each electrode.

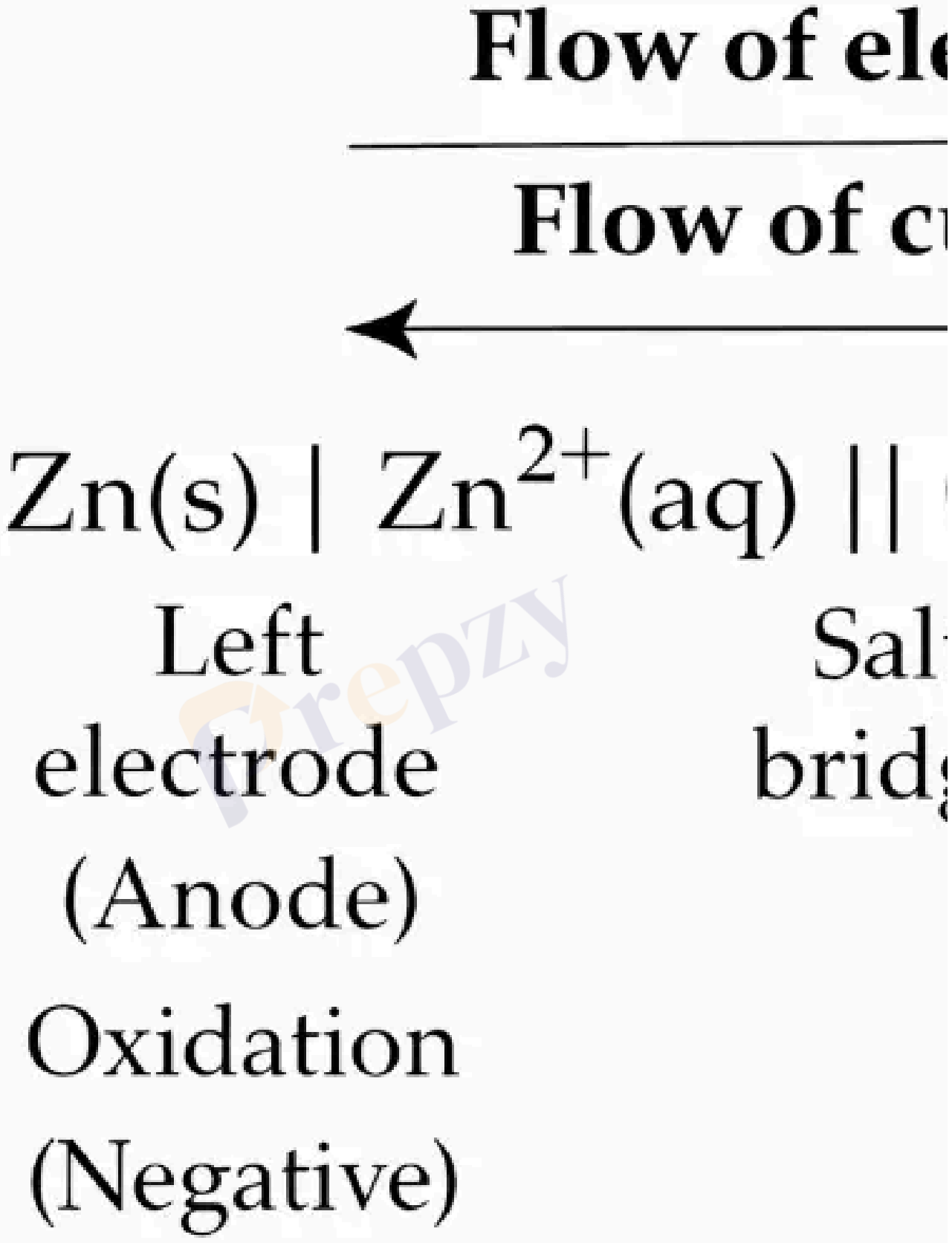
Salt Bridge

Inverted U-tube containing electrolyte connecting two half cells, maintaining electrical neutrality.

Functions of Salt Bridge

- Completes the circuit without mixing solutions.
- Maintains electrical neutrality by ion flow.

Representation of Electrochemical Cell



Standard Electrode Potential

Potential of electrode under standard conditions (1 M concentration, 1 atm pressure, 298 K).

Electrochemical Series

Arrangement of electrodes in decreasing order of standard reduction potentials.

Feasibility of Reaction

Eb0cell = Eb0cathode - Eb0anode

Positive Eb0cell indicates feasible reaction.

Mnemonics

Concept: An Oil Rig Cat

Mnemonic: At the Anode, Oxidation Involves Loss of electrons.

Interpretation: Reduction Involves Gaining electrons at the Cathode.

Concept: Electrons flow From Anode To Cathode

Mnemonic: Fat Cat

Interpretation: LOAN: Left side, Oxidation, Anode, Negative

Concept: Soak a jerk

Mnemonic: SOAC a GERC

Interpretation: Strongest Oxidizing Agent at the Cathode Gains Electrons and is Reduced at the Ca

Concept: Activity Series of Metals

Mnemonic: Please Stop Calling Me A Cute Zebra I Like Her Call Smart Goat. Kangaroos Naturally M

Interpretation:

Calcium > Magnesium > Aluminium > (Carbon) > Zinc > Iron > Lead > Hydrogen > Copper > Silver > Gold

OR

K > Na > Mg > Al > Zn > Cr > Fe > Pb > H > Cu > Ag > Au

Concept: For Galvanic Cell

Mnemonic: LOAN

Interpretation: Loss of e^- □12□12□12; Oxidation □12□12□12; Anode □12□12□12; Negative

Concept: Electrolytic Cell

Mnemonic: LOAP

Interpretation: Loss of e^- □12□12□12; Oxidation □12□12□12; Anode □12□12□12; Positive

Solved Examples

Example 1: Balance the redox reaction using oxidation number method:

MnO_4^- + $C_2O_4^{2-}$ □12□12□12; MnO_2 + CO_2

Solution:

Assign oxidation numbers:

Mn in MnO_4^- = +7, Mn in MnO_2 = +4

C in $C_2O_4^{2-}$ = +3, C in CO_2 = +4

Change in oxidation number for Mn = 7 - 4 = 3 (reduction)

Change in oxidation number for C = 3 - 4 = -1 (oxidation)

Balance electrons and atoms accordingly.

Example 2: Write half reactions for the reaction:

Zn + Cu^{2+} □12□12□12; Zn^{2+} + Cu

Oxidation half reaction: Zn □12□12□12; Zn^{2+} + $2e^-$

Reduction half reaction: Cu^{2+} + $2e^-$ □12□12□12; Cu

Practice Set

- **Level 1:** Define combination and decomposition reactions with examples.
- **Level 2:** Explain the difference between direct and indirect redox reactions.
- **Level 3:** Balance the redox reaction: Fe_2O_3 + CO □12□12□12; Fe + CO_2

Answer Key

- **Level 1:** Combination reaction: two or more substances combine to form one compound, e.g., C + O□92 □12□12□12; CO□92. Decomp
- **Level 2:** Direct redox reactions occur in the same container (electrolytic cell); indirect redox reactions occur in separate containers co
- **Level 3:** Balanced reaction: Fe_2O_3 + 3CO □12□12□12; 2Fe + 3CO_2.

Quick Reference Table

Common Mistakes and Misconceptions

Glossary