



8. REDOX REACTIONS

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ERNAKULAM

A decorative border of roses in red, yellow, and orange colors, with green leaves and stems, framing the central text. The roses are arranged in a corner pattern at the top-right and bottom-left, with a horizontal stem extending from the bottom-left corner.

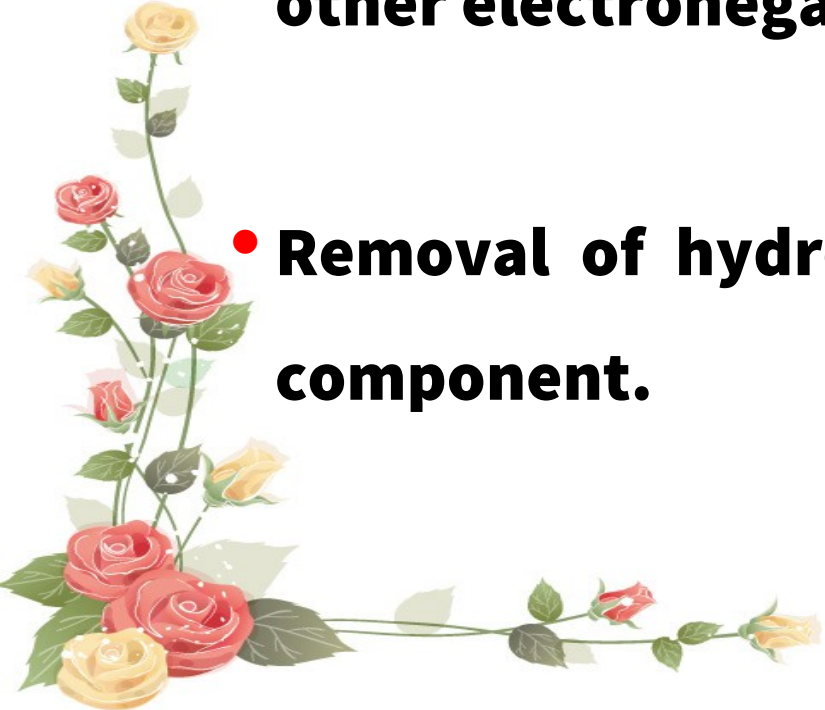
CLASSICAL CONCEPT OF OXIDATION AND REDUCTION



OXIDATION

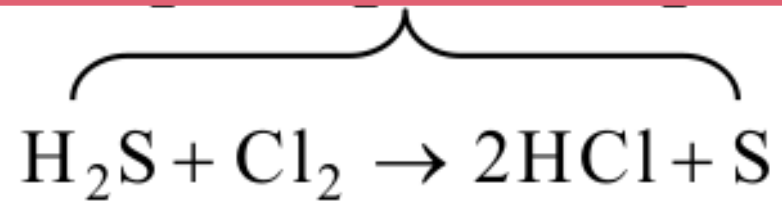
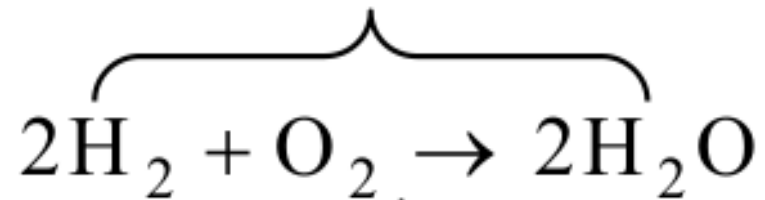
- **Oxidation is defined as addition of oxygen or any other electronegative component.**

Or

- **Removal of hydrogen or any other electropositive component.**
- 



EXAMPLES





REDUCTION

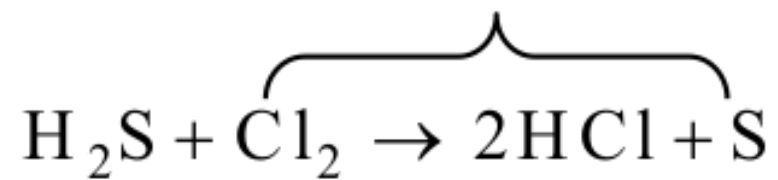
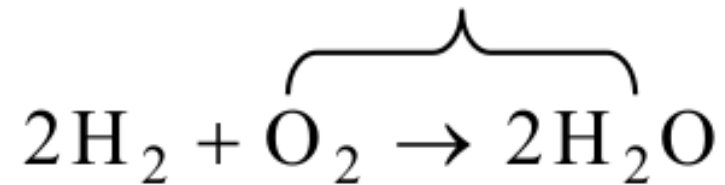
- **Reduction is defined as addition of hydrogen or any other electropositive component.**

Or

- **Removal of oxygen or any other electronegative component.**
- 



EXAMPLES



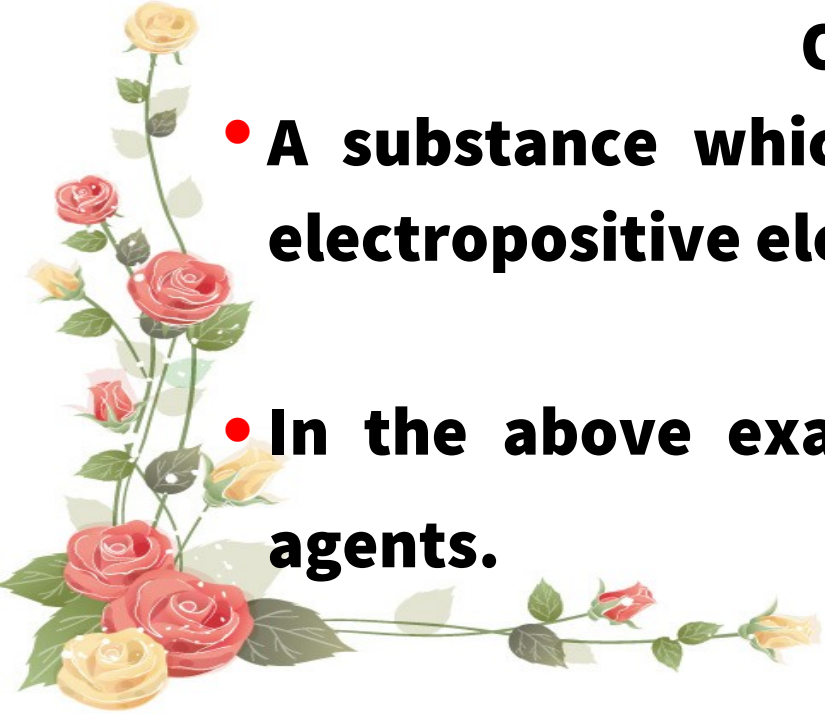


OXIDISING AGENT

- **A substance which provides oxygen or any electronegative element is called an oxidising agent.**

Or

- **A substance which removes hydrogen or any other electropositive element is called an oxidising agent.**

- **In the above examples, O_2 and Cl_2 act as oxidising agents.**
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REDUCING AGENT

- **A substance which provides hydrogen or any electropositive element is called a reducing agent.**

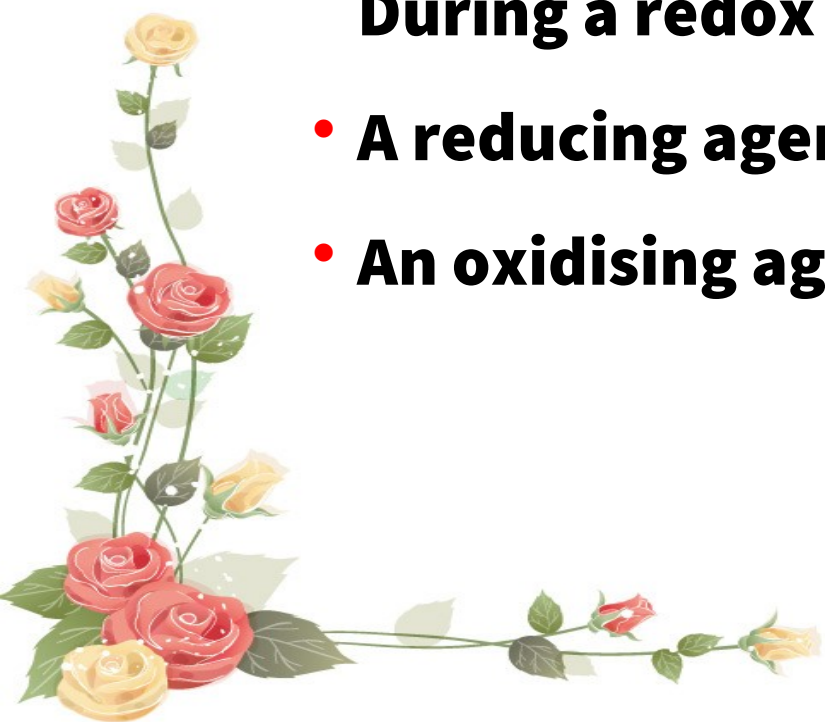
or

- **A substance which removes oxygen or any electronegative element is called a reducing agent.**
- 



NOTE

During a redox reaction:

- **A reducing agent undergoes oxidation.**
 - **An oxidising agent undergoes reduction.**
- 

A decorative border of roses in red and yellow, with green leaves, framing the central text. The roses are arranged in a corner pattern at the top-right and bottom-left, with a horizontal stem extending from the bottom-left corner.

ELECTRONIC CONCEPT OF OXIDATION AND REDUCTION



OXIDATION

- **Oxidation is the process involving loss of electrons.**



REDUCTION

- **Reduction is the process involving gain of electrons.**



OXIDISING AGENT

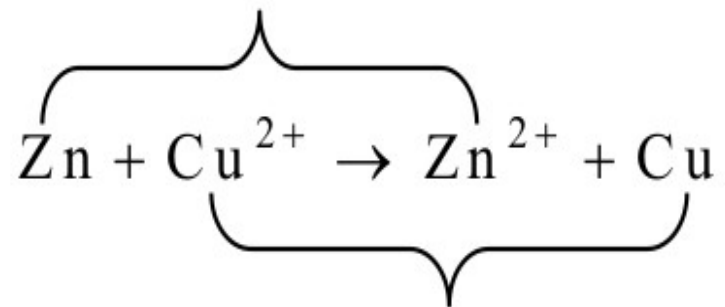
- **An oxidising agent is a substance whose atoms gain electrons.**

REDUCING AGENT

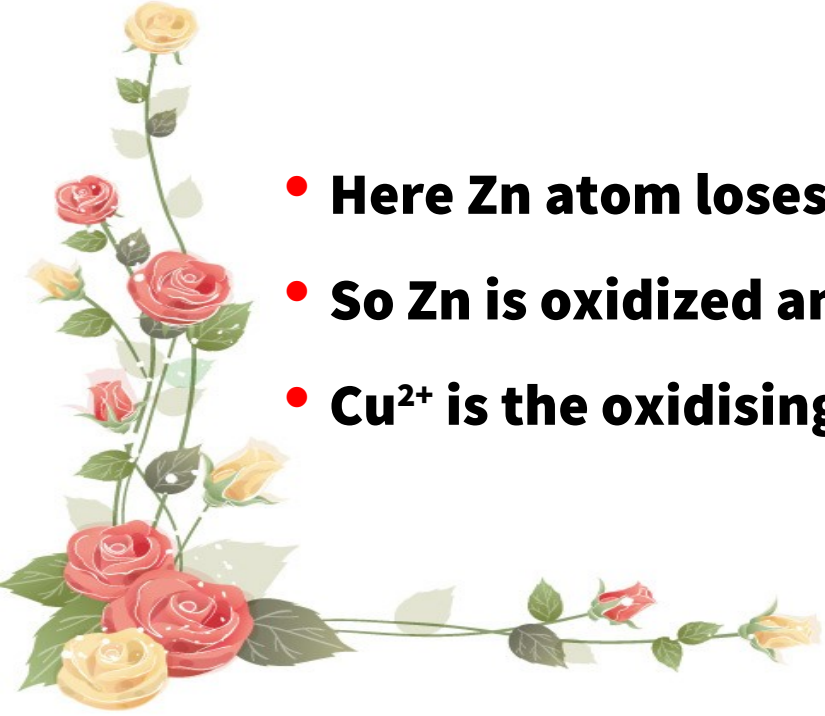
- **A reducing agent is a substance whose atoms lose electrons.**



OXIDATION



REDUCTION

- **Here Zn atom loses electrons while Cu^{2+} ions gains electrons.**
 - **So Zn is oxidized and Cu^{2+} is reduced.**
 - **Cu^{2+} is the oxidising agent and Zn is the reducing agent.**
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A decorative border of roses in red, yellow, and pink colors, with green leaves, framing the top and sides of the slide.

OXIDATION HALF AND REDUCTION HALF REACTIONS

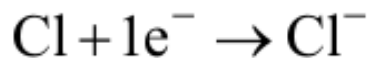
- **Every redox reaction consist of two half cell reactions.**
- **They are oxidation half reaction and reduction half reaction.**
- **Eg:- Reaction between Na and Cl.**



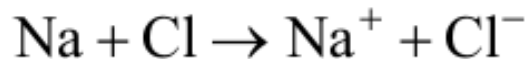
Na atom loses an electron to form Na⁺.



Cl atom gains an electron to form Cl⁻.



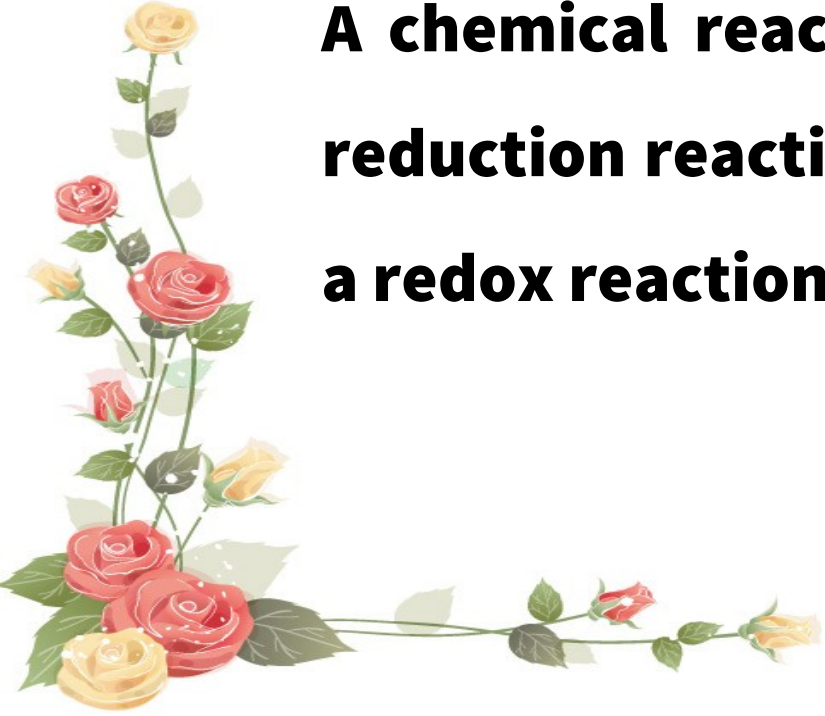
Overall cell reaction (Redox reaction) is



A decorative border of roses in red, yellow, and pink colors, with green leaves, running along the top and right edges of the slide.

REDOX REACTION

A chemical reaction in which both oxidation and reduction reactions occur simultaneously is called a redox reaction.

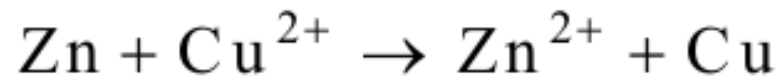
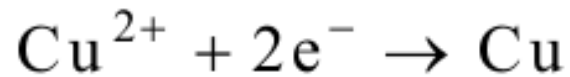
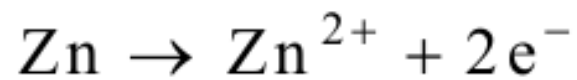
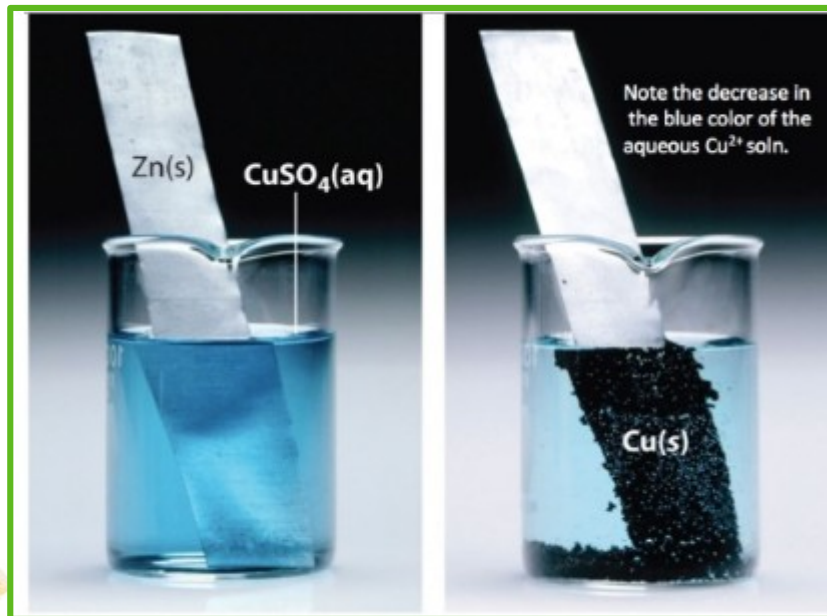
A decorative border of roses in red, yellow, and pink colors, with green leaves, running along the bottom and left edges of the slide.



EXAMPLE-1

- * **A clean Zn strip is placed in a solution of CuSO_4 placed in a beaker.**
- * **The following changes are observed.**
- * **Zn metal starts to dissolve and as a result of this, its mass decreases.**
- * **Cu metal starts to deposit.**
- * **The blue colour of CuSO_4 solution begins to fade.**
- * **The reaction proceeds with the evolution of heat.**

REACTIONS





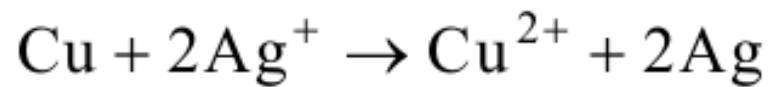
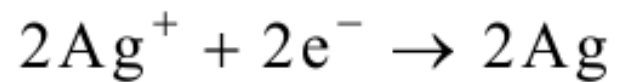
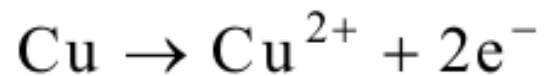
EXAMPLE-2

- **A clean copper strip is placed in a solution of AgNO_3 kept in a beaker.**
- **The following changes are observed.**
- **Copper strip starts to dissolve and as a result its mass decreases.**
- **Silver starts to deposit.**
- **Blue colour of Cu^{2+} ions appears.**
- **Reaction proceeds with the evolution of heat.**



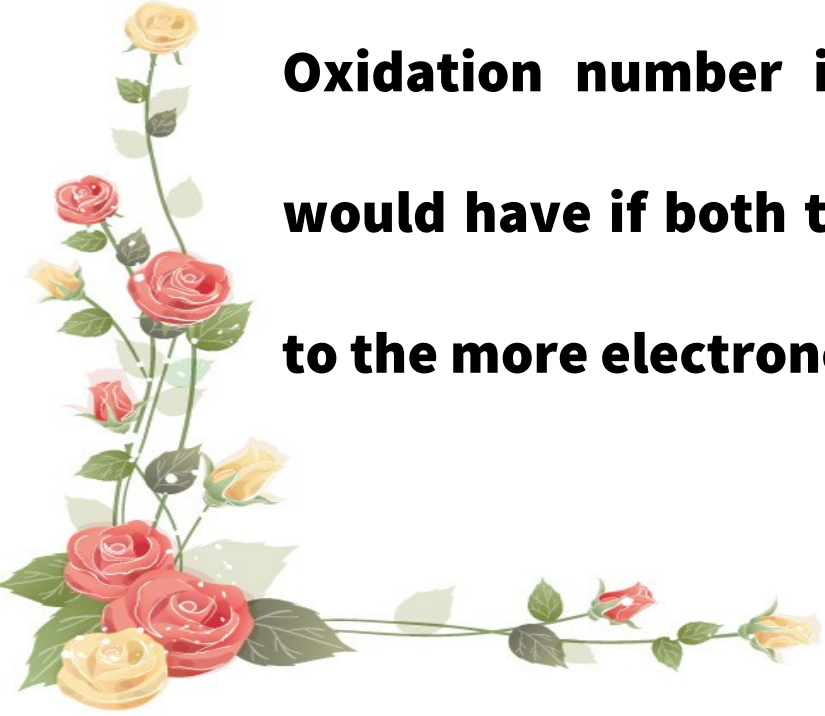


REACTIONS





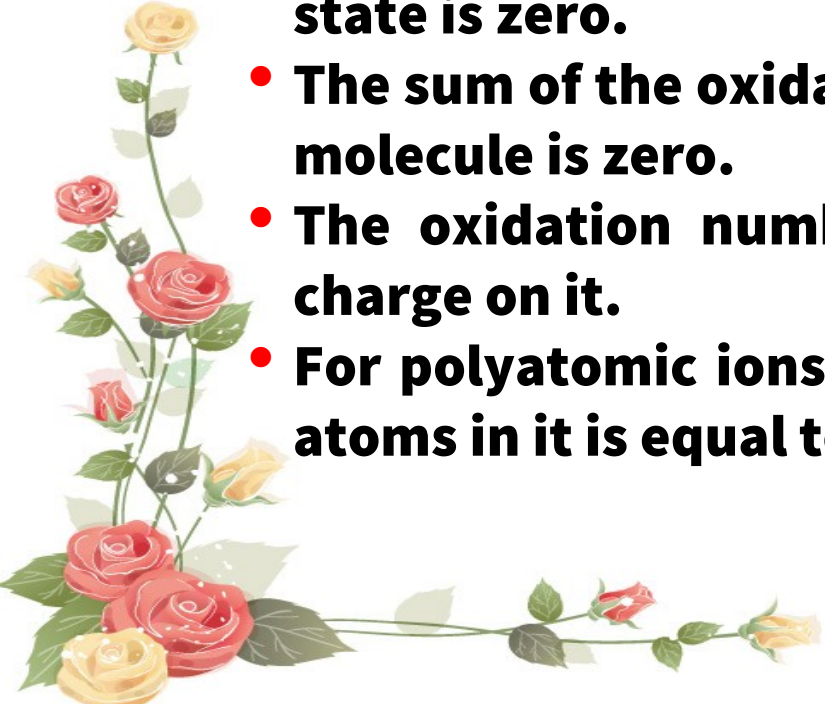
OXIDATION NUMBER OR OXIDATION STATE

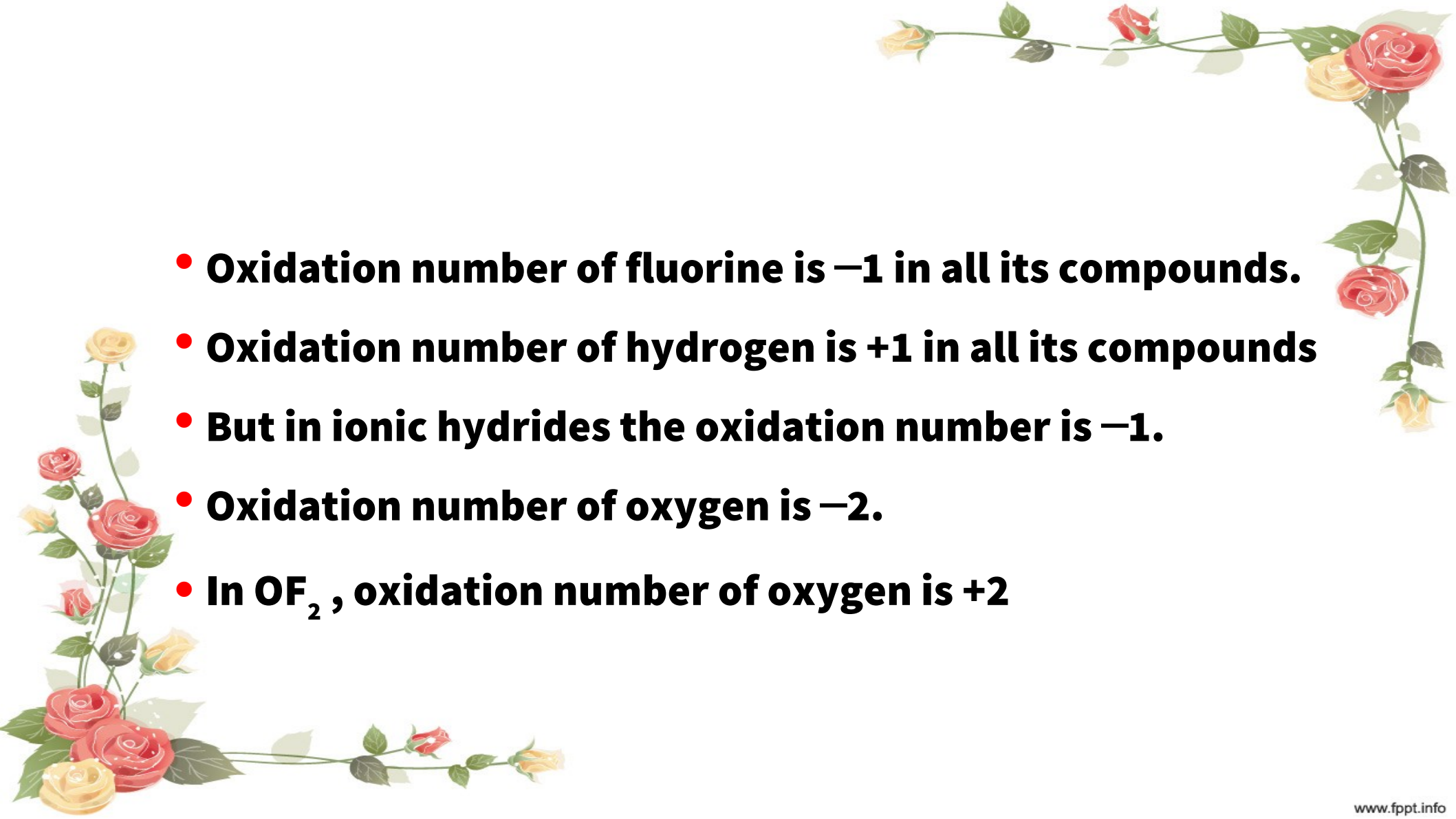


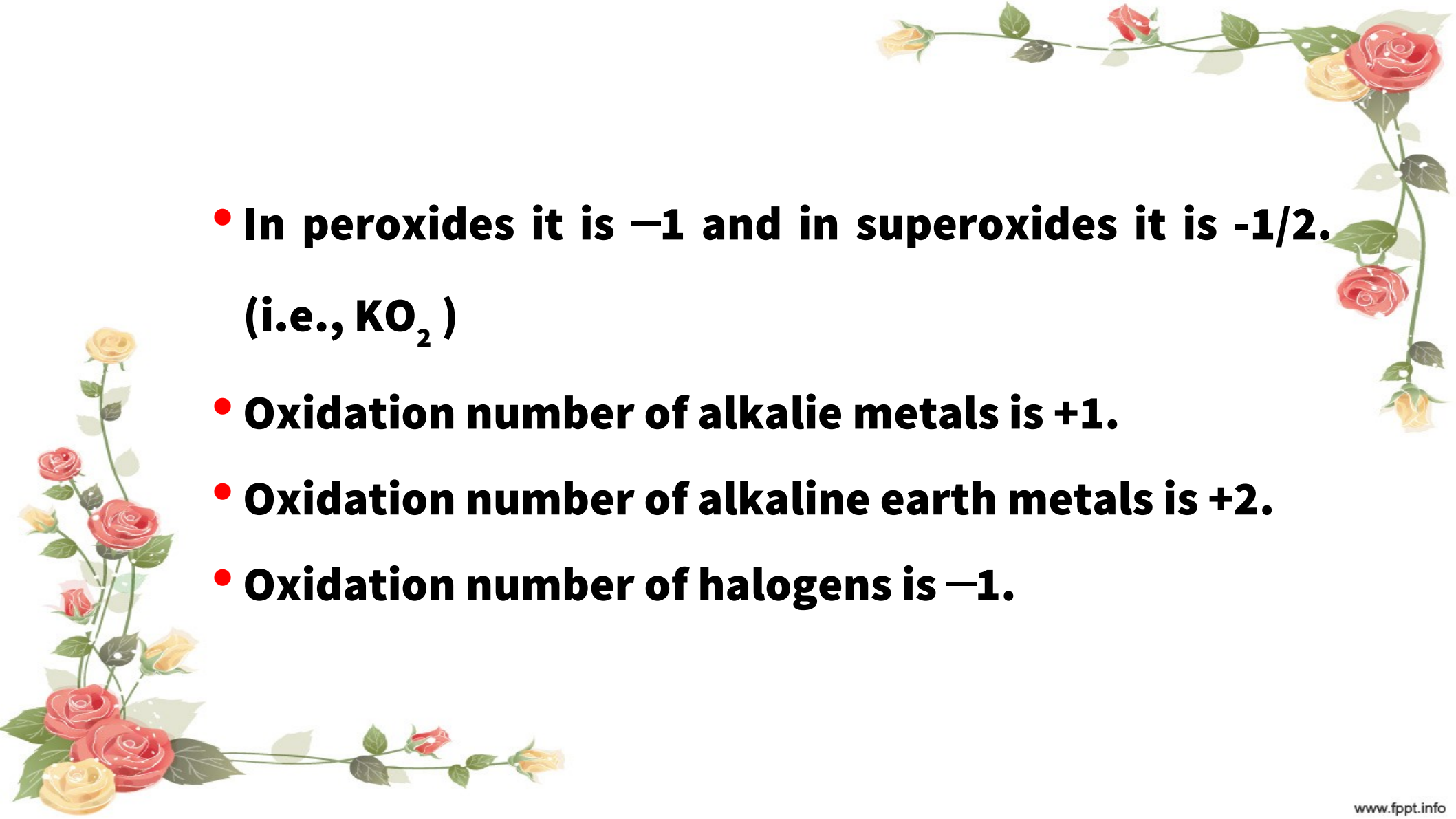
Oxidation number is defined as the charge that an atom would have if both the electrons in each bond were assigned to the more electronegative element.



RULES FOR ASSIGNING OXIDATION NUMBER

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- **Oxidation number of an element in the free or uncombined state is zero.**
 - **The sum of the oxidation numbers of all the atoms in a neutral molecule is zero.**
 - **The oxidation number of mono atomic ion is equal to the charge on it.**
 - **For polyatomic ions, sum of the oxidation numbers of all the atoms in it is equal to the charge on it.**

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- A decorative border of roses in red and yellow colors, with green leaves and stems, framing the central text.
- **Oxidation number of fluorine is -1 in all its compounds.**
 - **Oxidation number of hydrogen is $+1$ in all its compounds**
 - **But in ionic hydrides the oxidation number is -1 .**
 - **Oxidation number of oxygen is -2 .**
 - **In OF_2 , oxidation number of oxygen is $+2$**

- 
- The slide features decorative illustrations of roses in the corners. In the top right, a vine with green leaves and several red and yellow roses curves downwards. In the bottom left, a similar vine with red and yellow roses curves upwards. The central text is a list of oxidation numbers for various elements.
- **In peroxides it is -1 and in superoxides it is $-1/2$.
(i.e., KO_2)**
 - **Oxidation number of alkali metals is $+1$.**
 - **Oxidation number of alkaline earth metals is $+2$.**
 - **Oxidation number of halogens is -1 .**

A decorative border of roses in red and yellow colors, with green leaves and stems, framing the central text. The roses are arranged in a corner pattern, with some buds and some fully bloomed flowers.

OXIDATION AND REDUCTION IN TERMS OF OXIDATION NUMBER

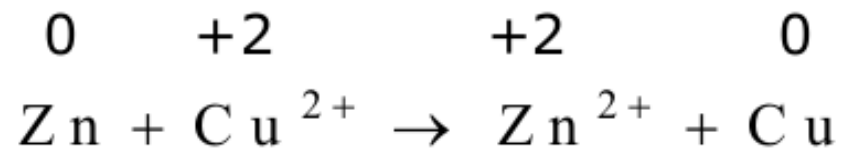


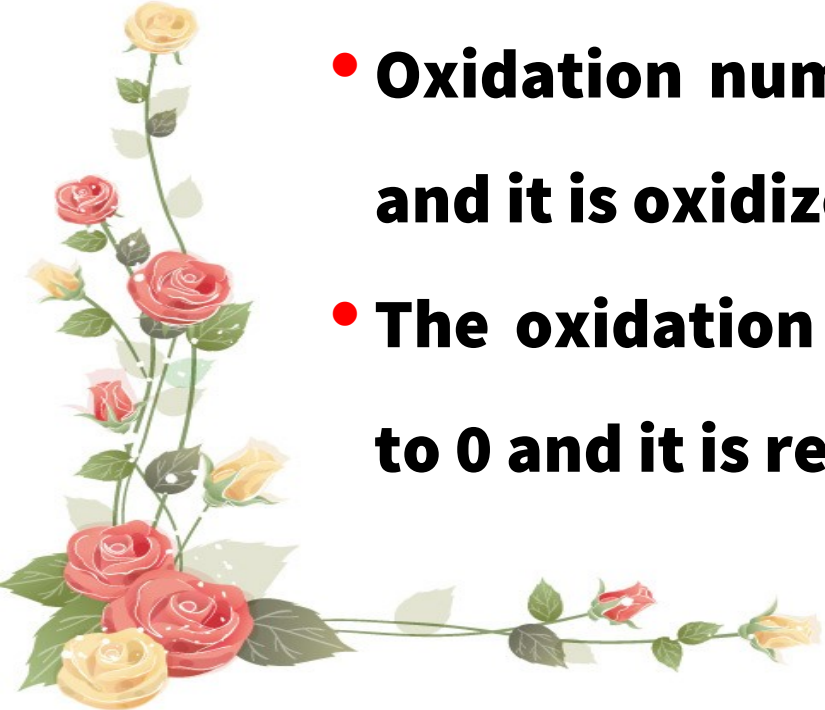
OXIDATION

- **A chemical change in which there is an increase in oxidation number.**

REDUCTION

- **A chemical change in which there is a decrease in oxidation number.**



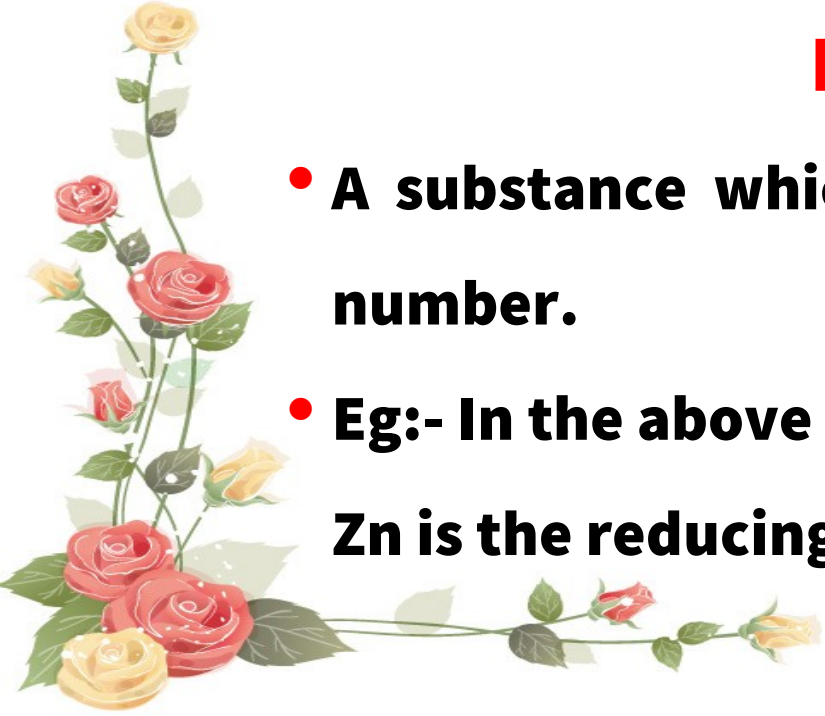
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- **Oxidation number of Zn increases from 0 to +2 and it is oxidized.**
 - **The oxidation number of Cu decreases from +2 to 0 and it is reduced.**



OXIDISING AGENT

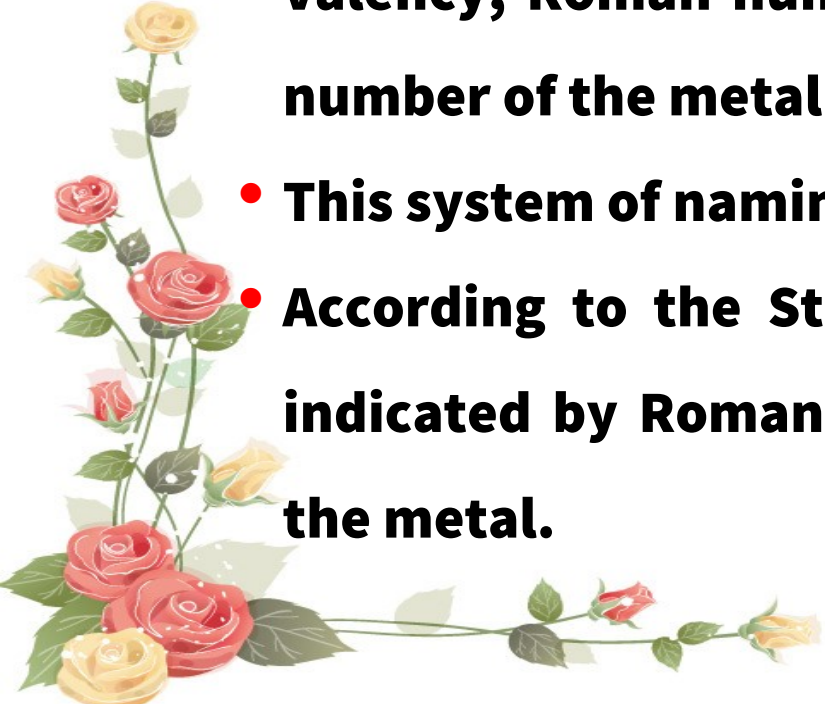
- A substance which undergoes a decrease in oxidation number.

REDUCING AGENT

- A substance which undergoes an increase in oxidation number.
 - Eg:- In the above example, Cu^{2+} is the oxidising agent and Zn is the reducing agent.
- 




OXIDATION NUMBER AND NOMENCLATURE

- In the naming of compounds of metals which exhibit variable valency, Roman numerals are used to indicate the oxidation number of the metal atoms.
 - This system of naming is known as the '**Stock System**'.
 - According to the Stock System, the oxidation numbers are indicated by Roman Numerals in brackets after the name of the metal.
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EXAMPLES



Cu_2O : Copper (I) Oxide

CuO : Copper (II) Oxide

SnO_2 : Tin (IV) Oxide

SnO : Tin (II) Oxide

FeSO_4 : Iron (II) Sulphate

FeO : Iron (II) Oxide

Fe_2O_3 : Iron (III) Oxide

MnO : Manganese (II) Oxide

MnO_2 : Manganese (IV) Oxide

A decorative border of roses in red and yellow, with green leaves, running along the top and right edges of the slide.

CALCULATION OF OXIDATION NUMBER





Calculate the oxidation Number of Mn in KMnO_4 ?

Let the oxidation number of Manganese = x

Let the oxidation number of Oxygen = $-2 \times 4 = -8$

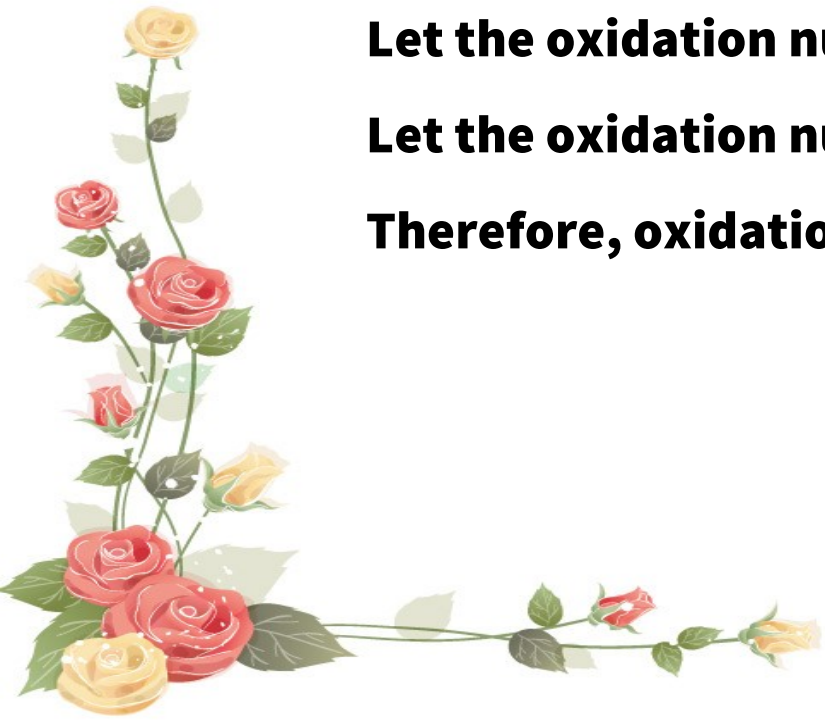
Let the oxidation number of Potassium = +1

Therefore, oxidation number of Manganese =

$$+1 + x - 8 = 0$$

$$x = -1 + 8$$

$$x = +7$$





Calculate the oxidation Number of Cr in $K_2Cr_2O_7$?

Let the oxidation number of Chromium = $2x$

Let the oxidation number of Oxygen = $-2 \times 7 = -14$

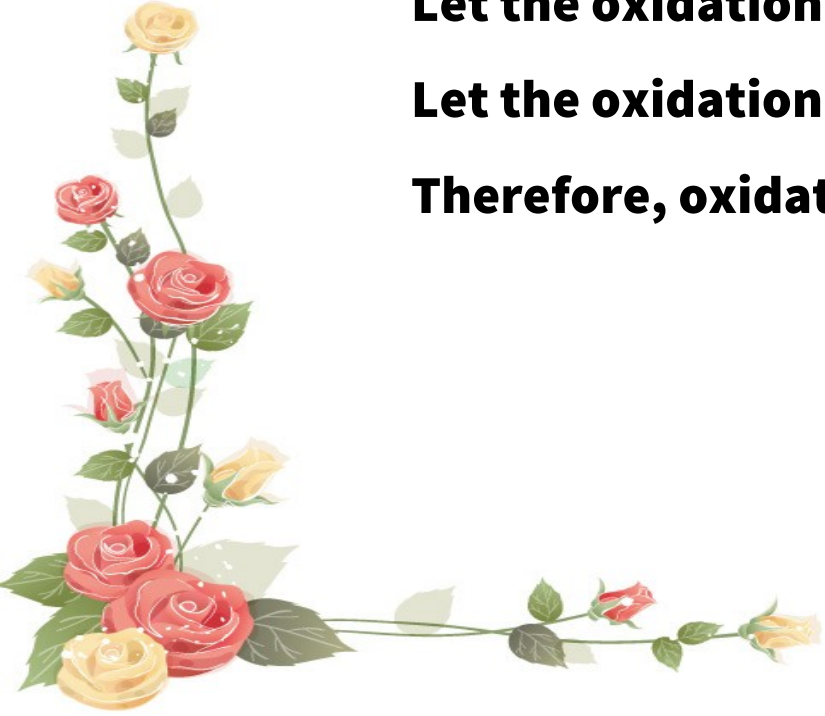
Let the oxidation number of Potassium = $+1 \times 2 = +2$

Therefore, oxidation number of Chromium =

$$+2 + 2x - 14 = 0$$

$$2x = -2 + 14$$

$$2x = +12$$

$$x = +6$$




Calculate the oxidation Number of C in CO_3^{2-} ?

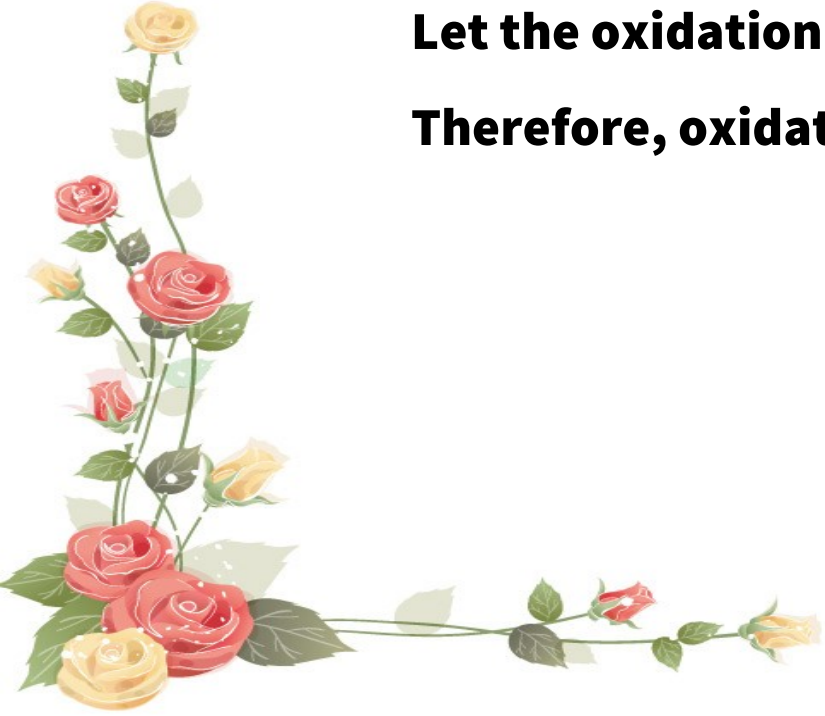
Let the oxidation number of Carbon = x

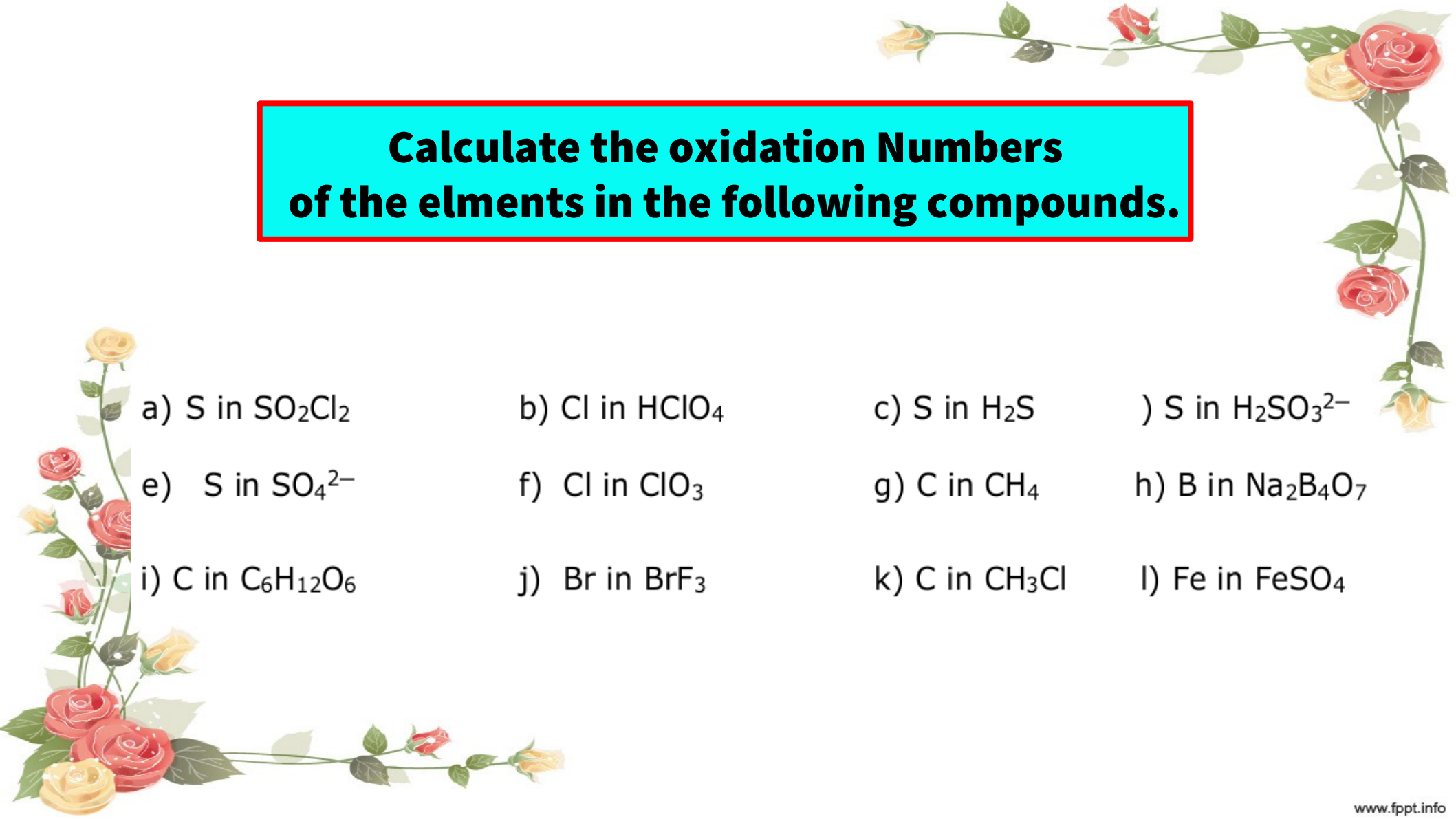
Let the oxidation number of Oxygen = $-2 \times 3 = -6$

Therefore, oxidation number of Carbon =

$$x - 6 = -2$$

$$x = -2 + 6$$

$$x = +4$$




**Calculate the oxidation Numbers
of the elements in the following compounds.**

a) S in SO_2Cl_2

b) Cl in HClO_4

c) S in H_2S

d) S in $\text{H}_2\text{SO}_3^{2-}$

e) S in SO_4^{2-}

f) Cl in ClO_3

g) C in CH_4

h) B in $\text{Na}_2\text{B}_4\text{O}_7$

i) C in $\text{C}_6\text{H}_{12}\text{O}_6$

j) Br in BrF_3

k) C in CH_3Cl

l) Fe in FeSO_4

A decorative border of roses in red and yellow, with green leaves, running along the top and right edges of the slide.

REDOX REACTIONS AND ELECTRODE PROCESSES



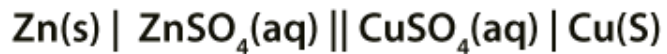
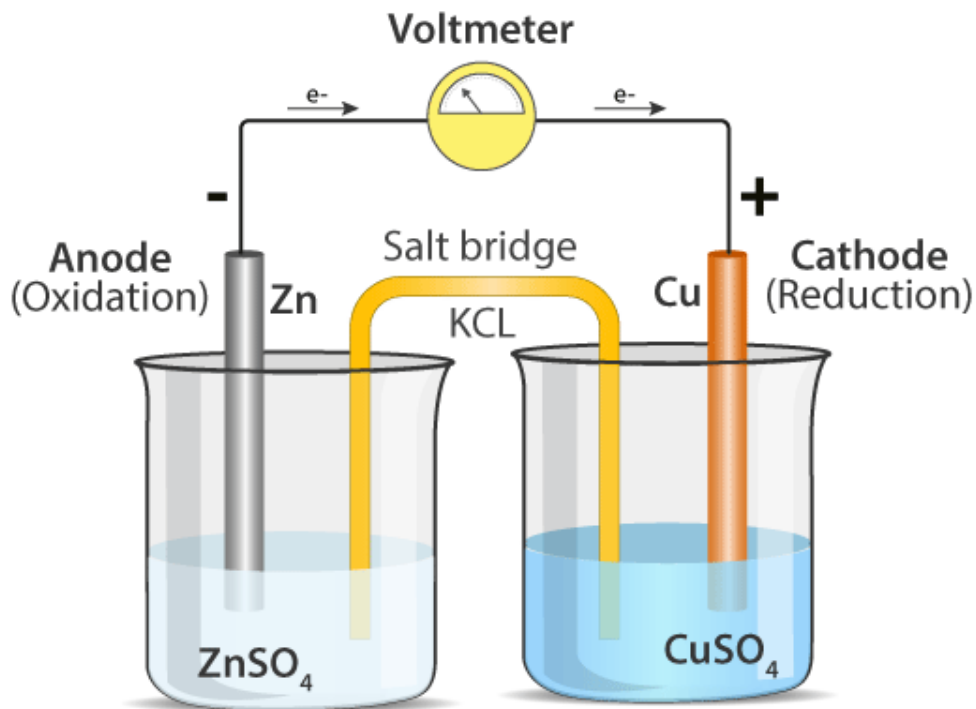
A decorative border of roses in red, yellow, and pink colors, with green leaves, framing the top and sides of the slide.

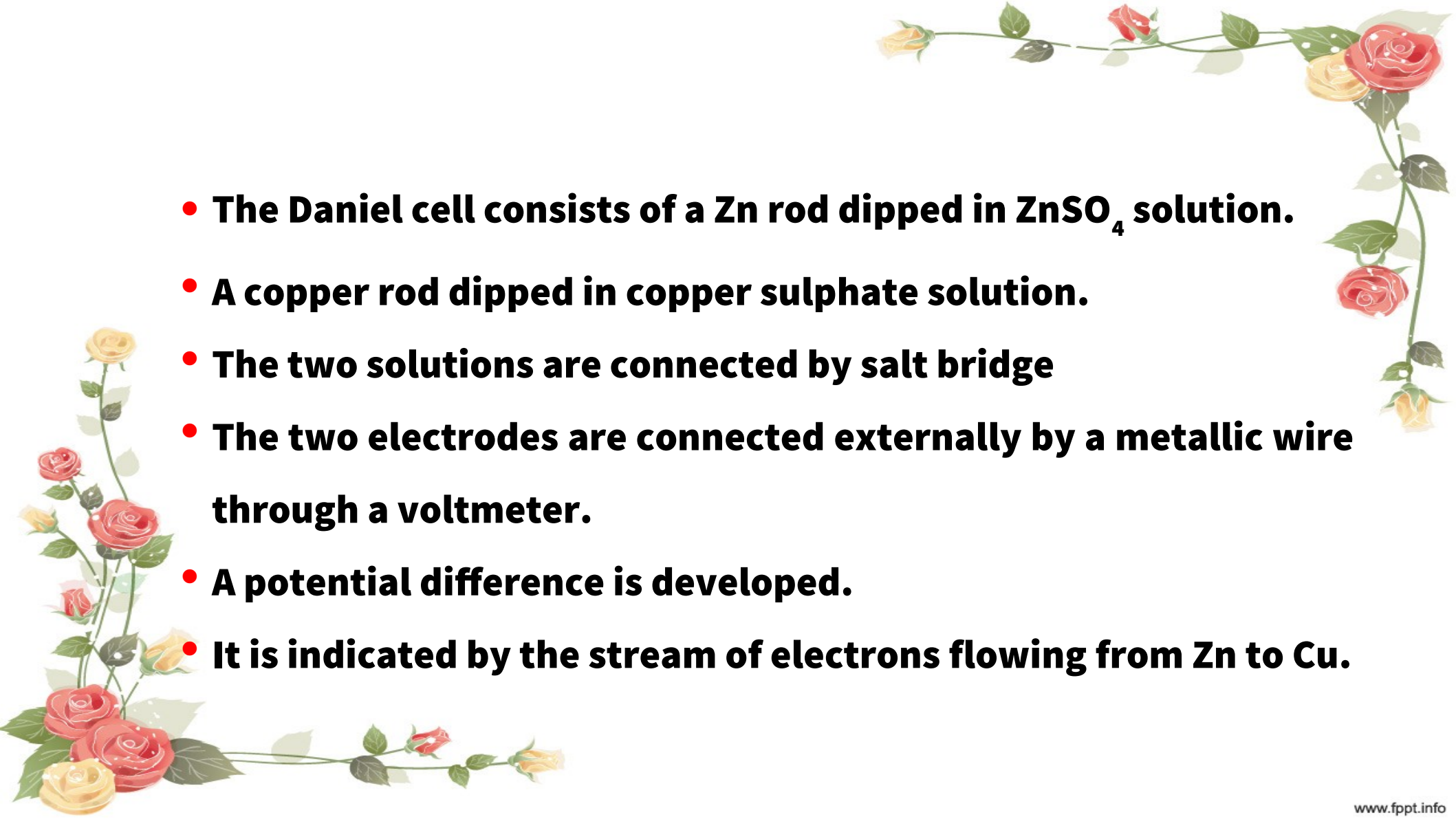
ELECTROCHEMICAL CELL OR GALVANIC CELL

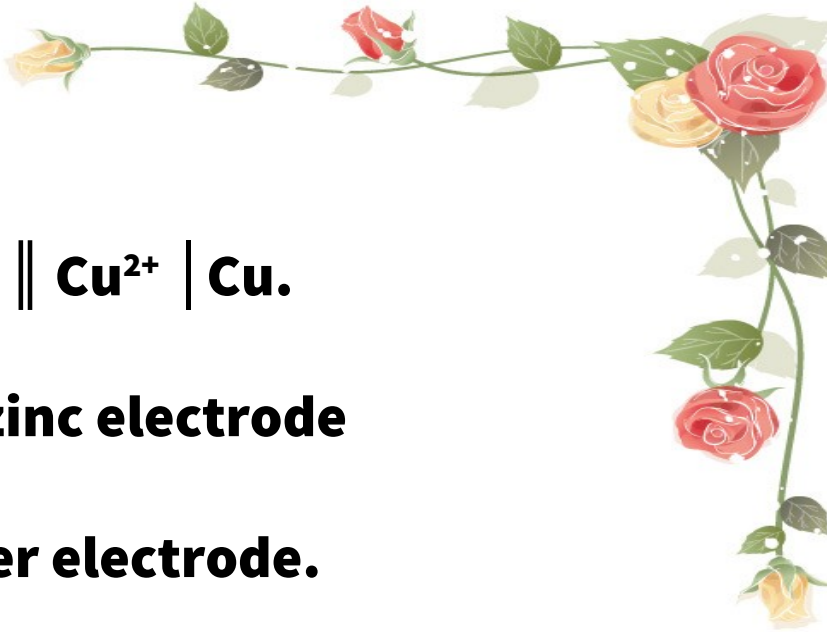
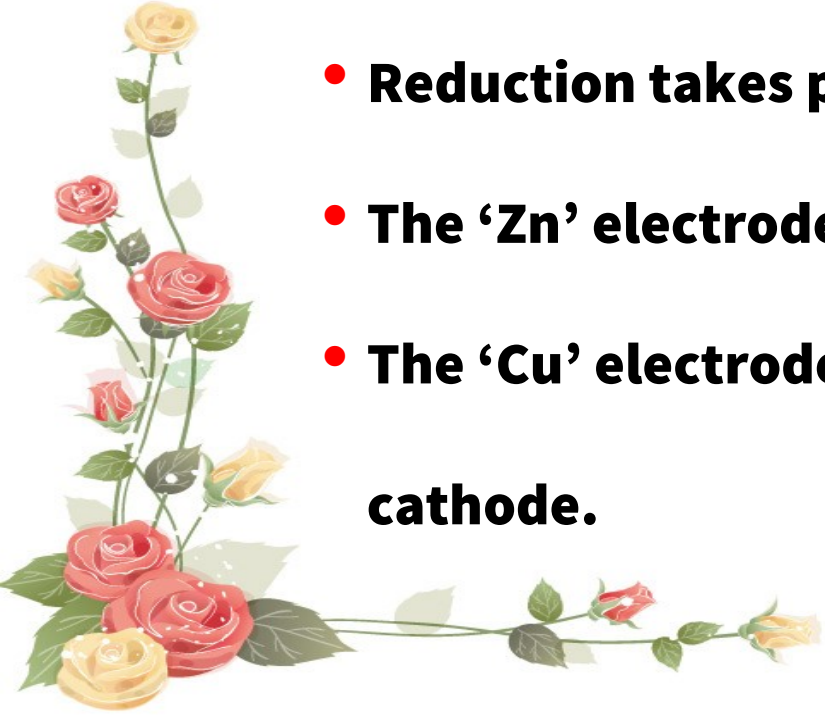
An electrochemical cell is a device used for the conversion of chemical energy into electrical energy.

Eg:- Daniel Cell

CONSTRUCTION AND WORKING OF DANIEL CELL

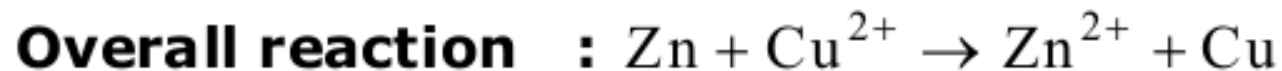
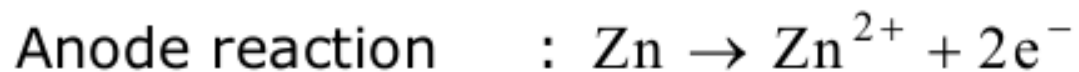


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- A decorative border of roses in shades of red, pink, and yellow, with green leaves, framing the text on the left and right sides of the slide.
- **The Daniel cell consists of a Zn rod dipped in ZnSO_4 solution.**
 - **A copper rod dipped in copper sulphate solution.**
 - **The two solutions are connected by salt bridge**
 - **The two electrodes are connected externally by a metallic wire through a voltmeter.**
 - **A potential difference is developed.**
 - **It is indicated by the stream of electrons flowing from Zn to Cu.**

- 
- 
- **The cell is represented as, $\text{Zn} \mid \text{Zn}^{2+} \parallel \text{Cu}^{2+} \mid \text{Cu}$.**
 - **Here oxidation takes place at the zinc electrode**
 - **Reduction takes place at the copper electrode.**
 - **The 'Zn' electrode at which oxidation takes place is the anode**
 - **The 'Cu' electrode at which reduction takes place is the cathode.**



CELL REACTIONS



The flow of electrons from Zn to Cu produces a current in the circuit.





SALT BRIDGE

- **Salt bridge is a 'U' shaped tube.**
- **It contains a concentrated solution of an electrolyte like KCl , KNO_3 , NH_4NO_3 etc mixed with gelatin or agar-agar.**

A decorative border of roses in red, yellow, and pink, with green leaves, framing the top, bottom, and sides of the slide.

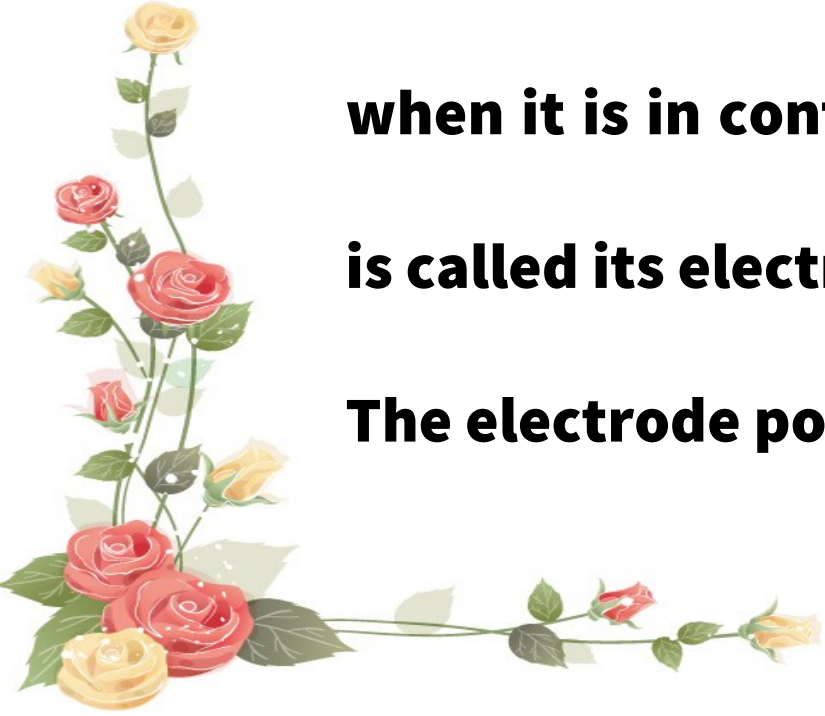
FUNCTIONS OF SALT BRIDGE

- **It allows the movement of ions from one solution to other without mixing of the two solutions.**
- **It maintains the electrical neutrality of the solution.**



ELECTRODE POTENTIAL

The tendency of an electrode to lose or gain electrons when it is in contact with its own ions in the solution is called its electrode potential.

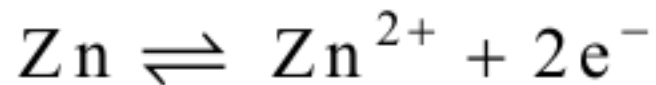
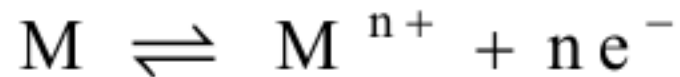


The electrode potential may be of two types.



1. OXIDATION POTENTIAL

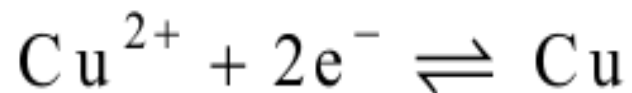
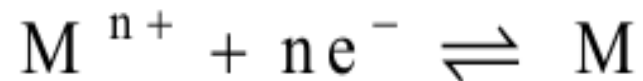
The tendency of an electrode to lose electrons.





2. REDUCTION POTENTIAL

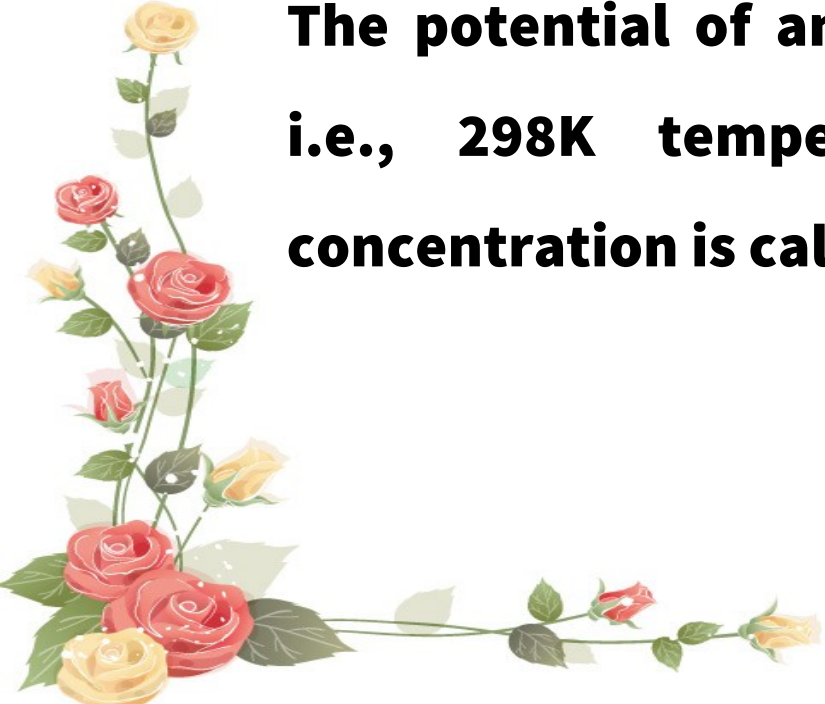
The tendency of an electrode to gain electrons.





STANDARD ELECTRODE POTENTIAL (E°)

The potential of an electrode under standard conditions i.e., 298K temperature, 1 atm pressure and 1M concentration is called standard electrode potential (E°).

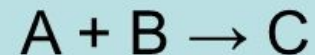




TYPES OF REDOX REACTIONS



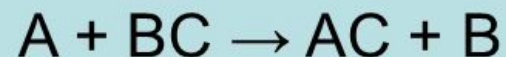
1. COMBINATION REACTIONS



2. DECOMPOSITION REACTIONS



3. DISPLACEMENT REACTIONS



4. DISPROPORTIONATION REACTION

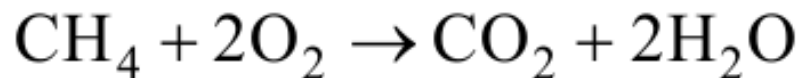
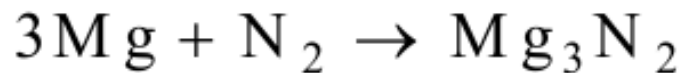
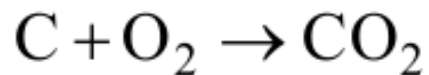


1. COMBINATION REACTIONS

A combination reaction may be represented as



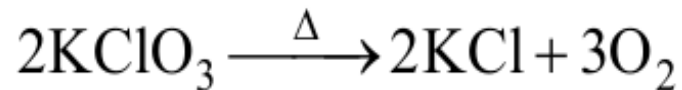
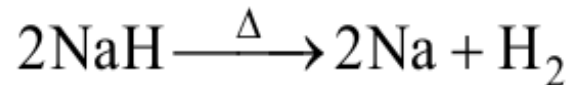
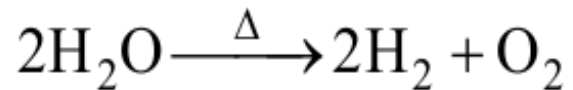
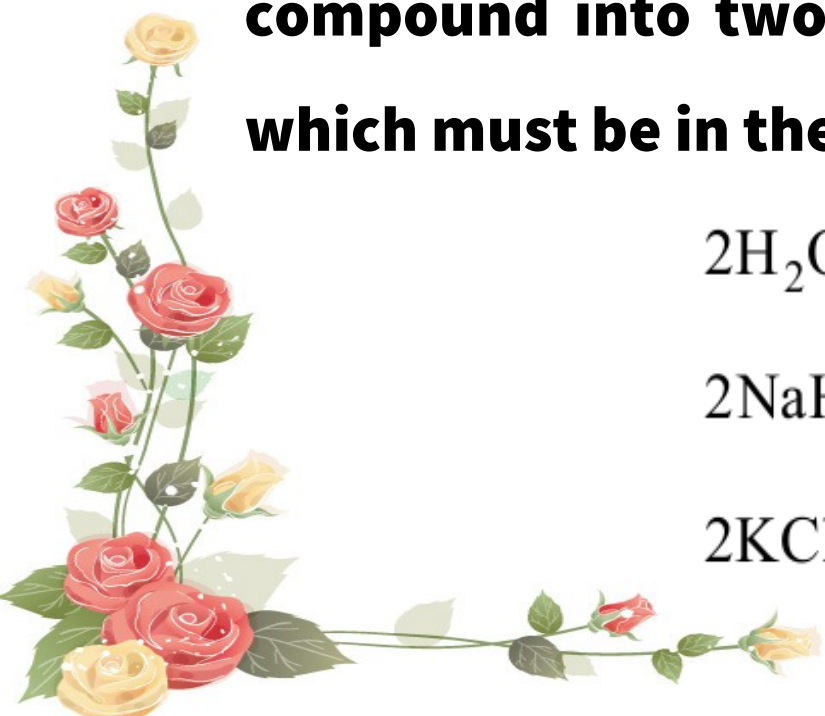
Either A or B or both A and B must be in the elemental form.





2. DECOMPOSITION REACTIONS

A decomposition reaction leads to the breakdown of a compound into two or more components at least one of which must be in the elemental state.





All decomposition reactions are not redox reactions

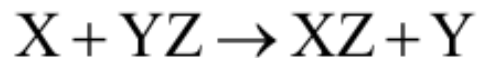




3. DISPLACEMENT REACTIONS

In a displacement reaction, an ion or an atom in a compound is replaced by an ion or atom of another element.

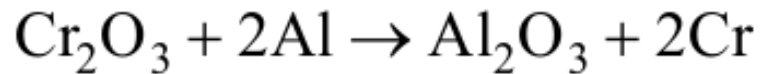
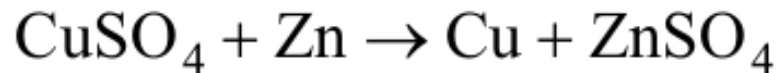
It may be denoted as





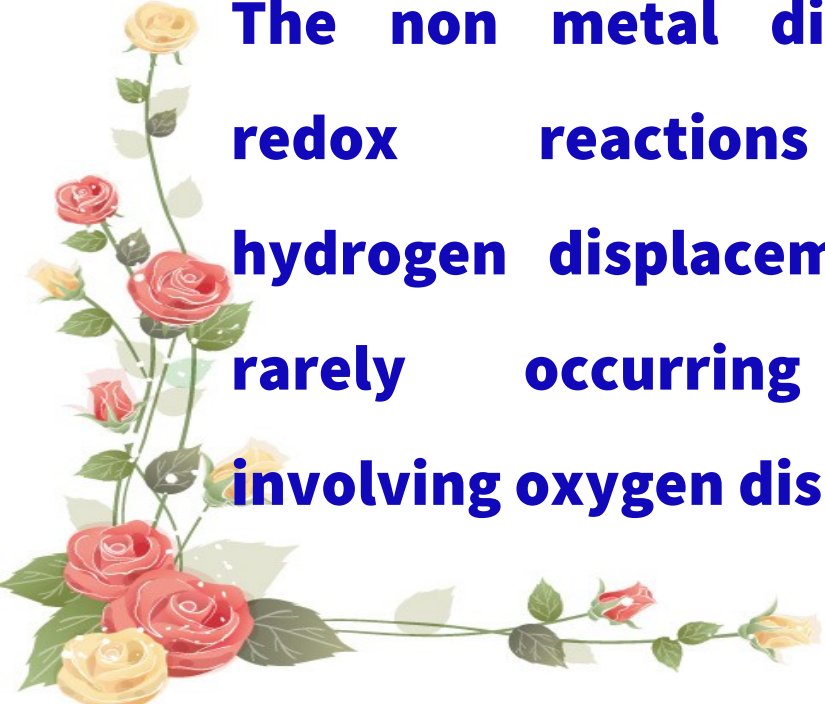
A. METAL DISPLACEMENT

A metal in a compound can be displaced by another metal in the uncombined state.

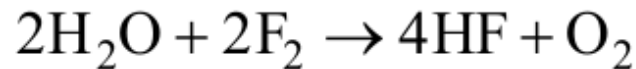
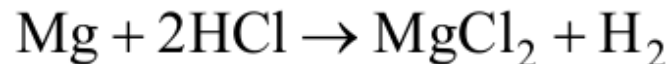
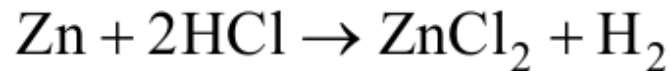
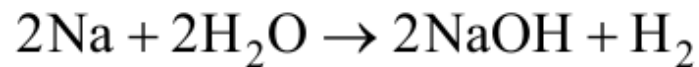




B. NON METAL DISPLACEMENT



The non metal displacement redox reactions include hydrogen displacement and a rarely occurring reaction involving oxygen displacement.

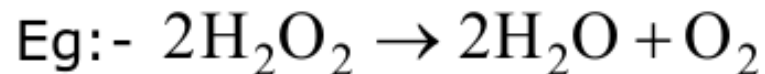




4. DISPROPORTIONATION REACTION

In this reaction, an element in one oxidation state is simultaneously oxidized and reduced.

One of the reacting substances always contains an element that can exist in at least three oxidation states.

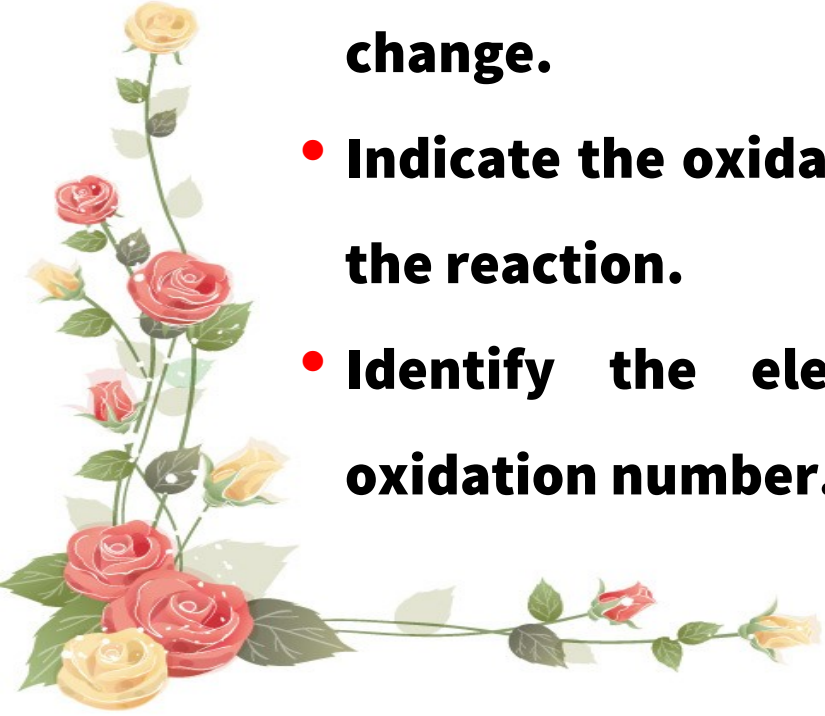


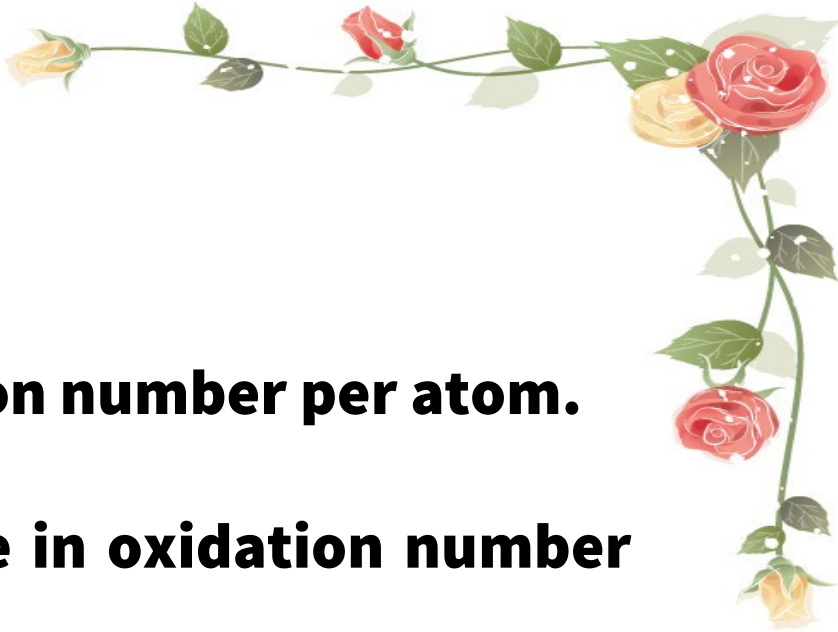


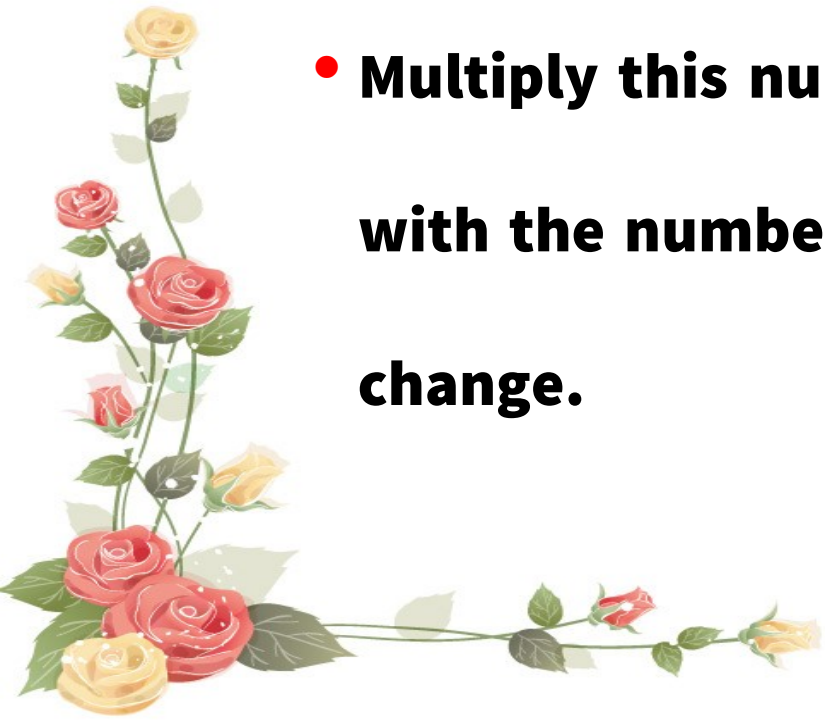
BALANCING OF REDOX REACTIONS

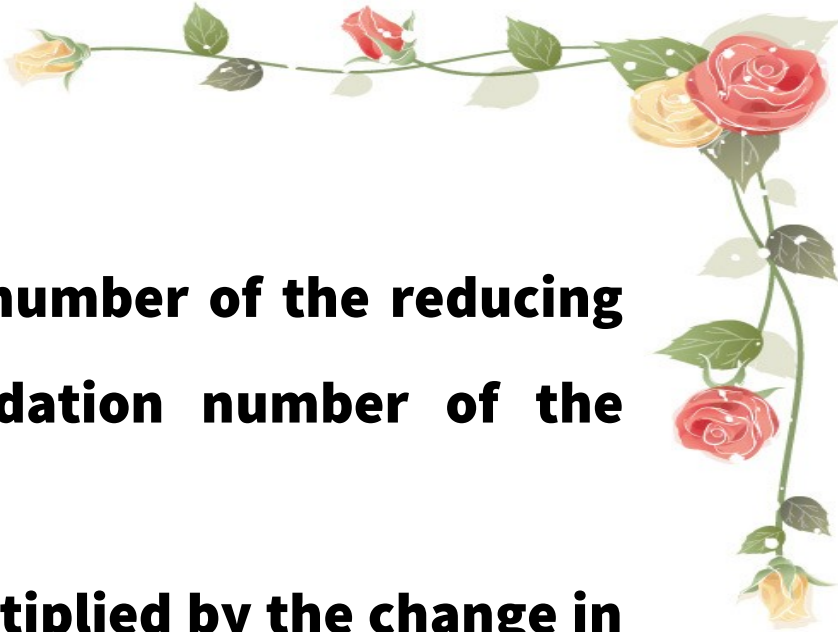


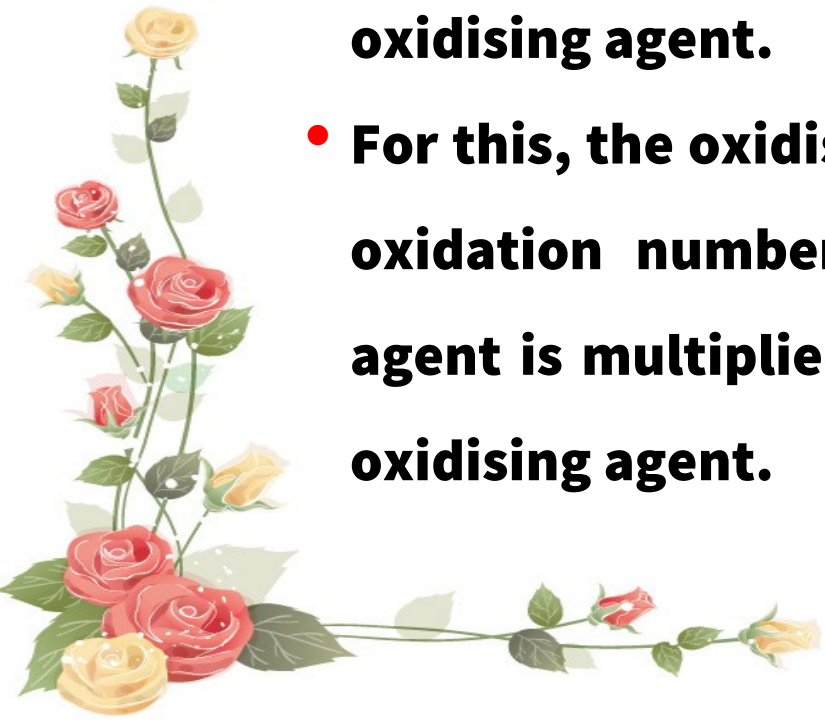
1. OXIDATION NUMBER METHOD

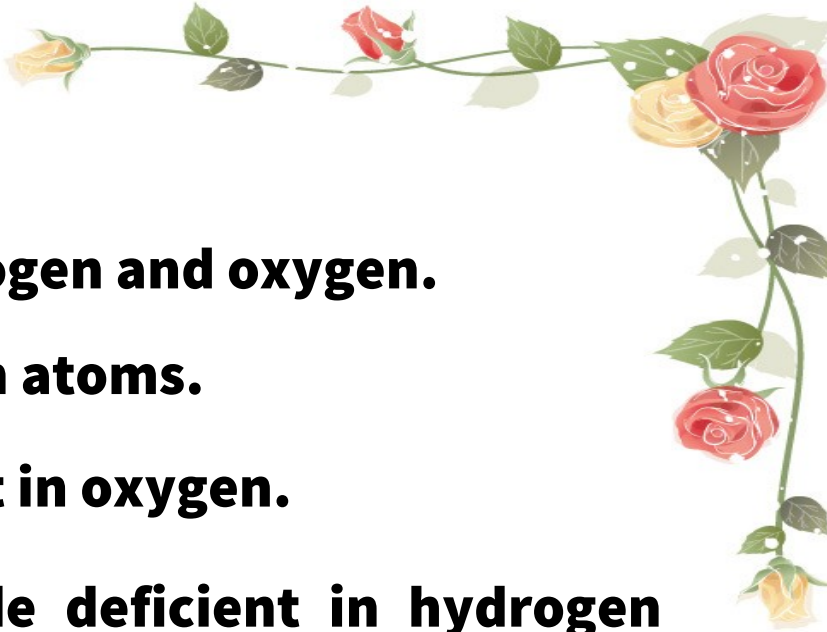
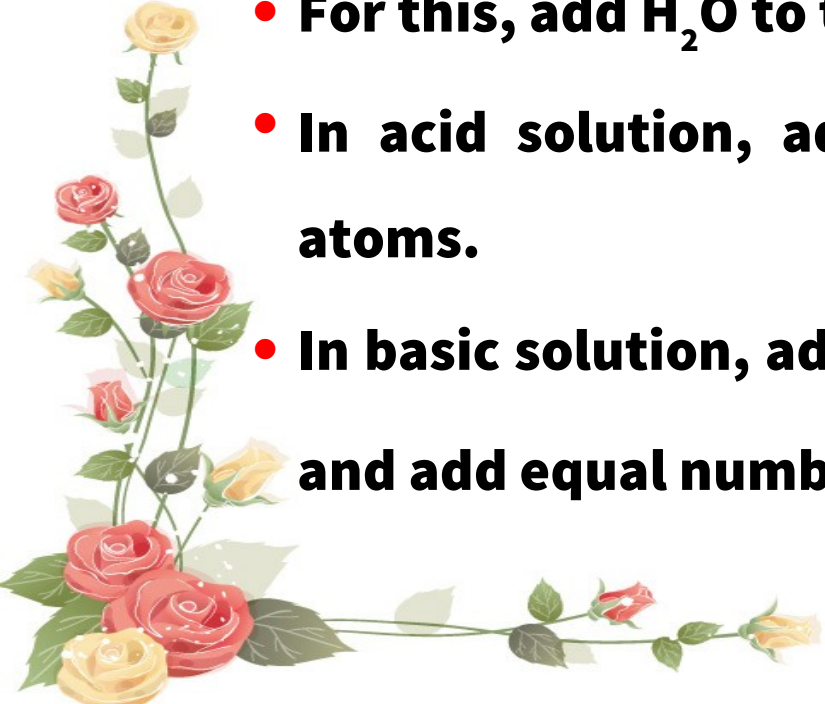
- **The various steps involved in this method are:**
 - **Write the skeletal equation representing the chemical change.**
 - **Indicate the oxidation numbers of all atoms involved in the reaction.**
 - **Identify the elements which undergo change in oxidation number.**
- 

- 
- A decorative border of roses in red and yellow, with green leaves, running along the top and right edges of the slide.
- **Calculate the change in oxidation number per atom.**
 - **Multiply this number of change in oxidation number with the number of atoms which are undergoing the change.**



- 
- A decorative border of roses and green leaves runs along the top and right edges of the slide. The roses are in various stages of bloom, with colors ranging from light yellow to deep red.
- **Equate the increase in oxidation number of the reducing agent with the decrease in oxidation number of the oxidising agent.**
 - **For this, the oxidising agent is multiplied by the change in oxidation number of reducing agent and the reducing agent is multiplied by the change in oxidation number of oxidising agent.**



- 
- 
- **Balance all other atoms except hydrogen and oxygen.**
 - **Finally balance hydrogen and oxygen atoms.**
 - **For this, add H_2O to the side deficient in oxygen.**
 - **In acid solution, add H^+ to the side deficient in hydrogen atoms.**
 - **In basic solution, add H_2O to side deficient in hydrogen atoms and add equal number of OH^- ions on the other side.**

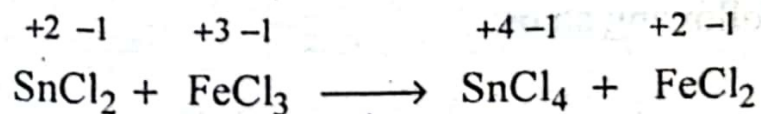
Example. 13.3. Balance the equation,



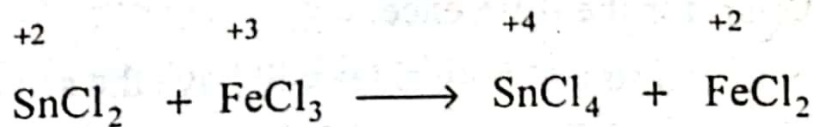
Solution:

1. Skeleton equation is, $\text{SnCl}_2 + \text{FeCl}_3 \longrightarrow \text{SnCl}_4 + \text{FeCl}_2$

2. Denote the oxidation numbers.

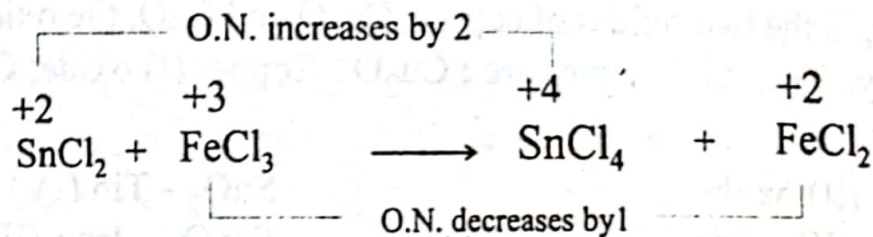


3. Identify the element which undergo change in oxidation numbers

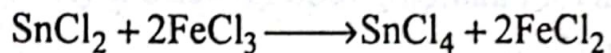


Oxidation number of Sn in SnCl_2 changes from +2 to +4 while that of Fe in FeCl_3 changes from +3 to +2. Thus, SnCl_2 is the reducing agent and FeCl_3 is the oxidising agent.

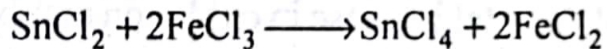
4. Calculate the change in oxidation number per formula unit of both oxidising and reducing agents.



5. Multiply SnCl_2 by 1 and FeCl_3 by 2.



6. Balance all other atoms except H and O

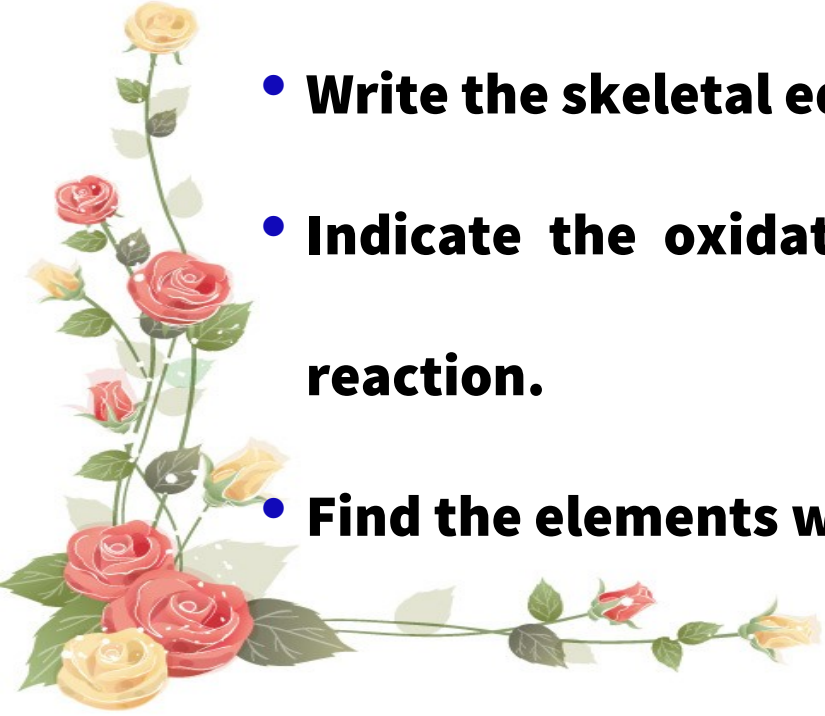


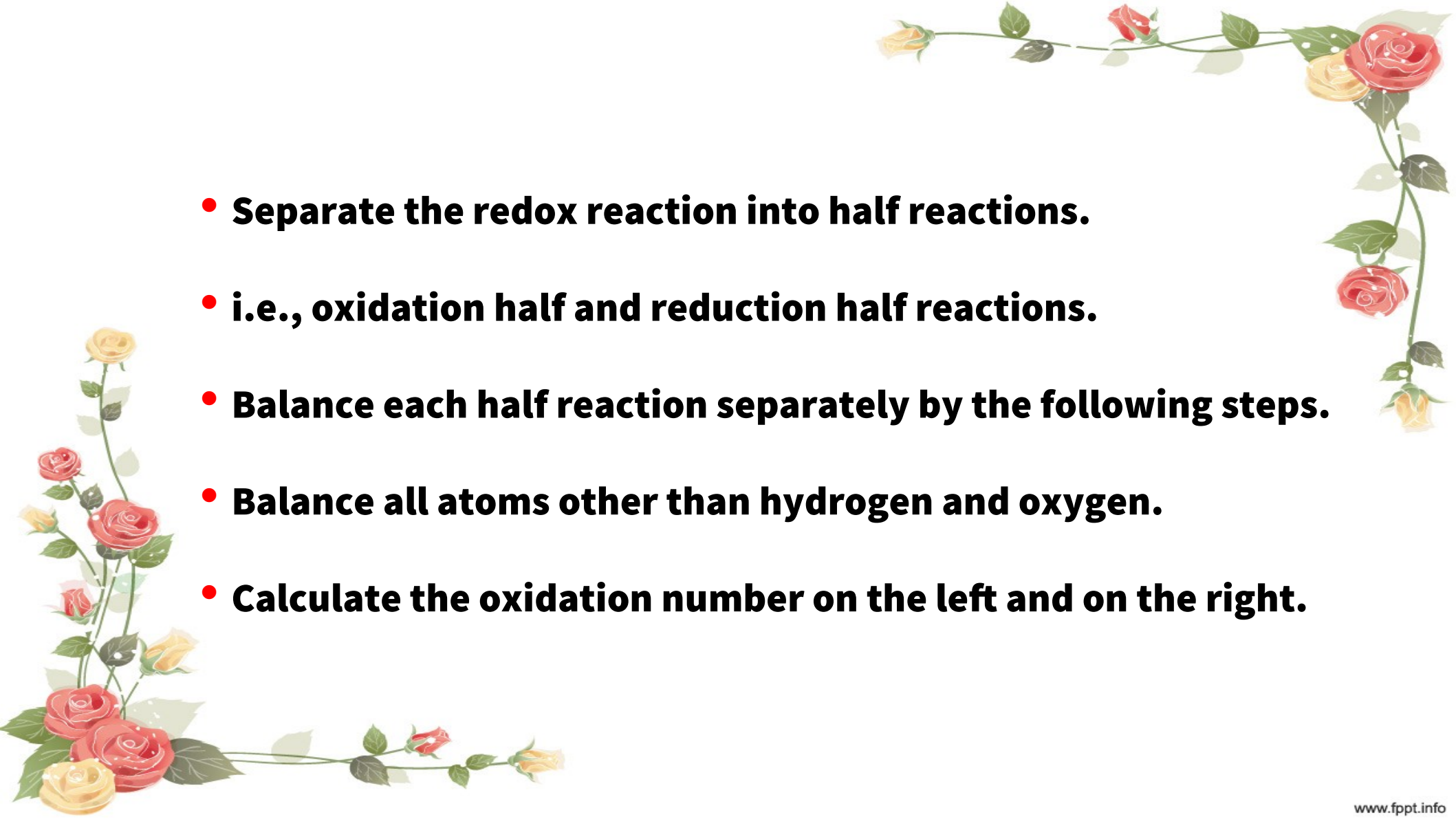
7. Balance H and O atoms. This step is not required in this case since H and O are not involved.

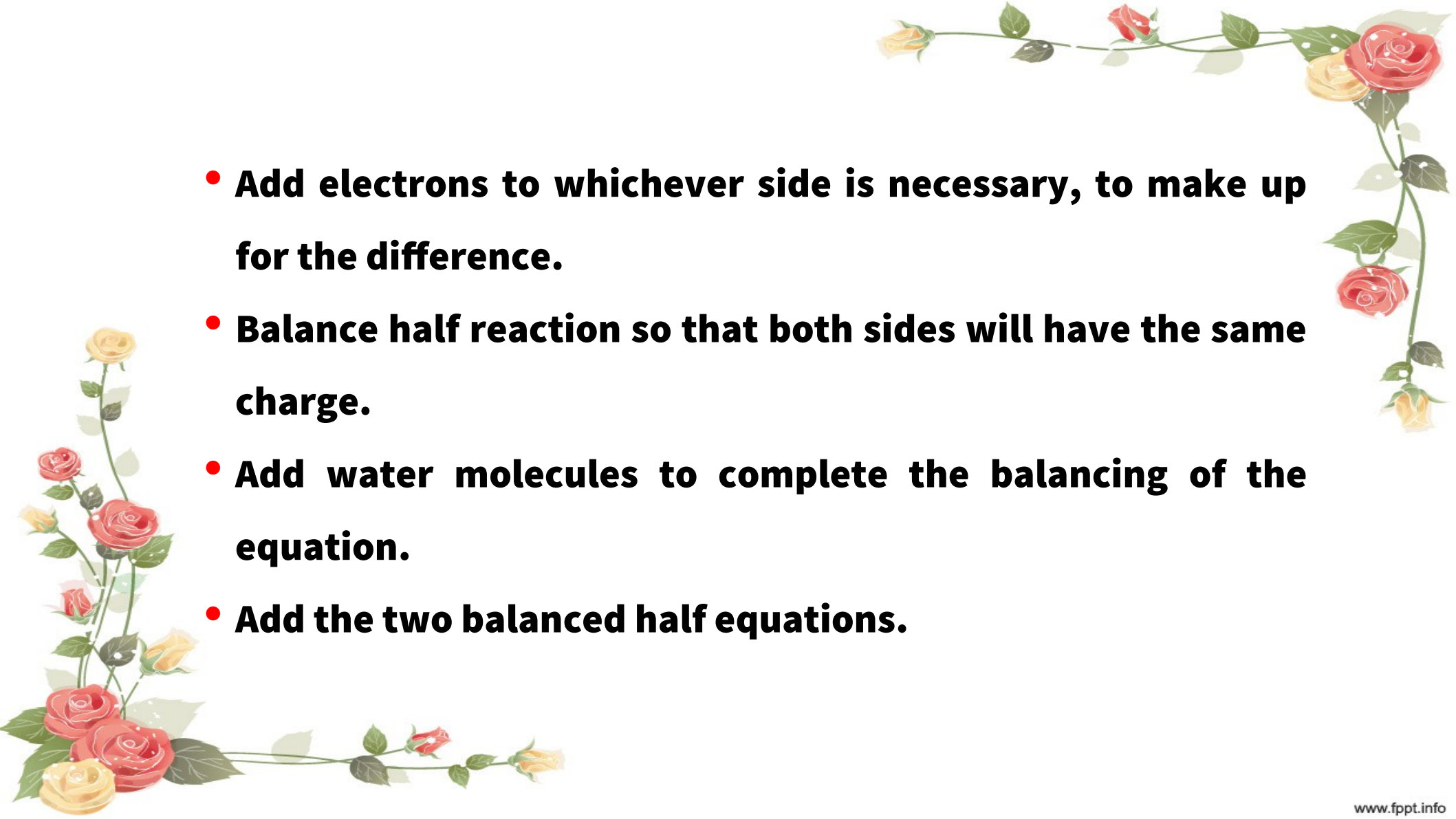
\therefore Balanced equation is $\text{SnCl}_2 + 2\text{FeCl}_3 \longrightarrow \text{SnCl}_4 + 2\text{FeCl}_2$



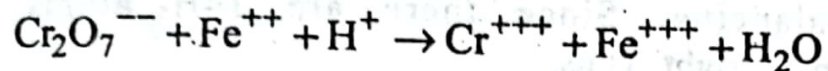
2. ION ELECTRON METHOD OR HALF REACTION METHOD

- 
- **The various steps involved in this method are**
 - **Write the skeletal equation represents the chemical change.**
 - **Indicate the oxidation numbers of all atoms involved in the reaction.**
 - **Find the elements whose oxidation numbers are changed.**

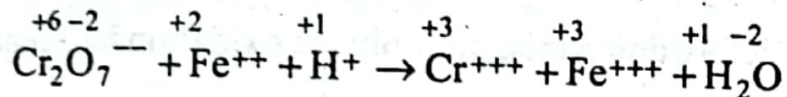
- 
- A decorative border of roses in red and yellow, with green leaves, framing the central text. The roses are arranged in a curved path around the text.
- **Separate the redox reaction into half reactions.**
 - **i.e., oxidation half and reduction half reactions.**
 - **Balance each half reaction separately by the following steps.**
 - **Balance all atoms other than hydrogen and oxygen.**
 - **Calculate the oxidation number on the left and on the right.**

- 
- A decorative border of roses in red and yellow, with green leaves, framing the text. The roses are arranged in a curved path around the central text area.
- **Add electrons to whichever side is necessary, to make up for the difference.**
 - **Balance half reaction so that both sides will have the same charge.**
 - **Add water molecules to complete the balancing of the equation.**
 - **Add the two balanced half equations.**

Balance the redox reaction



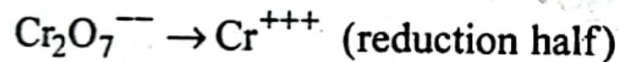
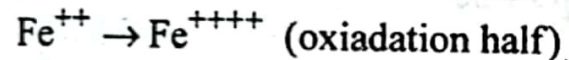
Solution : Step (1) Find the elements whose oxidation numbers are changed.



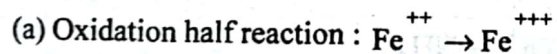
In this, the oxidation number of chromium decreases from +6 to +3 i.e., Cr undergoes reduction and the oxidation number of Fe^{++} increases from +2 to +3 i.e., Fe^{++} is oxidised to Fe^{+++}

Step (2) Separate the redox reaction into two half reactions

The half reactions are:

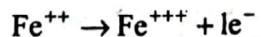


Step (3) Balance each half reaction separately

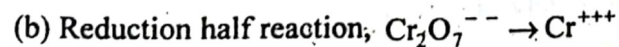


- i. Balance all atoms other than O and H. In this, other atoms are already balanced.
- ii. Calculate the oxidation number on both sides and add electrons to account for the difference.

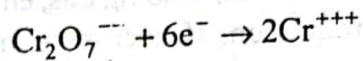
In this, Ox:No on left is +2 and that on right is +3. To account for the difference add one electron to the right. Thus we get,



- iii. Balance the charge on either side
In this, charge is already balanced.
- iv. Add Water: In view of oxygen and hydrogen being absent, this step is not necessary.

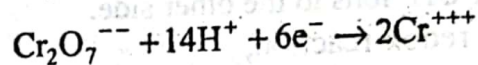


- i. Balance all atoms other than O and H
There are two Cr atoms on the left, but only one on right.
Therefore, $\text{Cr}_2\text{O}_7^{--} \rightarrow 2\text{Cr}^{+++}$
- ii. Calculate oxidation number on both sides and add electrons to account for the difference. The ox: no: of Cr on the left is +6 and on the right is +3. Each Cr atom must gain three electrons. Since there are two Cr atoms, add six electrons on the left. Thus,

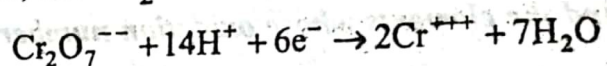


iii. Balance the charge on either side

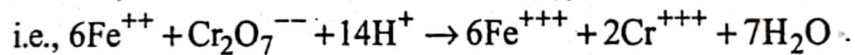
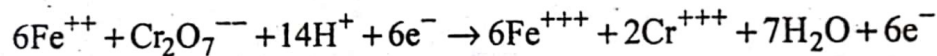
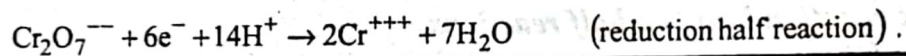
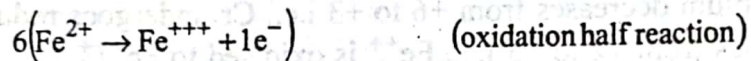
Since the reaction is occurring in acid medium, H^+ ions will be added to account for the extra positive charge on one side or the other. The total charge on the left is -8; on the right is +6. Therefore, 14H^+ will be added to the left. Thus,



iv. Add water to complete the balancing. Since there are 14H atoms and 7 O atoms on the left side, add $7\text{H}_2\text{O}$ on the right. Thus,



Step (4) Add the two half reactions together. Before doing this, multiply the oxidation half reaction by 6 so that electrons are balanced.

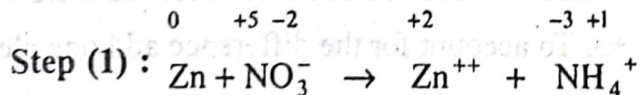


This is the balanced equation.

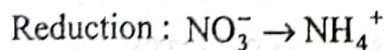
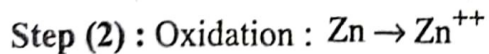
Example 13.5 Balance the following redox reaction occurring in basic medium.



Solution:

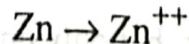


In this, Zn undergoes oxidation and NO_3^- undergoes reduction.



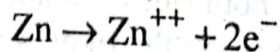
Step (3) : Balance each half reaction separately as,

(a) oxidation half reaction:



i. Balance all atoms other than H and O: already done

ii. Add electrons to make up for the difference in oxidation number,

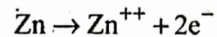


iii. Balance the charges : already done

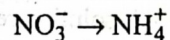
iii. Balance the charges : already done

iv. No need to add water

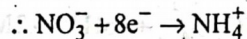
Therefore, the balanced oxidation half reaction is,



(b) Reduction half reaction



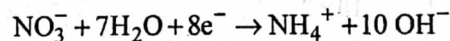
- i. Balance atoms other than H and O: already done
- ii. Add electrons to make up for the difference in oxidation number. As the oxidation number of nitrogen changes from +5 to -3, there is a difference of 8 electrons:



- iii. Balance the charges: There are 9 negative charges on the left, on the right it is +1. As the reaction is in basic medium add 10 OH⁻ on the right.

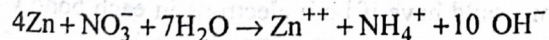
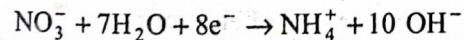
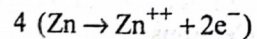


- iv. Add water to complete balancing.



This is the balanced reduction half reaction.

Step (4) Add the two half reactions. Before doing this, the oxidation half reaction is multiplied by 4 so that electrons are balanced.



This is the final balanced equation.

Thank
you

