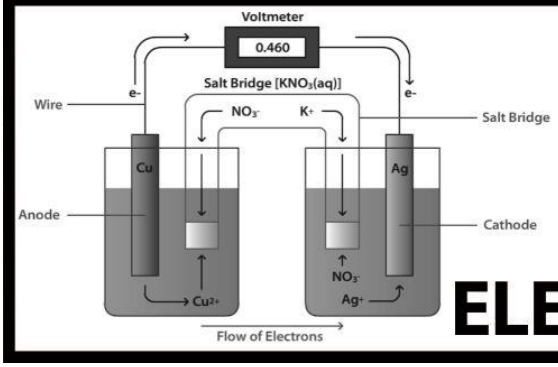


CHAPTER 7

ELECTROCHEMISTRY

INTRODUCTION

Q.1 Define electrochemistry. **(BWP 2016, LHR, GRW 2014, RWP 2017 G-I, FSD 2017 G-I)*(K.B)***

Ans: **ELECTROCHEMISTRY**

Definition:

*"The branch of chemistry that deals with the **relationship between electricity and chemical reactions** is called electrochemistry".*

Q.2 What are the reactions involved in electrochemistry? ***(K.B)***

Ans: **REACTIONS INVOLVED**

Electrochemistry involves **oxidation** and **reduction reactions**, which are also known as **redox reactions**. There are **two types of redox reactions**:

- Spontaneous reactions
- Non-spontaneous reactions

Q.3 Differentiate between spontaneous and non-spontaneous reactions.
(BWP 2017, SWL, SGD 2016, LHR 2014, 16)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between spontaneous and non-spontaneous reactions are as follows:

Spontaneous Reactions	Non-spontaneous Reactions
Definition	
• Spontaneous reactions are those which **take place on their own without an external agent**.	• Non-spontaneous reactions are those which **takes place in the presence of an external agent**.
Example	
• Reactions taking place in **Voltaic** and **Galvanic cell** and **corrosion** process $Zn_{(s)} + CuSO_{4(s)} \longrightarrow ZnSO_4 + Cu$	• Reactions taking place in **electrolytic cells** like **electrolysis of fused NaCl** to produce sodium and chlorine. $2NaCl \xrightarrow[\text{current}]{\text{Electric}} 2Na + Cl_2$

INTRODUCTION

MULTIPLE CHOICE QUESTIONS

1. Oxidation and reduction reactions are also known as: ***(K.B)***

(A) Redox (B) non-spontaneous
(C) Neutralization (D) Decomposition

2. Relationship between electricity and chemical reactions is studied in: ***(K.B)***

(A) Electrochemistry (B) Analytical chemistry
(C) Nuclear chemistry (D) Physical chemistry

7.1 OXIDATION AND REDUCTION

Q.1 Explain oxidation and reduction reactions on the basis of addition and removal of hydrogen and oxygen. **(GRW 2014), (LHR 2014,16, FSD 2016)*(U.B)***

Ans: **OXIDATION AND REDUCTION REACTIONS IN TERM OF LOSS OR GAIN OF HYDROGEN AND OXYGEN**

Oxidation:

*"Oxidation is defined as **addition of oxygen** or **removal of hydrogen** during a chemical reaction".*

Reduction:

*"Reduction is defined as **addition of hydrogen** or **removal of oxygen** during a chemical reaction".*

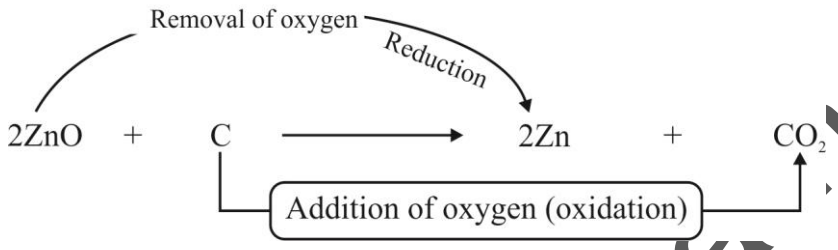
Both of these processes **take place simultaneously in a reaction**.

Examples:

(i) Addition or removal of oxygen:

A reaction between zinc oxide and carbon takes place by the removal of oxygen **(reduction)** from zinc oxide and addition of oxygen **(oxidation)** to carbon.

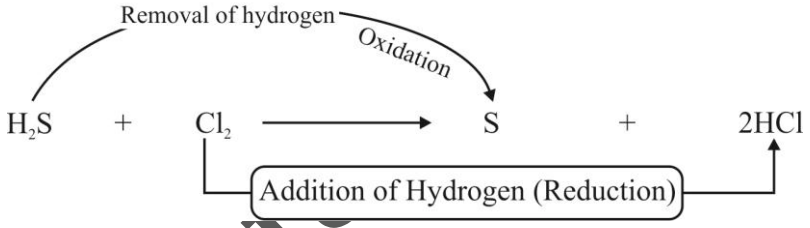
$$2ZnO + C \longrightarrow 2Zn + CO_2$$



(ii) Addition or removal of hydrogen:

A reaction between hydrogen sulphide and chlorine takes place by oxidation of hydrogen sulphide and reduction of chlorine. Hydrogen is being removed from H_2S and added to chlorine.

$$H_2S + Cl_2 \longrightarrow 2HCl + S$$



Q.2 Explain oxidation and reduction in terms of loss or gain of electrons.

(LHR 2016 G-II, DGK 2017)*(U.B)*

Ans: OXIDATION AND REDUCTION IN TERMS OF LOSS OR GAIN OF ELECTRONS

Electronic Concept:

"There are many chemical reactions which do not involve oxygen or hydrogen but they are considered redox reactions. To deal with these reactions, a new concept "loss or gain of electrons" is used called electronic concept".

According to electronic concept of oxidation and reduction:

Oxidation:

*"Oxidation is **loss of electrons by an atom or an ion**".*

Examples:

$$Zn \longrightarrow Zn^{+2} + 2e^-$$
$$Fe^{+2} \longrightarrow Fe^{+3} + 1e^-$$

Reduction:

*"Reduction is **gain of electrons by an atom or ion**".*

Examples:

$$2H^+ + 2e^- \longrightarrow H_2$$
$$Cl_2 + 2e^- \longrightarrow 2Cl^-$$

Explanation:

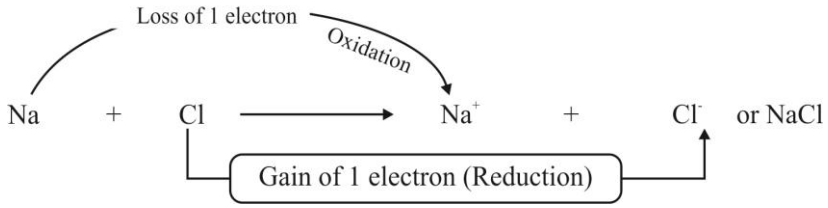
(Reaction Between Sodium and Chlorine)

A reaction between sodium metal and chlorine takes place in **three steps**.

(i) Loss of Electron by Sodium Atom:

First sodium atom losses an electron, to form sodium ion.

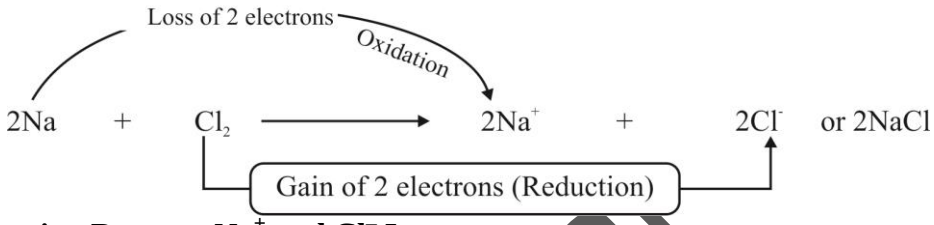
$$Na \longrightarrow Na^+ + l\,e^- \quad \textbf{(oxidation)}$$



(ii) Gain of Electron by Chlorine Atom:

Simultaneously, this electron is accepted by chlorine atom (reduction process), as chlorine atom needs one electron to complete its octet. As a result chlorine atom changes to chloride ion.

$$Cl_{(g)} + le^- \longrightarrow Cl^- \textbf{ (reduction)}$$



(iii) Attraction Between Na^+ and Cl^- Ions:

Ultimately, both these ions attract each other to form sodium chloride. Complete redox reaction is sum of the oxidation and reduction reactions between sodium and chlorine atoms and it is represented as;

$$Na^+ + Cl^- \longrightarrow NaCl$$

7.1 OXIDATION AND REDUCTION

SHORT QUESTIONS

Q.1 Explain the term oxidation on the basis of electronic concept with an example. **(MTN 2016, RWP 2017 G-I)*(U.B+A.B)***

Ans: *Answer give on pg # 232*

Q.2 Define redox reaction. **(LHR 2017 G-I)*(K.B)***

Ans: *Answer give on pg # 231*

7.1 OXIDATION AND REDUCTION

MULTIPLE CHOICE QUESTIONS

1. In an oxidation reaction electrons are: ***(K.B)***

(A) Absorbed (B) Lost (C) Gained (D) None of these

2. In reduction reaction electrons are: ***(K.B)***

(A) Lost (B) Gained (C) Kept constant (D) All of these

3. Removal of hydrogen is called: ***(K.B)***

(A) Oxidation (B) Reduction (C) Redox (D) Ionization

4. The addition of oxygen is called: ***(K.B)***

(A) Redox (B) Oxidation (C) Reduction (D) Catenation

5. $Cl_2 + 2e^- \rightarrow 2Cl^-$, is a an example of reaction: ***(U.B+A.B)***

(A) Oxidation (B) Reduction (C) Redox (D) None of these

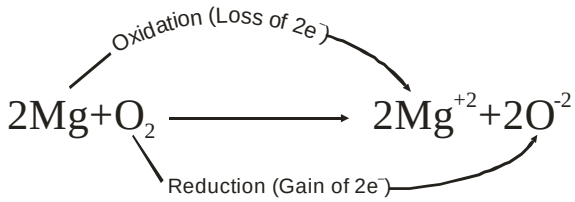
7.1 TEST YOURSELF

i. How can you justify that a reaction between magnesium and oxygen is a redox reaction, while the reaction shows only addition of oxygen (oxidation)? ***(U.B+A.B)***

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$

Ans: **REDOX REACTION**

Assigning oxidation states:



Reaction between magnesium and oxygen is a redox reaction instead of oxidation reaction because in this reaction magnesium loses two electrons which is called oxidation and oxygen gains two electrons which is called reduction.

ii. A reaction between carbon and oxygen involved only addition of oxygen (oxidation), but, it is called a redox reaction. Comment on this. ***(U.B+A.B)***

Ans: **REDOX REACTION**

Assigning oxidation sates to the elements:

$$C^\circ + O^\circ_2 \longrightarrow + C^{+4}O^{-2}_2$$

In this reaction, carbon has lost 4 electrons while O_2 has gained these 4 electrons. So in this reaction oxidation and reduction occur simultaneously which is collectively called redox reaction.

iii. Oxidation and reduction proceed simultaneously. Explain, with an example. ***(U.B+A.B)***

Ans: **REDOX REACTION**

Assigning oxidation states to the elements:

$$2H^0_2 + O^0_2 \rightarrow 2H^{+1}_2O^{-2}$$

In this reaction, hydrogen has lost 4 electrons while O_2 has gained these 4 electrons. So in this reaction oxidation and reduction occur simultaneously which is collectively called redox reaction.

iv. Identify which of the followings is oxidation or reduction reaction. ***(U.B+A.B)***

a. $K \longrightarrow K^+ + le^-$

b. $Br + le^- \longrightarrow Br^-$

c. $Cu \longrightarrow Cu^{+2} + 2e^-$

d. $I^- \longrightarrow I + 1e^-$

e. $Fe^{+2} \longrightarrow Fe^{+3} + 1e^-$

Ans: **OXIDATION OR REDUCTION REACTION**

a.	$K \longrightarrow K^+ + le^-$	Oxidation (Loss of electron)
b.	$Br + le^- \longrightarrow Br^-$	Reduction (Gain of electron)
c.	$Cu \longrightarrow Cu^{+2} + 2e^-$	Oxidation (Loss of electrons)
d.	$I^- \longrightarrow I + 1e^-$	Oxidation (Loss of electron)
e.	$Fe^{+2} \longrightarrow Fe^{+3} + 1e^-$	Oxidation (Loss of electron)

v. An element M reacts with another element X to form MX_2. In terms of loss or gain of electrons, identify the element which is oxidized and which is reduced. ***(U.B)***

Ans: **IDENTIFICATION OF ELEMENT**

Consider the reaction:

$$M + X_2 \longrightarrow MX_2$$

In this reaction, "M" releases two electrons and becomes "M^{+2}" so oxidation reaction is:

$$M \xrightarrow{\text{Oxidation}} M^{+2} + 2e^-$$

While "X" gains two electrons, so reduction reaction is

$$2X + 2e^- \xrightarrow{\text{Reduction}} 2X^-$$

So in this reaction "M" is oxidized and X is reduced.

vi. How can you justify that the following reaction is not only an oxidation reaction but also a complete redox reaction? ***(U.B)***

$$\mathbf{FeO + CO \longrightarrow Fe + CO_2}$$

Ans: **REDOX REACTION**

Assigning oxidation states to the elements:

$$Fe^{+2}O^{-2} + C^{+2}O^{-2} \longrightarrow Fe^0 + C^{+4}O_2^{-2}$$

In this reaction carbon has lost 2 electrons while Fe has gained these 2 electrons. So in this reaction oxidation and reduction occur simultaneously which is collectively called redox reaction.

vii. Explain the term oxidation on the basis of electronic concept with an example.
(RWP 2017 G-I, MTN 2016)*(U.B+A.B)*

Ans. **OXIDATION**

"The loss of electrons by an atom or an ion is called oxidation".

Example:

Mg loses 2 electrons to oxidize Mg and form Mg^{+2} ions:

$$Mg \xrightarrow{\text{Oxidation}} Mg^{+2} + 2e^-$$

7.2 OXIDATION STATE AND RULES FOR ASSIGNING OXIDATION STATE

Q.1 Describe the rules for assigning oxidation states. **(Ex-Q.1)**
(SWL, FSD, DGK, BWP, 2016, MTN, DGK, RWP 2017 G-I, II, GRW 2017 G-I)*(U.B+K.B)*

Ans: **OXIDATION STATES**

Definition:

"Oxidation state or oxidation number (O.N.) is the ***apparent charge assigned to an atom of an element in a molecule or in an ion****".*

It may be **positive** or **negative** or **whole number** or in **fraction** or **zero**.

Examples:

In **HCl**, oxidation number of **H** is **+1** and that of **Cl** is **–1**.

Rules for Assigning Oxidation Numbers (O.N.):

(i) O.N. of Elements in Free State:

The oxidation number of all elements in the free state is **zero**.

(ii) O. N. of Simple Ions:
The oxidation number of an ion consisting of a **single element** is the same as the **charge on the ion**.
(iii) O. N. of Elements in Groups:
The oxidation number of different elements in **Group-1 is +1,** in **Group-2 is +2** and in **Group-13 is +3**.
(iv) O.N. of Hydrogen:
The oxidation number of hydrogen in all its compounds is **+ 1** but in **metal hydrides** it is **-1.**
(v) O. N. of Oxygen:
The oxidation number of oxygen in all its compounds is **-2** but it is **-1 in peroxides** and **+2 in OF_2.**
(vi) O.N of Electronegative Atom:
In any substance the **more electronegative atom** has the **negative oxidation number.**
(vii) O.N. of Neutral Molecules:
In neutral molecules, the **algebraic sum of the oxidation numbers of all the elements is zero.**
(viii) O.N. of Complex Ions:
In ions, **the algebraic sum of oxidation number equals the charge on the ion.**

7.2 OXIDATION STATE AND RULES FOR ASSIGNING OXIDATION STATE

SHORT QUESTIONS

Q.1 What is meant by oxidation state? ***(K.B)***

Ans: *Answer give on pg # 235*

Q.2 Write any two rules for assigning oxidation number. ***(K.B)***

Ans:

RULES FOR ASSIGNING OXIDATION NUMBERS

The rules for assigning oxidation number are as follows:
O.N of elements in Free State:
The oxidation number of all elements in the free state is zero.
O. N. of Simple Ions:
The oxidation number of an ion consisting of a single element is the same as the charge on the ion.

7.2 OXIDATION STATE AND RULES FOR ASSIGNING OXIDATION STATE

MULTIPLE CHOICE QUESTIONS

1. In HCl oxidation number of H is: **(GRW 2014)*(K.B)***
(A) –1 (B) +1 (C) +2 (D) –2

2. Oxidation number of all the elements in free state is: **(GRW 2016 G-I)*(K.B)***
(A) One (B) Two (C) Three (D) Zero

3. The oxidation number of Group-1 elements is: ***(K.B)***
(A) +1 (B) +2 (C) +3 (D) +4

4. The oxidation number of hydrogen in metal hydrides is: **(GRW 2016)*(K.B)***
(A) –1 (B) +1 (C) +2 (D) –2

5. The oxidation number of sulphur in H_2SO_4 is: **(GRW 2014)*(U.B)***
(A) +1 (B) +4 (C) +6 (D) +8

6. The oxidation number of oxygen in peroxide is: ***(K.B)***
(A) Zero (B) –1 (C) –2 (D) +2

7. **The oxidation number of 'N' in HNO_3 is:** **(LHR 2016 G-II)*(U.B)***
(A) +3 (B) +5 (C) –3 (D) +6

8. **Oxidation number of chromium in $K_2Cr_2O_7$ is:** **(GRW 2016 G-I, RWP 2017 G-I)*(U.B)***
(A) +2 (B) +7 (C) +14 (D) +6

9. **The algebraic sum of oxidation number in neutral molecules is:** ***(K.B)***
(A) 1 (B) 2 (C) 0 (D) 5

10. **In ions the algebraic sum of oxidation number is equal to:** ***(K.B)***
(A) Ions (B) Charge (C) Atom (D) Molecule

11. **Oxidation number of chlorine in $KClO_3$ is:** **(GRW 2017 G-II, LHR 2017 G-II, RWP 2017 G-I)*(U.B)***
(A) +1 (B) +3 (C) +5 (D) +7

12. **Oxidation number of oxygen in OF_2 is:** **(LHR 2016 G-I, RWP 2017 G-II, FSD 2017 G-II)*(K.B)***
(A) –1 (B) +1 (C) –2 (D) +2

NUMERICAL EXAMPLE

NUMERICAL EXAMPLE 7.1

Find oxidation number of nitrogen in HNO_3. When oxidation numbers of H = + 1 & O = –2.
(LHR 2014, 15, 16, GRW 2017 G-I)*(U.B+A.B)*

NUMERICAL

Solution:

Given Data:

Oxidation number of hydrogen in HNO_3=H=+1
Oxidation number of oxygen in HNO_3=O= –2

To Find:

Oxidation number of N in HNO_3 = ?

Calculations:

HNO_3 = [O.N.of H]+[O.N.of N]+3[O.N.of O]=0

$$[+1]+[N]+3[-2]=0$$
$$+1+N-6=0$$
$$N-5=0$$
$$\boxed{N=+5}$$

Result:

The oxidation number of N is +5 in HNO_3

NUMERICAL EXAMPLE 7.2

Calculate the oxidation number of sulphur in H_2SO_4, when O.N of H = + 1 and O.N of O =-2. **(SWL 2017)*(U.B+A.B)***

NUMERICAL

Solution:

Given data:

Oxidation number of hydrogen in H_2SO_4 = H = +1
Oxidation number of oxygen in H_2SO_4 = O = –2

To find:

Oxidation number of sulphur in H_2SO_4 = ?

Calculations:

H_2SO_4 = 2[O.N.of H]+[O.N.of S]+4[O.N.of O]=0

$$2[+1]+[S]+4[-2]=0$$
$$+2+S-8=0$$
$$S-6=0$$
$$\boxed{S=+6}$$

Result:

The oxidation number of S is +6 in H_2SO_4.

NUMERICAL EXAMPLE 7.3

Find out the oxidation number of chlorine in $KClO_3$. As O.N. of K = +1 and O.N of O = –2.
(GRW 2014, SWL 2016)*(U.B+A.B)*

NUMERICAL

Solution:

Given data:

Oxidation number of potassium in $KClO_3$ = K = +1
Oxidation number of oxygen in $KClO_3$ = O = –2

To find:

Oxidation number of chlorine in $KClO_3$ = ?

Calculations:

$KClO_3$=[O.N.of K]+[O.N.of Cl]+3[O.N. of O]=0

$$[+1]+[Cl]+3[-2]=0$$
$$+1+Cl-6=0$$
$$Cl-5=0$$
$$\boxed{Cl=+5}$$

Result:

Oxidation number of Cl is +5 in $KClO_3$.

7.2 TEST YOURSELF

i. Find out the oxidation numbers of the following elements marked in bold in the formulae: Ba_3 $(\mathbf{P}O_4)_2$, $Ca\mathbf{S}O_4$, $Cu(\mathbf{N}O_3)_2$, $Al_2(\mathbf{S}O_4)_3$. ***(U.B+A.B)***

Ans: **NUMERICAL**

Oxidation numbers of the element are calculated as follows:

Ba_3 $(\mathbf{P}O_4)_2$:

$$2[\text{O.N.of Ba}] + 2[\text{O.N.of P}] + 8[\text{O.N.of O}] = 0$$
$$3[+2] + 2[\text{P}] + 8[-2] = 0$$
$$+6 + 2\text{P} - 16 = 0$$
$$2\text{P} - 10 = 0$$
$$2\text{P} = 10$$
$$\text{P} = \frac{10}{2}$$
$$\boxed{\text{P} = +5}$$

$Ca\mathbf{S}O_4$:

$$[\text{O.N of Ca}] + [\text{O.N of S}] + 4[\text{O.N of O}] = 0$$
$$[+2] + [\text{S}] + 4[-2] = 0$$
$$+2 + \text{S} - 8 = 0$$
$$\text{S} - 6 = 0$$
$$\boxed{\text{S} = +6}$$

Cu $(\mathbf{N}O_3)_2$:

$$[\text{O.N.of Cu}] + 2[\text{O.N.of N}] + 6[\text{O.N.of O}] = 0$$
$$[+2] + 2[\text{N}] + 6[-2] = 0$$
$$+2 + 2\text{N} - 12 = 0$$
$$2\text{N} - 10 = 0$$
$$2\text{N} = +10$$
$$\text{N} = \frac{10}{2}$$
$$\boxed{\text{N}=+5}$$

$Al_2(SO_4)_3$:

$$2[\text{O.N.of Al}] + 3[\text{O.N.of S}] + 12[\text{O.N.of O} = 0]$$
$$\Rightarrow 2[+3] + 3[S] + 12[-2] = 0$$
$$\Rightarrow +6 + 3S - 24 = 0$$
$$\Rightarrow 3S - 18 = 0$$
$$\Rightarrow 3S = +18$$
$$\text{S} = \frac{18}{3}$$
$$\boxed{\text{S}=+6}$$

ii. In a compound MX_3, find out the oxidation number of M and X. ***(U.B+A.B)***

Ans: **OXIDATION NUMBER OF M AND X**

Compound = MX_3

If we consider that the oxidation number of M = +3

Then, [O.N. of M] + 3 [O.N. of X] = 0

$$(+3) + 3[\text{O.N. of X}] = 0$$

$$3[\text{O.N. of X}] = -3$$

$$[\text{O.N. of X}] = \frac{-3}{3}$$

$$[\text{O.N of X}] = -1$$

Thus in a compound O.N. of M is +3 and that of X is -1.

iii. Why the oxidation number of oxygen in OF_2 is + 2? ***(U.B)***

Ans: **OXIDATION NUMBER OF OXYGEN IN OF_2**

The oxidation number of oxygen in OF_2 is +2 because **fluorine is more electronegative as compared to oxygen**. Therefore, fluorine will carry negative (–) charge while oxygen will carry (+2) charge on it.

iv. In H_2S, SO_2 and H_2SO_4, the sulphur atom has different oxidation numbers. Find out the oxidation number of sulphur in each compound. **(SWL 2016)*(U.B+A.B)***

Ans: **OXIDATION NUMBER OF SULPHUR**

H_2S:

$$2[\text{O.N of H}] + [\text{O.N. of S}] = 0$$

$$2[+1] + [\text{S}] = 0$$

$$+2 + \text{S} = 0$$

$$\text{S} = -2$$

SO_2:

$$[\text{O.N. of S}] + 2[\text{O.N. of O}] = 0$$

$$[\text{S}] + 2[-2] = 0$$

$$\text{S} - 4 = 0$$

$$\text{S} = +4$$

H_2SO_4:

$$2[\text{O.N of H}] + [\text{O.N of S}] + 4[\text{O.N of O}] = 0$$

$$2[+1] + [\text{S}] + 4[-2]0$$

$$+2 + \text{S} - 8 = 0$$

$$\text{S} - 6 = 0$$

$$\text{S} = +6$$

v. An element X has oxidation state 0. What will be its oxidation state when it gains three electrons? ***(U.B)***

Ans: **OXIDATION STATE OF X**

When an element X° gains the three electrons it will have oxidation state –3 such as**:**

$$X^\circ + 3e^- \longrightarrow X^{-3}$$

vi. An element in oxidation state +7 gains electrons to be reduced to oxidation state +2. How many electrons did it accept? ***(U.B)***

Ans: **OXIDATION STATE +7 TO +2**

When an element in oxidation state +7 gains electrons to be reduced to oxidation state +2 it will accept 5 electrons in its valance shell as shown by the equation.

$$X^{+7} + 5e^{-} \longrightarrow X^{+2}$$

vii. If the oxidation state of an element changes from +5 to – 3. Has it been reduced or oxidized? How many electrons are involved in this process? ***(U.B)***

Ans: **OXIDATION OF ELEMENTS +5 TO –3**

If the oxidation state of an element changes from +5 to -3, then it will be reduced. In this process of reduction.

$$A^{+5} + 8\bar{e} \longrightarrow A^{-3}$$

7.3 OXIDIZING AND REDUCING AGENTS

Q.1 Explain oxidizing and reducing agents with the help of suitable examples. ***(U.B+A.B)***

Ans: **Oxidizing Agent:**

"An oxidizing agent is the ***species that oxidizes a substance by taking electrons from it****".*

OR

"The substance (atom or ion) which is ***reduced itself by gaining electrons from other substance*** *is also called oxidizing agent".*

Examples:

- **Non-metals (O_2,$C\ell_2$,F_2)** are oxidizing agents because they accept electrons being more electronegative elements.
- **Strong acids** like **HNO_3, H_2SO_4** etc.

Reducing Agent:

"Reducing agent is the species that ***reduces a substance by donating electron to it****".*

OR

"The substance (atom or ion) which is ***oxidized by losing electrons to other substance*** *is also called reducing agent".*

Examples:

Metals are good reducing agents like:

- Zinc
- Iron
- Aluminum etc.

Explanation:

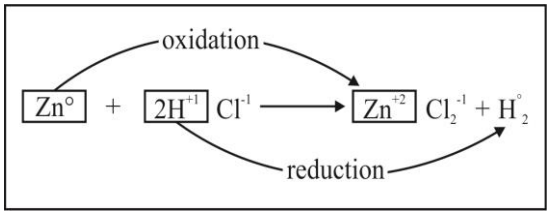
(i) Reaction Between Zn and HCl:

Let us discuss a reaction of Zn metal with hydrochloric acid:

$$Zn_{(s)} + 2HC\ell_{(aq)} \longrightarrow ZnC\ell_{2(aq)} + H_{2(g)}$$

The oxidation states or oxidation numbers of all the atoms or ions in this reaction are indicated below

$$Zn + 2H^{+}C\ell^{-1} \longrightarrow Zn^{+2} + C\ell_2^{-1} + H_2$$



Let us find the atoms, which are oxidized or reduced or whether there is a change in their oxidation state. It is indicated as follows: In this reaction, **zinc is oxidized** and **acts as a reducing agent**. **Hydrogen is reduced** and **acts as an oxidizing agent**.

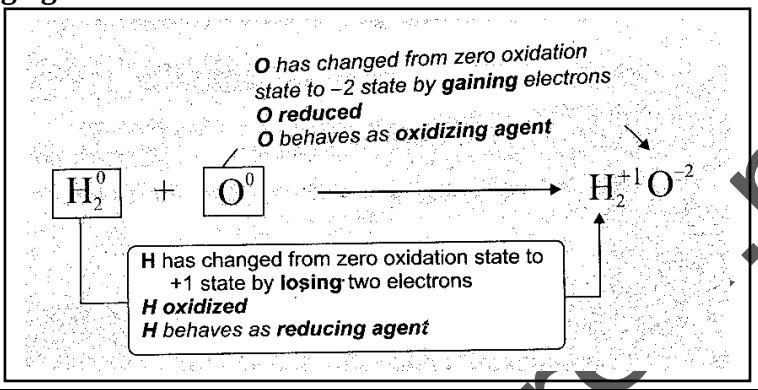
(ii) Reaction Between H and O:

In case of formation of water from hydrogen and oxygen gases, redox reaction takes place as follows:

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$$

$$2H_2^0 + O_2^0 \longrightarrow 2H_2^{+1}O^{-2}$$

In this reaction, **H is oxidized** and **acts as are reducing agent**. **O is reduced** and **acts as an oxidizing agent**.



7.3 OXIDIZING AND REDUCING AGENTS

SHORT QUESTIONS

Q.1 Define oxidizing agent. Give example. **(DGK 2016)(K.B+A.B)**

Ans: *Answer give on pg # 240*

Q.2 Define reducing agent. Give example. **(SWL 2017, GRW 2016 G-I)(K.B+A.B)**

Ans: *Answer give on pg # 240*

Q.3 Calculate oxidation number of sulphur in $CaSO_4$. **(DGK 2017)(U.B+A.B)**

Ans: *Answer give on pg # 239*

7.3 OXIDIZING AND REDUCING AGENTS

MULTIPLE CHOICE QUESTIONS

1. In the redox reaction between Zn and HCl the oxidizing agent is: ***(U.B+A.B)***

(A) Zn (B) H^+ (C) Cl^- (D) H

2. Chemical reaction in which oxidation state of one or more substances change are called: ***(U.B)***

(A) Hydrogenation (B) Oxidation reaction

(C) Redox reaction (D) Catenation

3. The substance which reduces itself is called: ***(U.B)***

(A) Oxidizing agent (B) Reducing agent (C) Electrolyte (D) Ionic compound

4. Non-metals are: ***(A.B)***

(A) Reducing agents (B) Oxidizing agents

(C) Electronegative elements (D) Both B and C

5. Good reducing agents are: ***(A.B)***

(A) Non-metals (B) Metalloids (C) Halogens (D) Metals

6. Oxidizing agent is a substance which: *(U.B)*

(A) Oxidizes itself and reduces other (B) Oxidizes itself and oxidizes other

(C) Reduces itself and oxidizes other (D) Reduces itself and reduces other

7.3 TEST YOURSELF

i. In the following reaction, how can you justify that H_2S is oxidized and SO_2 is reduced. *(U.B+A.B)*

$$SO_2 + 2H_2S \longrightarrow 2H_2O + 3S$$

Ans: **H_2S OXIDIZED AND SO_2 REDUCED ELEMENT**

In this reaction hydrogen is removed from H_2S, therefore H_2S is oxidized while oxygen is removed from SO_2, therefore SO_2 is reduced to S.

ii. The reaction between MnO_2 and HCl is a redox reaction written as balance chemical equation. *(U.B)*

$$\mathbf{MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2}$$

Find out:

(A) The substance oxidized. *(U.B+A.B)*

(B) The substance reduced. *(U.B+A.B)*

(C) The substance which acts as oxidizing agent. *(U.B+A.B)*

(D) The substance which acts as reducing agent. *(U.B+A.B)*

Ans: Assigning oxidation states to the elements

$$Mn^{+4}O_2^{-2} + 4H^{+1}Cl^{-1} \longrightarrow Mn^{+2}Cl_2^{-2} + 2H_2^{2+}O^{-2} + Cl_2^0$$

(A) Cl^- is oxidized

(B) Mn^{+4} is reduced

(C) MnO_2 is oxidizing agent.

(D) HCl is reducing agent

iii. The following reactions are redox reactions. Find out the element which has been reduced and the element which has been oxidized? *(U.B+A.B)*

(a) $Zn+CuSO_4 \longrightarrow ZnSO_4 + Cu$

(b) $Cu+2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$

(c) $H_2S + Cl_2 \longrightarrow 2HCl + S$

Ans:

(a) $Zn^0 + Cu^{+2}SO_4^{-2} \longrightarrow Zn^{+2}SO_4^{-2} + Cu^0$

Zn is oxidized and Cu is reduced.

(b) $Cu^0 + 2Ag^{+1}NO_3^{-1} \longrightarrow Cu^{+1}\left(NO_3^{-1}\right)_2 + 2Ag^0$

Cu is oxidized and Ag is reduced.

(c) $H_2^{2(+1)}S^{-2} + Cl_2^0 \longrightarrow 2H^{+1}Cl^{-1} + S^0$

S is oxidized and Cl is reduced.

iv. Why the following reaction is not a redox reaction? Explain with reasons? *(U.B)*

$NaOH + HCI \longrightarrow NaCl + H_2O$

Ans: This is an example of neutralization reaction rather than a redox reaction because in acid base reactions acid reacts with a base to form salt and water more there is no change in oxidation number of any of the specie.

$$Na^{+1}O^{-2}H^{+1} + H^{+1}Cl^{-1} \longrightarrow Na^{+1}Cl^{-1} + H_2^{-2}O^{-2}$$

7.5 ELECTROCHEMICAL CELLS

Q.1 What are electrochemical cells? Explain the concept of electrolytes.

(GRW 2014, BWP 2017, FSD 2016,17)*(U.B+K.B)*

Ans:

ELECTROCHEMICAL CELL

*"Electrochemical cell is a **system in which two electrodes are dipped in the solution of an electrolyte or molten mass**".*

Electrochemical cell is an **energy storage device** in which either a **chemical reaction takes place by using electric current (electrolysis)** or **chemical reaction produces electric current**.

Types of electrochemical cells:

(i) Electrolytic cells

(ii) Galvanic cells or Voltaic cells

(i) Electrolytic cells:

*The type of electrochemical reaction in which a **non-spontaneous chemical reaction takes place when electric current is passed through an electrolyte** is called an electrolytic cell.*

Examples:

- Down's cell
- Nelson cell etc.

(ii) Galvanic cells or Voltaic cells:

*The type of electrochemical cell in which a **spontaneous chemical reaction takes place and generates electric current** is called Galvanic or Voltaic cell.*

Example:

- Daniel cell
- Dry cell

CONCEPT OF ELECTROLYTES

Definition:

*"The **substance which can conduct electricity in their aqueous solution or molten state** is called electrolyte"*

Electrolytes are classified into **two groups depending upon their extent of ionization in solution**.

(i) Strong Electrolytes

(ii) Weak Electrolytes

(i) Strong Electrolytes:

*"The electrolytes **which ionize almost completely in solution and produce more ions**, are called strong electrolytes".*

Examples:

Strong electrolytes are aqueous solutions of **NaCl, NaOH** and **H_2SO_4** etc.

$$NaOH_{(s)} \longrightarrow Na^{+} + OH^{-}$$

(ii) Weak Electrolytes:

*"The electrolytes **which ionize to a small extent when dissolved in water and could not produce more ions** are called weak electrolytes".*

Examples:

Acetic acid (CH_3COOH), and **$Ca(OH)_2$** when dissolved in water, ionizes to a small extent. These are good examples of weak electrolytes. Weak electrolytes do not ionize completely. For example, ionization of acetic acid in water produces less ions:

$$CH_3COOH_{(l)} + H_2O_{(l)} \longrightarrow CH_3COO^{-}_{(aq)} + H_3O^{+}_{(aq)}$$

As a result the **weak electrolyte is a poor conductor of electricity**.

NON-ELECTROLYTES **(LHR 2017 G-I, II)**

"The substances, ***which do not ionize in their aqueous solution and do not allow the current to pass through their solutions****, are called non-electrolytes".*

Examples:

- Sugar solution
- Benzene

Q.2 What is electrolysis? Write a note on electrolytic cells.(MTN 2017, DGK 2017, GRW 2016 G-II)*(U.B+A.B)*

OR

How can a non- spontaneous reaction be carried out in on electrolytic cell? Discuss in detail. **(Ex-Q.3)*(U.B+A.B)***

Ans:

ELECTROLYSIS

Definition:

"The ***chemical decomposition of a compound into its components by passing current through the solution of the compound or in the molten state of the compound*** *is called electrolysis".*

Example:

Electrolysis of NaCl into Na and Cl.

Electrolytic Cell:

"The ***type of electrochemical cell in which a non-spontaneous chemical reaction takes place when electric current is passed through the electrolyte,*** *is called an electrolytic cell".*

Example:

Down's cell, **Nelson's cell**.

Construction of an Electrolytic Cell:

An electrolytic cell **consists of a solution of an electrolyte**, **two electrodes (anode and cathode)** that are **dipped in the electrolytic solution** and **connected to the battery**.

Anode:

The **electrode connected to positive terminal** is called anode.

Cathode:

Electrode connected to the negative terminal is called cathode.

Working of an Electrolytic Cell:

When electric current is applied from battery, the ions in the electrolyte migrate to their respective electrodes. The **anions,** which are negatively charged, **move towards the anode** and **discharge there by losing their electrons**. Thus **oxidation takes place at anode**. While **cations**, which are positively charged ions, **move towards cathode**. Cations **gain electrons from the electrode** and as a result **reduction takes place at cathode**.

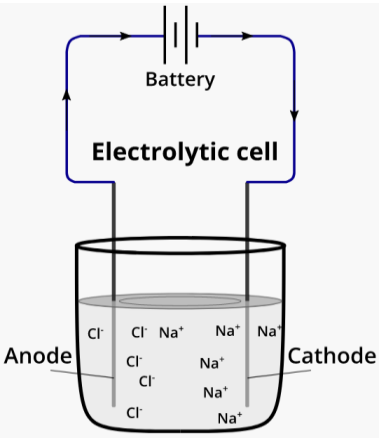


Figure: Electrolytic Cell

Example: (Electrolysis of fused sodium chloride):

When fused salt of sodium chloride is electrolyzed the following reactions take place during this process.

Ionization Reaction:

$$NaCl_{(s)} \rightleftharpoons Na^{+} + Cl^{-}$$

Oxidation Reaction at Anode:

$$2Cl^{-}_{(l)} \longrightarrow Cl_{2\,(g)} + 2e^{-}$$

Reduction Reaction at Cathode:

$$2Na^{+}_{(l)} + 2e^{-} \longrightarrow 2\,Na$$

Overall Reaction:

$$2Na^{+} + 2e^{-} \longrightarrow 2Na$$

$$2Cl^{-}_{(l)} \longrightarrow Cl_{2\,(g)} + 2e^{-}$$

$$2Na^{+} + 2Cl^{-} \longrightarrow 2Na + Cl_2$$

Q.3 Discuss the electrolysis of water.

(Ex-Q.4)(DGK 2017, MTN 2016, SGD 2017, GRW 2017 G-II, LHR 2016 G-I)*(U.B+K.B+A.B)*

Ans:

ELECTROLYSIS

*"The **chemical decomposition of a compound into its components by passing current through the solution of the compound or in the molten state** of the compound is called electrolysis".*

Electrolysis of Water:

Extent of Ionization of Water:

Pure water is a very weak electrolyte. It ionizes to a very small extent. The **concentrations of** hydrogen ions **(H^+)** and hydroxide ions **(OH^-)** are **both** at **10^{-7} mol dm^{-3} respectively**. When a **few drops of an acid** are **added in water**, its **conductivity improves**.

$$4H_2O_{(\ell)} \xrightarrow{Acid} 4H^{+}_{(aq)} + 4OH^{-}_{(aq)}$$

Working:

When an electric current is passed through this **acidified** water, **OH^- (anions) move towards positive electrode (anode)** and **H^+ (cations) move towards negative electrode (cathode)** and discharge takes place at these electrodes. They **produce oxygen** and **hydrogen gases respectively at anode and cathode**.

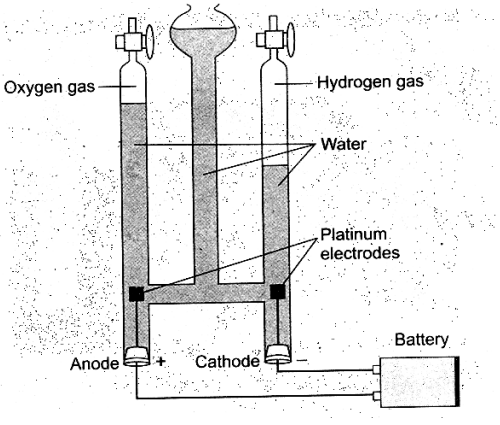


Figure: Electrolytic Cell showing Electrolysis of water

Oxidation Reaction at Anode:

$$4OH^{-}_{(aq)} \longrightarrow 2H_2O_{(\ell)} + O_{2(g)} + 4e^{-}$$

Reduction Reaction at Cathode:

$$4H^{+}_{(aq)} + 4e^{-} \longrightarrow 4H_{(g)}$$

$$4H_{(g)} \longrightarrow 2H_{2(g)}$$

Overall Reaction:

$$2H_2O_{(\ell)} \longrightarrow O_{2(g)} + 2H_{2(g)}$$

Q.4 Discuss the construction and working of a cell in which electricity is produced.
(Ex-Q.5)(MTN, DGK 2016, FSD 2017)*(U.B+A.B)*

OR

What is meant by Galvanic cell? Write construction and working of Daniel's cell.*(U.B+A.B)*

Ans:

GALVANIC CELL

"*The **electrochemical cell in which a spontaneous chemical reaction takes place and generates electric current** is called **Galvanic** or **Voltaic cell**".*

Examples:

- Daniel cell
- Dry cell

Introduction:

A. **Volta (1745-1827)** was an Italian physicist known especially for the development of the **first electric cell in 1800.**

A. Votla (1745-1827) was an Italian physicist known especially for the development of the first electric cell in 1800.

CONSTRUCTION AND WORKING OF DANIEL'S CELL

(A) Construction:

Galvanic cell **consists of two cells**, each called as **half-cell**, **connected electrically by a salt-bridge**. In each of the **half-cell,** an **electrode is dipped in 1M solution of its own salt and connected through a wire to an external circuit.**

(i) Left Half Cell (Oxidation half-cell):

The left half-cell consists of an electrode of **zinc metal dipped in 1 M solution of zinc sulphate**.

(ii) Right Half Cell (Reduction half-cell):

The right half-cell is a **copper electrode dipped in 1M solution of copper sulphate**.

(iii) Salt Bridge:

"*Salt bridge is a **U-shaped glass tube. It consists of saturated solution of strong electrolyte supported in a jelly type material. The ends of the U tube are sealed with a porous material like glass wool**".*

Function of the Salt Bridge:

- It keeps the solutions of two half cells neutral by **providing a pathway for migration of ions**.
- It provides a **contact between two half cells**.

(B) Working:

The **Zn metal has tendency to lose electrons more readily than copper**. As a result **oxidation takes place at Zn-electrode**. The **electrons flow from Zn-electrode through the external wire** in a circuit **to copper electrode**. These **electrons are gained by the copper ions of the solution** and **copper atoms deposit at the electrode**. The respective oxidation and reduction processes going on at two electrodes are as follows:

Half Cell Reaction at Anode (oxidation):

$$Zn_{(s)} \longrightarrow Zn^{+2}_{(aq)} + 2e^-$$

Half Cell Reaction at Cathode (reduction):

$$Cu^{+2}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$$

Overall Galvanic Reaction is the sum of these two half-cell reactions:

$$Zn_{(s)} + Cu^{+2}{}_{(aq)} \longrightarrow Zn^{+2}{}_{(aq)} + Cu_{(s)}$$

As a result of redox reaction **electric current is produced**.

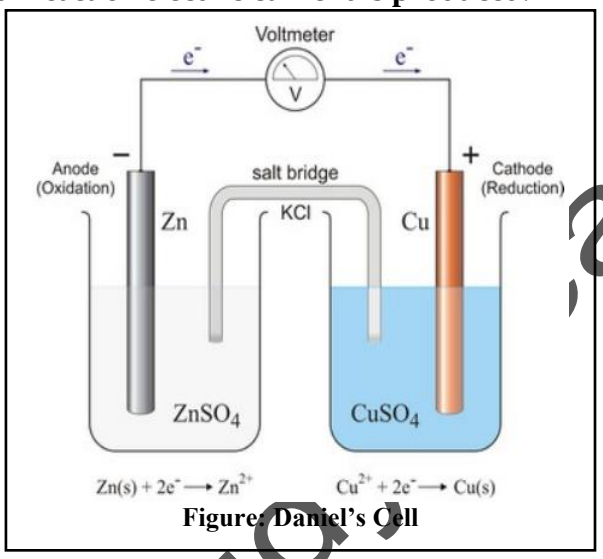


Figure: Daniel's Cell

Uses:

The **batteries** which are **used for starting automobiles**, **running calculators** and **toys** etc. work on the principle of Galvanic cell.

Q.5 What is the difference between electrolytic and galvanic cell?

(LHR 2015,2016 G-I, SGD, GRW 2016, RWP 2017 G-I, FSD 2017 G-II)*(U.B)*

Ans:

DIFFERENTIATION

The differences between electrolytic cell and galvanic cell are as follows.

Electrolytic Cell	Galvanic Cell
Nature of Cell	
• It consists of one complete cell, connected to a battery.	• It consists of two half cells connected, through a salt bridge.
Charge on Electrodes	
• Anode has positive charge while cathode has negative charge.	• Anode has negative charge while cathode has positive charge.
Conversion of Energy	
• Electrical energy is converted into chemical energy.	• Chemical energy is converted into electrical energy.

Reaction	
• Current is used for a non-spontaneous chemical reactions to take a place.	• Redox reactions take place spontaneously and produce electric current.
Examples	
• Down's cell • Nelson cell	• Daniel cell • Dry Cell

7.5 ELECTROCHEMICAL CELLS

SHORT QUESTIONS

Q.1 What are electrochemical cells? **(LHR 2015, FSD, RWP 2016, DGK 2017, SGD 2016,17, GRW 2017 G-II)*(K.B)***

Ans: *Answer give on pg # 243*

Q.2 Name the types of electrochemical cells? ***(K.B)***

Ans: *Answer give on pg # 243*

Q.3 What is an electrolytic cell? ***(K.B)***

Ans: *Answer give on pg # 244*

Q.4 What is Galvanic or Voltaic cells? **(SGD 2017 G-II)*(K.B)***

Ans: *Answer give on pg # 246*

Q.5 What happens at cathode in the galvanic cell? **(BWP 2016)*(U.B)***

Ans: **REACTION AT CATHODE IN GALVANIC CELL**

In galvanic cell, reduction take place at cathode as

$$Cu^{+2}_{(eq)} + 2e^- \rightarrow Cu_{(s)}$$

7.5 ELECTROCHEMICAL CELLS

MULTIPLE CHOICE QUESTIONS

1. Formula of hydronium ion is: ***(K.B)***

(A) H^+ (B) OH^- (C) H_3O^+ (D) None of these

2. An example of non-electrolyte is: **(GRW 2017 G-I)*(K.B)***

(A) Glucose (B) HCl (C) H_2SO_4 (D) H_2CO_3

3. An example of weak electrolyte is: **(LHR 2016 G-I, FSD 2017 G-II)*(K.B)***

(A) NaOH (B) CH_3COOH (C) H_2SO_4 (D) NaCl

4. During electrolysis which reaction takes place at anode? ***(K.B)***

(A) Catenation (B) Oxidation (C) Reduction (D) Addition

5. Which one is conductor? ***(K.B)***

(A) Naphthalene (B) Paraffin wax (C) Plastic (D) HCl

6. Which of the following is good electrolyte? ***(K.B)***

(A) NaCl (B) H_2SO_4 (C) NaOH (D) All of these

7. In which cell spontaneous chemical reaction takes place? **(GRW 2014, LHR 2016)*(K.B)***

(A) Electrolytic cell (B) Galvanic cell (C) Nelsons cell (D) Downs cell

8. Types of electrochemical cells are: **(GRW 2014)*(K.B)***

(A) 2 (B) 3 (C) 4 (D) 5

9. Spontaneous redox reactions produce current in: *(K.B)*

(A) Voltaic cell (B) Electrolytic cell (C) Galvanic cell (D) Both A and C

10. During the formation of water from hydrogen and oxygen which one of the following does not occur? *(U.B)*

(A) Hydrogen has oxidized (B) Oxygen has reduced
(C) Oxygen gain electron (D) Hydrogen behave has oxidizing agent

11. Which one of the following is not an electrolytic cell? *(K.B+A.B)*

(A) Down's cell (B) Galvanic cell (C) Nelson's cell (D) Both A and C

12. In Zn-Cu galvanic cell, Zn is dipped in: *(K.B)*

(A) $ZnSO_{4(aq)}$ (B) $Zn\ (NO_3)_{2(aq)}$
(C) $CuSO_{4(aq)}$ (D) Both A and B

13. In Zn-Cu galvanic cell Zn is used as: *(K.B)*

(A) Cathode (B) Anode
(C) Electrode (D) All of these

14. In $Zn + Cu^{+2} \rightarrow Zn^{+2} + Cu$, Zn is: *(U.B)*

(A) Oxidized (B) Reduced
(C) Neutralized (D) Decomposed

15. The electrolytic cell is made up of: *(K.B)*

(A) Cement (B) Glass
(C) Wood (D) All of these

16. Which one is strong electrolyte? **(GRW 2016, RWP 2017 G-II, FSD 2017 G-I)** *(K.B)*

(A) NaOH (B) $Ca(OH)_2$
(C) CH_3COOH (D) H_2O

17. Which one of the following electrolytes produces less ions in water? **(LHR 2014)** *(K.B)*

(A) H_2SO_4 (B) NaOH
(C) $Ca(OH)_2$ (D) NaCl

18. Which one of the following is not an electrolyte? *(K.B)*

(A) Sugar solution (B) Sulphuric acid solution
(C) Lime solution (D) Sodium chloride solution

19. Which one of the following ionizes to a small extent in water? *(K.B)*

(A) $Ca(OH)_2$ (B) NaCl
(C) NaOH (D) H_2SO_4

20. In electrochemical cell electrodes are dipped in? *(K.B)*

(A) Solute (B) Solvent
(C) Solution (D) Water

21. Electricity cannot pass through? *(K.B)*

(A) Solid NaCl (B) Aqueous NaCl
(C) Molten NaCl (D) Water

7.4 TEST YOURSELF

i. Why are the strong electrolytes termed as good conductors? *(U.B)*

Ans: **STRONG ELECTROLYTE A CONDUCTOR**

Strong electrolytes are good conductor because they are completely ionized in aqueous solutions and produce more ions which helps in conduction.

ii. Does non-electrolyte form ions in solution? ***(U.B)***

Ans: **NON ELECTROLYTE**

Non-electrolytes exist in the form of molecules. They do not form ions in solution and do not allow the current to pass through their solutions.

iii. What is difference between a strong electrolyte and a weak electrolyte?
(FSD 2016, SGD 2016, 17, SWL 2016, MTN 2017)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between strong electrolyte and weak electrolyte are as follows:

Strong Electrolyte	Weak Electrolyte
Definition	
• The electrolytes which ionize almost completely in aqueous solutions and produce more ions, are called strong electrolytes.	• The electrolytes which ionize to a small extent when dissolved in water and could not produce more ions are called weak electrolytes.
Examples	
• Strong electrolytes are aqueous solutions of NaCl, NaOH and H_2SO_4. $NaOH_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$	• Weak electrolytes are the aqueous solution of acetic acid $Ca(OH)_2$ etc. $CH_3COOH_{(l)} + H_2O_{(l)} \longrightarrow CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

iv. Identify a strong or weak electrolyte among the following compounds. **(LHR 2016 G-I)**
$CuSO_4$, H_2CO_3, $Ca(OH)_2$, HCl, $AgNO_3$ ***(U.B+A.B)***

Ans: **STRONG OR WEAK ELECTROLYTE**

- $CuSO_4$: Strong electrolyte
- H_2CO_3: Weak electrolyte
- $Ca(OH)_2$: Weak electrolyte
- HCl: Strong electrolyte
- $AgNO_3$: Strong electrolyte

v. Which force drives the non-spontaneous reaction to take place? ***(U.B)***

Ans: **FORCE DRIVING THE NON SPONTANEOUS REACTION**

Non-spontaneous reactions take place in the presence of an external agent. The external agent are electrons that cause electricity. So, electric energy helps the non-spontaneous reactions to proceed.

vi. Which type of chemical reaction takes place in electrolytic cell? ***(U.B+K.B)***

Ans: **CHEMICAL REACTION IN A ELECTROLYTIC CELL**

Non-spontaneous chemical reactions take place in electrolytic cell with the help of electricity.

Example: $2NaCl \longrightarrow 2Na_{(e)} + Cl_{2(g)}$

vii. What type of reaction takes place at anode in electrolytic cell? ***(U.B+K.B)***

Ans: **REACTION AT ANODE**

Oxidation takes place at anode in electrolytic cell. Anode is a positively charged electrode.

$$2C1^- \longrightarrow CI_2 + 2e^-$$

viii. Why the positively charged electrode is called anode in electrolytic cell? ***(U.B)***

Ans: **POSITIVELY CHARGED ELECTRODE**

The positively charged electrode is called anode in electrolytic cell because it is connected to the positive (+) terminal of the battery and anions move towards it for oxidation.

$$2C1^- \longrightarrow 2CI + 2e^-$$

ix. In the electrolysis of water, towards which terminal H^+ ions move? ***(U.B+A.B)***

Ans: **MOVEMENT OF H+ ION**

In the electrolysis of water, H^+ ions move towards the cathode and reduced to hydrogen gas which is liberated.

$$2H^+ + 2e^- \longrightarrow H_{2(g)}$$

x. In the electrolysis of water, where is the oxygen produced? ***(U.B+A.B)***

Ans: **PRODUCTION OF OXYGEN**

In the electrolysis of water oxygen is produced at anode.

$$4OH^- \longrightarrow 2H_2O_{(aq)} + O_{2(g)} + 4e^-$$

xi. Towards which electrode of the electrolytic cell moves the cations and what does they do there? ***(U.B)***

Ans: **MOVEMENT OF CATIONS**

In the electrolytic cell cations carry (+) charge, they move towards the cathode and are reduced there.

Such as: $4H^+ + 4\bar{e} \longrightarrow 2H_{2(g)}$

xii. How the half cells of a galvanic cell are connected? What is function of salt bridge? ***(U.B+K.B)***

Ans: **CONNECTION OF HALF CELLS**

The two half cells of the galvanic cell are connected by salt bridge.

Function of Salt Bridge:

- The function of salt bridge is to maintain the electric neutrality between the two half cells of a galvanic cell and thus maintain the flow of ionic current.
- It provides a contact between two half cells.

7.6 ELECTROCHEMICAL INDUSTRIES

Q.1 How sodium metal is manufactured from fused NaCl?

(LHR, SGD 2016, GRW 2014, 16 G-I)*(U.B+A.B)*

Ans: **MANUFACTURE OF SODIUM METAL FROM FUSED NACL**

Principle:

On the industrial scale molten sodium metal is obtained by the **electrolysis of fused NaCl** in the **Down's cell**.

CONSTRUCTION AND WORKING

Construction and working of Down's cell is as follows:

(A) Construction:

This electrolytic cell is a **circular furnace**. In the **center** there is a **large block of graphite**, which acts as an **anode** while **cathode** around it is made of **iron**.

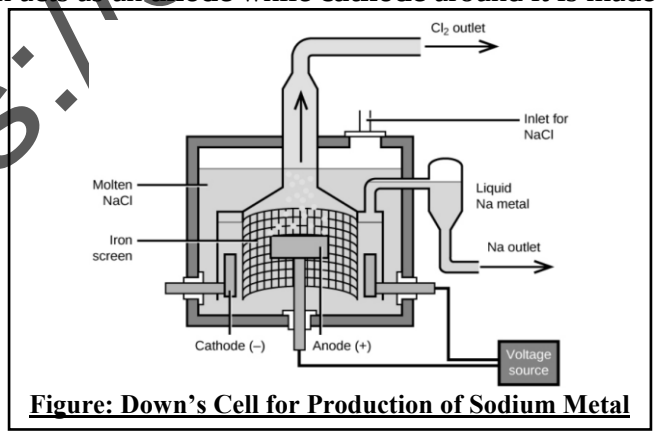


Figure: Down's Cell for Production of Sodium Metal

(B) Working:

Ions Present:

The fused NaCl produces Na^+ and Cl^- ions, which migrate to their respective electrodes on passage electric current.

Separation of Electrodes:

The electrodes are separated by **steel gauze** to prevent the contact between the products.

Chemical Reactions:

The Cl^- ions are **oxidized** to **give Cl_2** gas at the **anode**. It is **collected over the anode** within an inverted cone-shaped structure while Na^+ are **reduced at cathode** and **molten Na metal floats** on the denser molten salt mixture from where it is **collected in a side tube**. Following reactions take place during the electrolysis of the molten sodium chloride:

Ionization of Molten NaCl:

$$2NaCl \rightleftharpoons 2Na^+ + 2Cl^-$$

Reaction at Anode (oxidation):

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

Reaction at Cathode (reduction):

$$2Na^+ + 2e^- \longrightarrow 2Na$$

Overall reaction:

$$2NaCl \longrightarrow 2Na + Cl_2$$

Q.2 How can we prepare NaOH from brine on commercial scale? Discuss its chemistry along with diagram? **(Ex-Q.6)(U.B+A.B)**

Ans: **MANUFACTURE OF NaOH (CAUSTIC SODA)**

Principle:

On industrial scale caustic soda, (sodium hydroxide) NaOH, is produced in **Nelson's cell** by the **electrolysis of aqueous solution of NaCl, called brine**.

CONSTRUCTION AND WORKING OF CELL

Construction and working of Nelson's cell is as follows:

Construction:

It consists of a **steel tank** in which **graphite anode** is **suspended in the center of a U shaped perforated iron cathode**. This **iron cathode** is **internally lined** with **asbestos diaphragm**. **Electrolyte (brine)** is present **inside** the **iron cathode**.

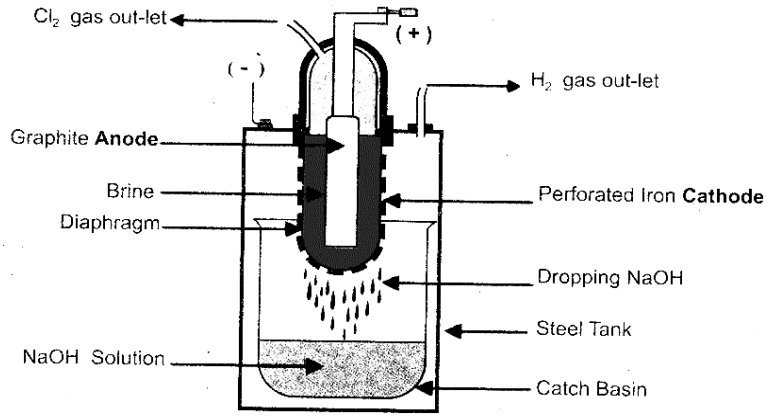


Figure: Nelson's Cell for Production of NaOH

Working:

Ions Present:

Aqueous solution of sodium chloride consists of Na^+, Cl^-, H^+ and ^-OH ions.

Chemical Reactions:

These ions move towards their respective electrodes and redox reactions take place at these electrodes. When electrolysis takes place **Cl^- ions** are **discharged at anode** and **Cl_2 gas rises into the dome** at the top of the cell. The **H^+ ions** are **discharged at cathode** and **H_2 gas escapes through a pipe**. The **sodium hydroxide solution** slowly **percolates** into a **catch basin**.

Ionization of Brine:

$$2NaCl_{(aq)} \longrightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)}$$

Reaction at Anode (oxidation):

$$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$$

Reaction at Cathode (reduction):

$$2H_2O + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$$

$$2Na^+_{(aq)} + 2OH^-_{(aq)} \longrightarrow 2NaOH_{(aq)}$$

Overall Cell Reaction:

$$2NaCl_{(aq)} + 2H_2O_{(\ell)} \longrightarrow H_{2(g)} + Cl_{2(g)} + 2NaOH_{(aq)}$$

7.6 ELECTROCHEMICAL INDUSTRIES

SHORT QUESTIONS

Q.1 Which solution is used as an electrolyte in Nelson's cell? ***(K.B)***

Ans: **ELECTROLYTE IN NELSON CELL**

An aqueous solution of NaCl called brine is used as an electrolyte in Nelson's cell.

Q.2 How molten Na is manufactured on industrial scale? ***(A.B)***

Ans: **MANUFACTURING OF Na**

On industrial scale molten sodium metal is obtained by the electrolysis of fused NaCl in the Down's Cell.

Q.3 What is Brine? ***(K.B)***

Ans: **BRINE**

"Concentrated solution of NaCl is called brine".

Q.4 Name the by-products produced in Nelson's cell? ***(K.B)***

Ans: **BY PRODUCT IN NELSON CELL**

Hydrogen gas (H_2) and chlorine gas (Cl_2) are the by-product of Nelson's cell.

$$2NaCl_{(q)} + 2H_2O \rightarrow H_{2(g)} + Cl_2 + 2NaOH$$

7.6 ELECTROCHEMICAL INDUSTRIES

MULTIPLE CHOICE QUESTIONS

1. Anode of Down's cell is made up of: **(LHR 2014)*(K.B)***

(A) Steel (B) Copper (C) Zinc (D) Graphite

2. Electrolysis of fused NaCl is done in the cell: ***(A.B)***

(A) Electrolytic cell (B) Voltaic cell (C) Down's cell (D) Faraday's

3. Cl_2 gas is formed when Cl^- ions are: ***(U.B)***

(A) Reduced (B) Oxidized

(C) Remained (D) Reacted with metals

7.5 TEST YOURSELF

i. Anode of Down's cell is made of a non-metal. What is its name? What is the function of this anode? ***(U.B+K.B)***

Ans:

ANODE OF DOWN'S CELL

Name of Non-metal:

In Down's cell anode is made of graphite.

Function of Anode:

Cl^- ions get oxidized to give chlorine gas at the anode, so its function is to oxidize Cl^- to $Cl_{2(g)}$. The Cl^- ions are oxidized there and produce Cl_2 gas at anode.

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

ii. Where does the sodium metal is collected in Down's cell? ***(K.B)***

Ans:

COLLECTION OF SODIUM METAL

In Down's cell Na^+ are reduced at cathode and molten Na-metal floats on the denser molten salt mixture from where it is collected in a side tube. Thus sodium metal is collected at cathode in Down's cell.

iii. What is the name of the by-product produced in the Down's cell? ***(K.B)***

Ans:

BY PRODUCT IN DOWN'S CELL

The name of by-product produced in the Down's cell is chlorine gas.

$$2NaCl \longrightarrow 2Na + Cl_2$$

iv. Are anode of Down's cell and Nelson's cell made up of same element? If yes what is the name? ***(U.B)***

Ans:

ANODE OF DOWN'S AND NELSON CELL

Yes, anode of Down's cell and Nelson cell are made of same element named as Carbon (graphite).

v. What is the shape of cathode in Nelson's cell? Why is it perforated? ***(U.B+K.B)***

Ans:

CATHODE IN NELSON'S CELL

Shape of Cathode:

In Nelson's cell the cathode is internally lined with asbestos diaphragm. It is U-shaped and perforated.

Why Perforated?

It is made perforated because sodium hydroxide slowly percolate through it into a catch basin.

vi. Which ions are discharged at cathode in Nelson's cell and what is produced at cathode? ***(U.B)***

Ans:

DISCHARGE OF IONS AND PRODUCT

Discharge of Ions:

The H^+ ions are discharged at cathode in Nelson's cell.

Product:

At cathode hydrogen (H_2) gas is produced.

$$2H^+ + 2e^- \longrightarrow H_{2(g)}$$

7.7 CORROSION AND ITS PREVENTION

Q.1 What is corrosion? How iron gets rusted?

(FSD 2016, 17, SGD 2016, 17, DGK 2017, LHR 2015, GRW 2016 G-I)*(U.B+A.B)*

OR

Discuss the redox reaction taking place in the rusting of iron in detail. **(Ex-Q.7)**

Ans:

CORROSION

Definition:

*"Corrosion is **slow and continuous eating away of a metal by the surrounding medium**".*

Conditions:

Corrosion is a **redox chemical reaction** that takes place by the action of **air** and **moisture** with the metals.

Example:

The most common example of corrosion is **rusting of iron**.

RUSTING OF IRON

*"**Corrosion** is a **general term** but **corrosion of iron** is called **rusting**. **Formation of hydrated iron oxide** $(Fe_2O_3.nH_2O)$ **at surface of iron** is called rusting".*

Conditions for Rusting:

The important condition for rusting is **moist air (air having water vapours in it)**. There will be no rusting in water vapours free of air or air free of water.

Process of Rusting:

(i) Anodic Region:

Stains and dents on the surface of the iron provide the sites for this process to occur. This region is called **anodic region** and following oxidation reaction takes place here:

$$2Fe \longrightarrow 2Fe^{2+} + 4e^-$$

This **loss of electrons damages the object**.

(ii) Cathodic Region:

The free electrons move through iron sheet, until they reach to **a region of relatively high O_2 concentration near the surface surrounded by water layer.** This region acts as cathode and **electrons reduce the oxygen molecule in the presence of H^+ ions:**

$$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$$

(iii) Provision of H^+ Ions:

The H^+ ions are provided by the **carbonic acid**, which is **formed** because of presence of **CO_2 in water**. That's why **acidic medium accelerates** the **process of rusting**.

$$H_2O + CO_2 \longrightarrow H_2CO_3$$

$$H_2CO_3 \longrightarrow H^+ + HCO_3^{-1}$$

The **overall redox process is completed without the formation of rust**.

$$2Fe + O_2 + 4H^+ \longrightarrow 2Fe^{+2} + 2H_2O$$

(iv) Formation of Rust:

The **Fe^{+2} formed spreads throughout the surrounding water and react with O_2 to form the salt $Fe_2O_3.nH_2O$ which is called rust.** It is also a redox reaction.

$$2Fe^{2+} + \frac{1}{2}O_2 + (2+n)H_2O \longrightarrow Fe_2O_3.nH_2O + 4H^+$$

Property of Rust Layer:

The rust layer of iron is **porous** and **does not prevent further corrosion**. Thus rusting continues until all the piece of iron is eaten up.

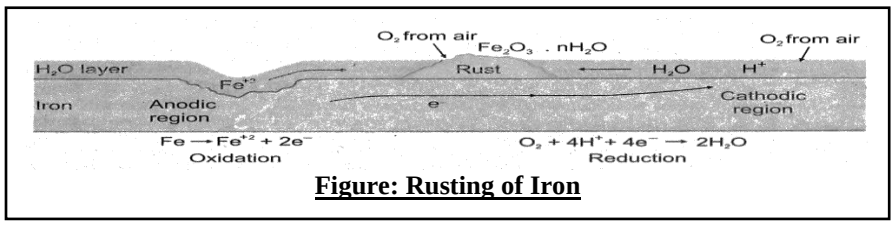


Figure: Rusting of Iron

Q.2 Describe the methods for the prevention of corrosion. **(SWL, SGD, RWP 2016)*(U.B+A.B)***

Ans:

CORROSION

Definition:

*"Correction is a **slow and continuous eating away of metal by the surrounding medium.***

Example:

The most common example of corrosion is **rusting of iron**".

METHODS FOR THE PREVENTION OF CORROSION

(i) Removal of Stains:

The **regions of stains** in an iron rod act as the **site for corrosion**. If the surface of iron is properly cleaned and stains are removed, it would prevent rusting.

(ii) Paints and Greasing:

Greasing, polishing or painting of the surface can prevent the rusting of iron. With development of technologies, modern paints contain a combination of chemicals called **stabilizers** that **provide protection against the corrosion** in addition to prevention against the **weathering** and other **atmospheric effects**.

(iii) Alloying:

*"Alloy is a **homogeneous mixture** of one metal with one or more other metals or non-metals. The process of formation of alloys is called alloying".*

Best Example:

The best example of alloying is the **'stainless steel',** which is a good **combination of iron, chromium** and **nickel**.

Significance of Alloying of Iron:

Alloying of iron with other metals has proved to be very successful technique against rusting.

(iv) Metallic Coating:

The best method for protection against the corrosion of **metals exposed to acidic conditions is coating the metal**.

Importance:

It is the most widely applied technique in the **food industry** where food is **'tin-packed'**. The **containers of iron are coated with tin or chromium to give it a longer life**.

Metals Used for Metallic Coating:

Corrosion resistant metals like **Zn, Sn** and **Cr** are **coated on the surface of iron** to protect it from corrosion.

Methods of Metallic Coating:

- Physical methods
- Chemical method **(Electroplating)**

Q.3 Discuss why galvanizing is considered better than tin plating? **(Ex-LQ.8)*(U.B+A.B)***

OR

Describe galvanizing and tinning (tin coating) in detail. ***(U.B+A.B)***

Ans: **GALVANIZING AND TIN PLATING**

(A) Galvanizing (Zinc Coating):

*"The **process of coating a thin layer of zinc on iron** is called galvanizing."*

Process:

This process is carried out by **dipping a clean iron sheet in a zinc chloride bath** and **then heating it**. After this **iron sheet is removed**, **rolled into molten zinc metal bath** and finally **air-cooled**.

Advantage:

Advantage of galvanizing is that **zinc protects the iron against corrosion** even **after the coating surface is broken**.

(B) Tin Plating (Tinning):

*"The **process of coating a thin layer of tin on iron** is called tinning".*

Process:

It involves the **dipping of the clean sheet of iron in a bath of molten tin** and then **passing it through hot pairs of rollers**.

Advantage:

Such sheets are used in the **beverage** and **food cans**.

Disadvantage:

The **tin protects** the iron only **as long as its protective layer remains intact**. **Once it is broken** and the **iron is exposed** to the **air** and **water**, a **galvanic cell is established** and **iron rusts rapidly**.

Comparison of Galvanizing and Tin Coating:

Advantage of galvanizing is that **zinc protects the iron against corrosion even after the coating surface is broken**. The tin protects the iron only as long as its protective layer remains intact. Once it is broken and the iron is exposed to the air and water, a galvanic cell is established and iron rusts rapidly. This is the main reason galvanizing is considered better than tin plating

7.7 CORROSION AND ITS PREVENTION

SHORT QUESTIONS

Q.1 What are the methods of metallic coating? **(SWL, BWP 2017)(K.B+A.B)**

Ans: *Answer give on pg # 256*

Q.2 What is advantage of zinc coating or galvanizing? **(DGK 2016, SGD 2017 G-I)(U.B+K.B)**

Ans: *Answer give on pg # 257*

Q.3 Define corrosion. **(LHR 2016 G-I)(K.B)**

Ans: *Answer give on pg # 255*

Q.4 What is rusting? **(K.B+A.B)**

Ans: *Answer give on pg # 255*

Q.5 Explain tin coating or tinning. **(MTN 2017)(U.B+A.B)**

Ans: *Answer give on pg # 257*

7.7 CORROSION AND ITS PREVENTION

MULTIPLE CHOICE QUESTIONS

1. The formula of rust is: **(LHR 2015)*(K.B)***

(A) $Fe_2O_3.nH_2O$ (B) Fe_2O_3

(C) $Fe(OH)_3.nH_2O$ (D) $Fe(OH)_3$

2. The most common example of corrosion is: ***(K.B+A.B)***

(A) Chemical decay (B) Rusting of iron

(C) Rusting of aluminium (D) Rusting of tin

3. Which medium accelerates the process of rusting? ***(U.B+K.B)***

(A) Acidic (B) Basic

(C) Buffer (D) Neutral

4. The best method for preventing corrosion of metal exposed to acidic condition is: ***(U.B+A.B)***

(A) Alloying (B) Painting

(C) Greasing (D) All of these

5. Which one of the following metal is used for galvanizing? ***(K.B)***

(A) Fe (B) Cu

(C) Cr (D) Zn

7.6 TEST YOURSELF

i. What is the difference between corrosion and rusting? **(MTN 2016, RWP 2017 G-II)*(U.B)***

Ans: **DIFFERENTIATION**

The differences between corrosion and rusting are as follows:

Corrosion	Rusting
Definition	
• Corrosion is a general term used for all the metals.	• Corrosion of iron is called rusting.
Continuity	
• Corrosion of some metal may be stopped.	• Rusting is the continuous process.
Nature of Reaction	
• It is redox reaction.	• It is also redox reaction.

ii. What happens to iron in the rusting process? ***(U.B)***

Ans: **IRON IN RUSTING**

During rusting Fe is oxidized to Fe^{2+}, that spread throughout the surrounding reacts with water and O_2 to form the salt ($Fe_2O_3.nH_2O$) called rust. Due to being porous the rusting process continuous until the whole piece of iron is eaten up.

iii. Rusting completes in how many redox reactions? ***(U.B+K.B)***

Ans: **NUMBER OF REDOX REACTION OF RUSTING**

Rusting completes in 2 redox reactions given below:

$$2Fe^{+2} + \frac{1}{2}O_{2(aq)} + 4H^{+}_{(q)} \rightarrow 2Fe^{+2} + 2H_2O$$

$$2Fe^{+2} + \frac{1}{2}O_2 + (2+n)H_2O \rightarrow Fe_2O_3.nH_2O + 4H^{+}$$

iv. Explain the role of O_2 in rusting? ***(U.B)***

Ans:

ROLE OF O_2 IN RUSTING

O_2 is necessary for rusting because in cathode region, the electrons released by iron, reduce oxygen in the presence of H^+ ions to form water. Oxygen acts as an oxidizing agent.

$$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O + Fe^{2+}$$

The Fe^{2+} are further oxidized to Fe^{3+}, which then combine with oxygen to form rust.

$$2Fe^{2+} + \frac{1}{2}O_2 + (n+2)H_2O \longrightarrow Fe_2O_3.nH_2O + 4H^+$$

v. State the best method for protection of metal from corrosion. ***(U.B+A.B)***

Ans:

PROTECTION FROM CORROSION

The best method for protection of metal from corrosion is the coating of highly resistant metal. Corrosion resistant metals like Zn, Sn and Cr are coated on the surface of metal to protect other metals from corrosion.

vi. What do you mean by galvanizing? **(LHR 2017 G-I)*(K.B)***

Ans:

GALVANIZING

The process of coating a thin layer of zinc on iron is called galvanizing.

Advantage:

It has advantage that it resists corrosion even if zinc coating is broken.

vii. What is the advantage of galvanizing? ***(K.B+A.B)***

Ans:

ADVANTAGE OF GALVANIZING

A big advantage of galvanizing is that zinc protects the iron against corrosion even after the coating surface is broken.

viii. Why tin plated iron is rusted rapidly when tin layer is broken? ***(U.B)***

Ans:

RAPID RUSTING OF TIN PLATED IRON

When tin layer s broken the iron is exposed to the air and water, a galvanic cell is established in which iron acts as anode and rusts rapidly.

ix. Name the metal which is used for galvanizing iron? ***(K.B)***

Ans:

GALVANIZING IRON

Zinc metal is used for galvanizing iron.

ELECTROLYTIC METHOD (ELECTROPLATING)

Q.1 What is electroplating? Write down procedure of electroplating? **(Ex-Q.9)*(U.B+A.B)***

Ans:

ELECTROPLATING

Definition:

"Electroplating is ***depositing of one metal over the other by means of electrolysis".***

Objectives:

This process is used to:

- **Protect metals against corrosion**
- **Improve their appearance,** shine and beauty

Principle:

Principle of electroplating is to **establish an electrolytic cell in which anode is made of the metal to be deposited and cathode of the object on which metal is to deposit**. The **electrolyte** is an **aqueous solution of a salt** of the **respective metal**.

PROCEDURE FOR ELECTROPLATING

The construction of apparatus and procedure for electroplating is as follows:

(i) Cleaning of Metal:

In this process the object to be electroplated is **cleaned with sand** and **washed with caustic soda solution** and finally **thoroughly washed with water**.

(ii) Anode:

The anode is made of the **metal**, which is **to be deposited** like **Cr, Ni**.

(iii) Cathode:

The cathode is **made up of** the **object** that is **to be electroplated** like some sheet made up of **iron**.

(iv) Electrolyte:

The electrolyte in this system is a **salt of the metal being deposited**.

(v) Electrolytic Tank:

The electrolytic tank is made of **cement**, **glass** or **wood** in which anode and cathode are suspended. The **electrodes are connected with a battery**.

(vi) Passing of Electric Current

When the **current is passed**, the **metal from anode dissolves in the solution** and **metallic ions migrate to the cathode** and **discharge** or **deposit on the cathode (object).** As a result of this discharge, a **thin layer of metal deposits on the object**, which then pulled out and cleaned.

Q.2 Describe electroplating of Silver. **(BWP 2017)*(U.B+A.B)***

Ans:

ELECTROPLATING OF SILVER

Principle:

The electroplating of silver is carried out by **establishing an electrolytic cell**.

Anode:

The **pure piece of silver strip** acts as anode.

Cathode:

The cathode is the **metallic object to be coated** such as **spoon**.

Electrolyte:

Both electrodes are dipped in **silver nitrate solution** used as an electrolyte.

Chemical Reactions:

When the **current is passed** through the cell, the **Ag^+ ions dissolve at the anode** and **migrate towards the cathode** where, **they discharge** and **deposit on the object** e.g. **spoon**. The chemical reaction can be represented as:

At Anode:

$$Ag_{(s)} \longrightarrow Ag^{+}_{(aq)} + 1e^{-}$$

At Cathode:

$$Ag^{+}_{(aq)} + 1e^{-} \longrightarrow Ag_{(s)}$$

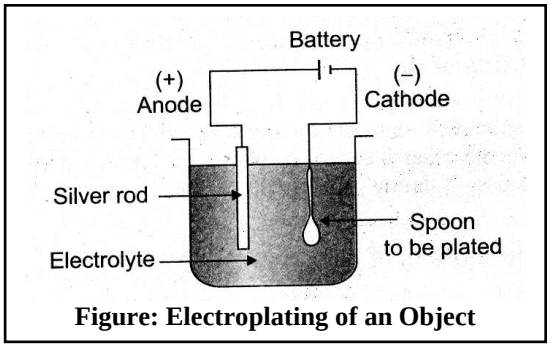


Figure: Electroplating of an Object

Uses:

Common examples of silver plating are **table wares**, **cutlery**, **jewelry** and **steel objects**.

Q.3 What is principle of electroplating? How electroplating of chromium is carried out?
(Ex-Q.10)*(U.B+A.B)*

Ans:

ELECTROPLATING

Principle:

The principle of electroplating is to **establish an electrolytic cell** in which **anode is made up of the metal to be deposited** and **cathode of the object on which metal is to be deposited**.

ELECTROPLATING OF CHROMIUM

Electrolyte:

The object to be electroplated dipped in **aqueous solution of $Cr_2(SO_4)_3$ containing a little sulphuric acid**. That act as an electrolyte.

Cathode:

The **object to be electroplated** acts as cathode.

Anode:

Anode is made of **antimonial lead**.

Chemical Reactions:

The **electrolyte ionizes** and **provides Cr^{3+} ions**, which **reduce** and **deposit at cathode**.
Electrolyte produces the following ions.

$$Cr_2(SO_4)_{3(aq)} \xrightarrow{water} 2Cr^{3+}_{(aq)} + 3SO^{2-}_{4(aq)}$$

Reactions at the electrodes are as follows.

At Anode:

$$4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^-$$

At Cathode:

$$Cr^{3+} + 3e^- \longrightarrow Cr$$

Plating of steel with Ni or Cu first and then Cr plating:

For **practical convenience**, the **steel** is usually **plated first with nickel or copper** and **then by chromium because it does not adhere well on the steel surface**. Moreover, **it allows moisture to pass through it** and **metal is stripped off**. The **nickel** or **copper provides adhesion** and then **chromium deposited over the adhesive layer of copper lasts longer**. This type of electroplating **resists corrosion** and **gives a bright silvery appearance** to the object.

Q.4 What is principle of electroplating? How electroplating of zinc and tin is carried out? ***(U.B+A.B)***

Ans:

ELECTROPLATING

Principle:

Principle of electroplating is to **establish an electrolytic cell in which anode is made of the metal to be deposited** and **cathode of the object on which metal is to deposit**. The **electrolyte** is in **aqueous solution of a salt** of the **respective metal**.

ELECTROPLATING OF ZINC

Cleaning of Target Metal:

The target metal is cleaned in **alkaline detergent** type solutions, and it is **treated with acid**, in order **to remove any rust or surface scales**.

Anode:

Zinc metal is used as anode.

Cathode:

The **metal to be plated** is used as cathode.

Electrolyte:

Aqueous solution of zinc sulphate ($ZnSO_4$) is used as an electrolyte.

Chemical Reactions:

When **electric current is passed** the **zinc is deposited on the metal by immersing it in a chemical bath containing electrolyte zinc sulphate**. A **current is applied**, which results in **zinc being deposited on the target metal** i.e. **cathode**.

At Anode:

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

At Cathode:

$$Zn^{2+} + 2e^- \longrightarrow Zn$$

ELECTROPLATING OF TIN

Cleaning of Target Metal:

The target metal is cleaned in **alkaline detergent** type solutions, and it is **treated with acid,** in order **to remove any rust or surface scales**.

Anode:

Tin metal is used as anode.

Cathode:

The **metal to be plated** is used as cathode.

Electrolyte:

Aqueous solution of tin sulphate ($SnSO_4$) is used as an electrolyte.

Cathode Material:

Tin is usually **electroplated on steel by placing the steel into a container containing a solution of tin salt**.

Chemical Reactions:

When an **electrical current passes** through the circuit, **tin metal ions** present in the solution **deposit on steel**.

At Anode:

$$Sn \longrightarrow Sn^{2+} + 2e^-$$

At Cathode:

$$Sn^{2+} + 2e^- \longrightarrow Sn$$

Q.5 What do you know about electrolytic refining of copper? **(LHR 2017 G-I)*(U.B+A.B)***

Ans:

ELECTROLYTIC REFINING OF COPPER

Impure copper is refined by the **electrolytic method** in the electrolytic cell.

Anode:

Impure copper acts as anode.

Cathode:

A **pure copper plate** acts as cathode

Electrolyte:

Copper sulphate solution in water is used as an electrolyte.

Reaction at Anode:

Oxidation reaction takes place at the anode. **Copper atoms from the impure copper lose electrons** to the anode and **dissolve in solution** as copper ions:

$$Cu \longrightarrow Cu^{2+}(aq) + 2e^{-} \quad \textbf{(Oxidation)}$$

Reaction at Cathode:

Reduction reaction takes place at the cathode. The **copper ions present in the solution** are **attracted to the cathode**. Where they **gain electrons** from the cathode and **become neutral** and **deposit on the cathode**.

$$Cu^{2+} + 2e^{-} \longrightarrow Cu \quad \textbf{(Reduction)}$$

Net Result:

In the process **impure copper is eaten up** and **purified copper atoms deposit on the cathode**. **99.9% pure copper** is obtained in this process.

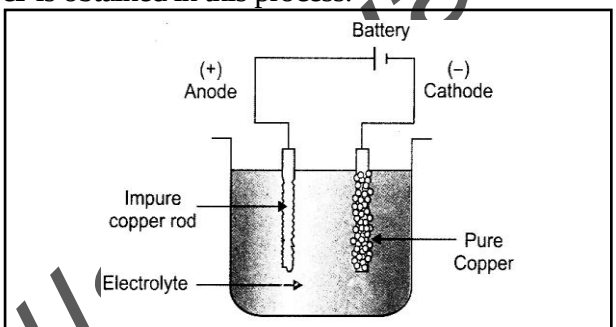


Figure: Refining of Copper in an Electrolytic Cell

ELECTROLYTIC METHOD (ELECTROPLATING)

SHORT QUESTIONS

Q.1 In electroplating of chromium which salt is used as an electrolyte? ***(K.B)***

Ans: *Answer give on pg #*

Q.2 Write the redox reaction taking place during electroplating of chromium. ***(U.B+A.B)***

Ans:

REACTION IN ELECTROPLATING OF CHROMIUM

$$Cr_2(SO_4)_3 \longrightarrow 2Cr^{3+} + 3SO_4^{2-}$$

At anode:

$$4OH^-_{(aq)} \rightarrow 2H_2O_{\ell} + 4e^- + O_2$$

At cathode:

$$Cr^{3+}_{(aq)} + 3e^- \rightarrow Cr_{(s)}$$

Overall reaction:

$$Cr_2(SO_4)_3 + 3e^- \rightarrow Cr_{(s)}$$

ELECTROLYTIC METHOD (ELECTROPLATING)

MULTIPLE CHOICE QUESTIONS

1. Stainless steel contains: ***(K.B)***

(A) Nickel (B) Iron (C) Chromium (D) All of these

2. Depositing of one metal over the other by means of electrolysis is: ***(K.B+A.B)***

(A) Corrosion (B) Reduction (C) Oxidation (D) Electroplating

7.7 TEST YOURSELF

i. Define electroplating? **(GRW 2016 G-I, II, RWP 2017 G-II, SGD 2017 G-II)*(K.B)***

Ans: *"Electroplating is **depositing of one metal over the other by means of electrolysis".***

Objectives:

This process is used to:

- **Protect metals against corrosion**
- **Improve their appearance,** shine and beauty

ii. How electroplating of zinc is carried out? ***(U.B+A.B)***

Ans. **ELECTROPLATING OF ZINC**

(A) Cleaning of Target Metal:

The target metal is cleaned in alkaline detergent type solutions, and it is treated with acid, in order to remove any rust or surface scales.

(B) Concentration of Cell:

Anode:

Zinc metal is used as anode.

Cathode:

The metal to be plated is used as cathode.

Electrolyte:

Aqueous solution of zinc sulphate ($ZnSO_4$) is used as an electrolyte.

Working of Cell:

When electric current is passed the zinc is deposited on the metal by immersing it in a chemical bath containing electrolyte zinc sulphate. A current is applied, which results in zinc being deposited on the target metal i.e. cathode.

At anode:

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

At cathode:

$$Zn^{2+} + 2e^- \longrightarrow Zn$$

iii. Which material is used to make cathode in electroplating? ***(K.B)***

Ans: **CATHODE ELECTROPLATING**

Some sheet of any metallic object to be electroplated is used to make cathode in electroplating.

iv. Why is the anode made up of a metal to be deposited during electrolysis? ***(U.B)***

Ans: **METAL IN MAKING ANODE**

The anode is made up of a metal to be deposited during electrolysis, because, when the current is passed, the metal from anode dissolves in the solution and metallic ions migrate to the cathode and deposit on it.

ANSWER KEYS

INTRODUCTION

1	A	2	A

7.1 OXIDATION AND REDUCTION

1	B	2	B	3	A	4	B	5	B

7.2 OXIDATION STATE AND RULES FOR ASSIGNING OXIDATION STATE

1	B	2	D	3	A	4	A	5	C	6	B
7	B	8	D	9	C	10	B	11	C	12	D

7.3 OXIDIZING AND REDUCING AGENTS

1	B	2	C	3	A	4	B	5	D	6	C

7.5 ELECTROCHEMICAL CELLS

1	C	2	A	3	B	4	B	5	D	6	D	7	B	8	A	9	D	10	C
11	B	12	A	13	B	14	A	15	D	16	A	17	C	18	A	19	A	20	C
21	A																		

7.6 ELECTROCHEMICAL INDUSTRIES

1	D	2	A	3	C

7.7 CORROSION AND ITS PREVENTION

1	A	2	B	3	A	4	A	5	D

ELECTROLYTIC METHOD (ELECTROPLATING)

1	D	2	D

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. Spontaneous chemical reactions take place in:
(GRW 2017 G-I, LHR 2016 G-II, SGD 2017 G-II, BWP 2017 G-I, BWP 2016 G-II, SGD 2016 G-II)*(K.B)*
(A) Electrolytic cell (B) Galvanic cell (C) Nelson's cell, (D) Down's cell

2. Formation of water from hydrogen and oxygen is:
(DGK 2016, 17 G-II, BWP 2016 G-II, SWL 2016 G-I)*(U.B+A.B)*
(A) Redox reaction (B) Acid-base reaction (C) Neutralization (D) Decomposition

3. Which one of the following is not an electrolytic cell?
(RWP 2017 G-II, SWL 2017 G-I, BWP 2016 G-I)*(K.B+A.B)*
(A) Downs cell (B) Galvanic cell (C) Nelson's cell (D) Both a and c

4. The oxidation number of chromium in $K_2Cr_2O_7$ is: ***(U.B+A.B)***
(LHR 2017 G-I, GRW 2016 G-I, RWP 2017 G-I, SGD 2017 G-II, BWP 2016 G-I, SGD 2016 G-I, FSD 2016 G-I)
(A) +2 (B) +6 (C) +7 (D) +14

5. Which one of the following is not an electrolyte?
(LHR 2017 G-I, BWP 2017 G-II, SWL 2017 G-II, MTN 2016 G-I, RWP 2016 G-I)*(K.B)*
(A) Sugar solution (B) Sulphuric acid solution
(C) Lime solution (D) Sodium chloride solution

6. The most common example of corrosion is: **(SWL 2016 G-I, SGD 2016 G-I, FSD 2016 G-I)*(A.B)***
(A) Chemical decay (B) Rusting of iron
(C) Rusting of aluminium (D) Rusting of tin

7. Nelson's cell is used to prepare caustic soda along with gases. Which of the following gas is produced at cathode? **(MTN 2017 G-I, SWL 2017 G-I, MTN 2016 G-I)*(U.B)***
(A) Cl_2 (B) H_2 (C) O_3 (D) O_2

8. During the formation of water from hydrogen and oxygen, which of the following does not occur? **(BWP 2017 G-I)*(U.B)***
(A) Hydrogen has oxidized (B) Oxygen has reduced
(C) Oxygen gains electrons (D) Hydrogen behaves as oxidizing agent

9. The formula of rust is: **(FSD 2017 G-I, DGK 2017 G-II, MTN 2017 G-II)*(K.B)***
(A) $Fe_2O_3.nH_2O$ (B) Fe_2O_3
(C) $Fe(OH)_3.nH_2O$ (D) $Fe(OH)_3$

10. In the redox reaction between Zn and HCl, the oxidizing agent is:
(LHR 2017 G-I, RWP 2016 G-I)*(U.B+A.B)*
(A) Zn (B) H+ (C) Cl– (D) H

ANSWER KEY

1	**B**	**2**	**A**	**3**	**D**	**4**	**B**	**5**	**A**	**6**	**B**	**7**	**B**
				8	**D**	**9**	**A**	**10**	**B**				

EXERCISE SHORT QUESTIONS

1. Define oxidation in terms of electrons. Give an example. **(RWP 2017 G-I, MTN 2016)*(U.B+K.B)***

Ans: **OXIDATION**

"Oxidation is the loss of electron by an atom or an ion.

Example:

$$Zn \longrightarrow Zn^{+2} + 2e^{-}$$

$$Fe^{+2} \longrightarrow Fe^{+3} + 1e^{-}$$

2. Define reduction in terms of loss or gain of oxygen or hydrogen. Give an example. ***(U.B+A.B)***

Ans: **REDUCTION**

"The addition of hydrogen or removal of oxygen during a chemical reaction."

Examples:

$$2ZnO + C \xrightarrow{\text{Reduction (Removal of oxygen)}} 2Zn + CO_2$$

3. What is difference between valency and oxidation state? ***(U.B)***

Ans: **DIFFERENTIATION**

The differences between Valency and oxidation number or state are as follows:

Valency	Oxidation Number
Definition	
• It is the combining capacity of an element in terms of the number of hydrogen atoms with which the element may combine.	• It is the charge which an atoms of the element has or appears to have when present in the combined state with their atoms.
Charge or Sign	
• It is purely a number and has no plus or minus sign associated with it. For example. Valency of N in NH_3 is 3 and that of H is 1.	• It is always assigned plus or minus sing except when it zero. For example oxidation number of N in NH_3 is -3 and that of H is +1

4. Differentiate between oxidizing and reducing agents.

(GRW 2016,17 G-II, RWP 2017 G-I, MTN 2017, FSD 2016 G-II)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between oxidizing agent and reducing agent are as follows as:

Oxidizing Agent	Reducing Agent
• A species that oxidizes a substance by taking electrons from it, is called an oxidizing agent.	• A species that reduces a substance by donating electrons to it is called reducing agent.
• It is itself reduced in a redox reaction	• It is itself oxidized in a redox reaction
• Non-metals (O_2, F_2, Cl etc.) are good oxidizing agents.	• Metals (Fe, Cu, Na etc.) are good reducing agents.
• They are more electronegative in nature.	• They are more electropositive.
• Their oxidation number decreases.	• Their oxidation number decreases.

5. Differentiate between strong and weak electrolytes.

(FSD 2016, 17, SGD 2016, 17, SWL 2016, MTN 2017)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between strong electrolyte and weak electrolyte are as follows:

Strong Electrolyte	Weak Electrolyte
Definition	
• The electrolytes which ionize almost completely in aqueous solutions and produce more ions, are called strong electrolytes.	• The electrolytes which ionize to a small extent when dissolved in water and could not produce more ions are called weak electrolytes.
Examples	
• Strong electrolytes are aqueous solutions of NaCl, NaOH and H_2SO_4. $NaOH_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$	• Weak electrolytes are the aqueous solution of acetic acid $Ca(OH)_2$ etc. $CH_3COOH_{(l)} + H_2O_{(l)} \longrightarrow CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

6. How electroplating of tin on steel is carried out? ***(U.B+A.B)***

Ans: **ELECTROPLATING OF TIN ON STEEL**

Electrolyte:

Tin is usually electroplated on steel by placing the steel into the container containing a solution of tin salt.

Cathode:

The steel is connected to an electrical circuit, acting as cathode.

Anode:

The anode is made up of tin.

Working:

When electrical current is passed through the circuit, tin metal ions present in the solution deposit on steel.

7. Why steel is plated with nickel before the electroplating of chromium. ***(U.B+A.B)***

Ans: **ELECTROPLATING OF CHROMIUM**

The steel is usually plated first with nickel or copper then by chromium because it does not adhere well on the steel surface. Moreover, it allows moisture to pass through it and metal is stripped off.

8. How can you explain, that following reaction is oxidation in terms of increase of oxidation number? ***(U.B+A.B)***

$$Al^o \longrightarrow Al^{+3} + 3e^-$$

Ans: **OXIDATION NUMBER**

Increase in oxidation number is called oxidation. Oxidation number of Al increases from zero to + 3 thus it is an oxidation reaction.

$$A\ell \longrightarrow A\ell^{+3} + 3e^-$$

9. How can you prove so it is an oxidation reaction with an example that conversion of an ion to an atom is an oxidation process? ***(U.B+A.B)***

Ans: **CONVERSION OF ION TO ATOM**

Conversion of anion into an atom is an oxidation process.

Example:

When anions (negatively charged ions) lose electron, they are converted into atoms and oxidized.

$$Cl^- \xrightarrow{\text{Oxidation}} Cl + 1e^-$$

10. Why does the anode carries negative charge in galvanic cell but positive charge in electrolytic cell? Justify with comments. ***(U.B)***

Ans: **NEGATIVE CHARGE ON ANODE**

In Galvanic cell, electrons are lost by the atoms at anode plate which makes it electron efficient therefore it carries negative charge. In electrolytic cell, electrons are gained by cations from anode which makes it electron deficient therefore it carries positive charge.

11. Where do the electrons flow from Zn electrode in Daniel's cell? ***(U.B)***

Ans: **ELECTRODE IN DANIEL'S CELL**

In Daniel cell, the electrons takes flow from Zn electrode (anode) towards the cathode made up of copper through the external circuit.

12. Why do electrodes get their names 'anode' and cathode in galvanic cell? ***(U.B)***

Ans: **ANODE AND CATHODE**

In galvanic cell anode and cathode get their names depending upon the process taking place on them.

Anode:

It is an electrode where oxidation takes places.

$$Zn \longrightarrow Zn^{+2} + 2e^{-}$$

Cathode:

It is an electrode where reduction takes place.

$$Cu^{+2} + 2\bar{e} \longrightarrow Cu$$

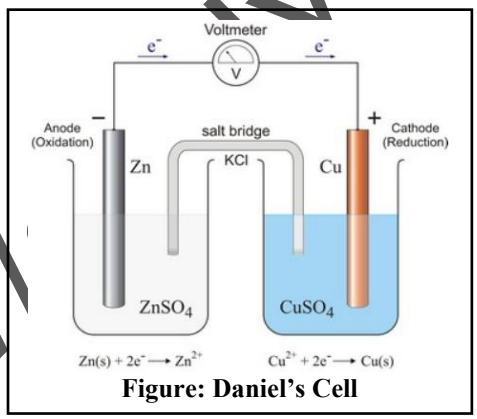


Figure: Daniel's Cell

13. What happens at the cathode in a galvanic cell? ***(U.B)***

Ans: **REACTION AT CATHODE IN GALVANIC CELL**

In galvanic cell, reduction takes place at the cathode as:

$$Cu^{+2}_{aq} + 2e^{-} \longrightarrow Cu_{s}$$

14. Which solution is used as an electrolyte in Nelson's cell? ***(K.B)***

Ans: **ELECTROLYTE IN NELSON'S CELL**

An aqueous solution of NaCl called brine is used as an electrolyte in Nelson's cell.

15. Name the by-products produced in Nelson's cell? ***(K.B)***

Ans: **BY PRODUCTS IN NELSON'S CELL**

Hydrogen gas (H_2) and chlorine gas (Cl_2) are the by-products of Nelson's cell.

$$2NaCl_{aq} + 2H_2O_{\ell} \longrightarrow \underbrace{H_{2(g)} + Cl_{2(g)}}_{\text{By-products}} + \underbrace{2NaOH_{aq}}_{\text{Product}}$$

16. Why galvanizing is done? **(GRW 2016 G-II)*(U.B+A.B)***

Ans: **GALVANIZING**

The process of coating a thin layer of zinc on iron is called galvanizing. Galvanizing is done to protect the iron against corrosion even after the required coating surface is broken.

17. Why an iron grill is painted frequently? **(MTN 2017)*(U.B+A.B)***

Ans: **PAINTING OF IRON GRILL**

Iron grill is painted frequently to protect it from rusting. Paint layer protect iron from attack of moisture and oxygen.

18. Why O_2 is necessary for rusting? ***(U.B)***

Ans: **RUSTING**

O_2 is necessary for rusting because it acts as oxidizing agent. It accepts electrons from Fe which is covered to Fe^{+2} and then to Fe^{+3}. Oxygen combines with Fe^{+3} to form rust ($Fe_2O_3.nH_2O$).

The overall cell reaction for corrosion of iron is:

$$O_{2(g)} + 4H^+_{(aq)} + 4e^- \longrightarrow 2H_2O_{(\ell)}$$

$$2Fe^{+2}_{(aq)} + \frac{1}{2}O_{2(g)} + (n+2)H_2O_{(\ell)} \longrightarrow Fe_2O_3.nH_2O_{(s)} + 4H^+_{(aq)}$$

19. In electroplating of chromium, which salt is used as an electrolyte? ***(K.B)***

Ans: **ELECTROPLATING OF Cr**

Chromium sulphate with few drops of H_2SO_4 acts as electrolyte in electroplating of chromium.

20. Write the redox reaction taking place during the electroplating of chromium? ***(U.B+A.B)***

21. In electroplating of silver, from where Ag + come and where they deposit? ***(U.B+A.B)***

Ans: **ELECTROPLATING OF SILVER**

In electroplating of silver, Ag^+ ions come from anode while they deposit at cathode.

22. What is the nature of electrode used in electroplating of chromium? ***(K.B)***

Ans: **NATURE OF ELECTRODE**

In electroplating of chromium, anode is made of antimonial lead while the object to be electroplated acts as cathode.

EXERCISE LONG QUESTIONS

1. Describe the rules for assigning the oxidation state.

Ans: *Answer given of pg # 235* a(Topic 7.2)

2. Find out the oxidation numbers of the underlined elements in the following compounds. ***(U.B+A.B)***

(a) **Na_2SO_4**

(b) **$AgNO_3$**

(c) **$KMnO_4$**

(d) **$K_2Cr_2O_7$**

(e) **HNO_2**

Ans: **OXIDATION NUMBERS OF UNDERLINED ELEMENTS**

(A) $Na_2\underline{S}_2O_4$:

$$2[\text{O.N of Na}]+[\text{O.N of S}]+4[\text{O.N of O}]=0$$

$$2[+1]+[S]+4[-2]=0$$

$$+2+S-8=0$$

$$S-6=0$$

$$S=+6$$

(B) $Ag\underline{N}O_3$:

$$[\text{O.N of Ag}]+[\text{O.N of N}]+3[\text{O.N of O}]=0$$

$$[+1]+[N]+3[-2]=0$$

$$+1+N-6=0$$

$$N-5=0$$

$$N=+5$$

(C) $K\underline{Mn}O_4$:

$$[\text{O.N of K}]+[\text{O.N of Mn}]+4[\text{O.N of O}]=0$$

$$[+1]+[Mn]+4[-2]=0$$

$$+1+Mn-8=0$$

$$Mn-7=0$$

$$Mn=+7$$

(D) $K_2\underline{Cr}_2O_7$:

$$2[\text{O.N of K}]+2[\text{O.N of Cr}]+7[\text{O.N of O}]=0$$

$$2[+1]+2[Cr]+7[-2]=0$$

$$+2+2Cr-14=0$$

$$2Cr-12=0$$

$$2Cr=+12$$

$$Cr=+6$$

(e) $H\underline{N}O_2$:

$$[\text{O.N.of H}]+[\text{O.N.of N}]+2[\text{O.N.of O}]=0$$

$$[+1]+[N]+2[-2]=0$$

$$+1+N-4=0$$

$$N-3=0$$

$$N=+3$$

2. How can a non-spontaneous reaction be carried out in an electrolytic cell? Discuss in detail.

Ans: *Answer give on pg # 244* (Topic 7.5)

3. Discuss the electrolysis of water.

Ans: *Answer give on pg #* 245 (Topic 7.5)

4. Discuss the construction and working of a cell in which electricity is produced.

Ans: *Answer give on pg #* 246 (Topic 7.5)

5. How we can prepare NaOH on commercial scale? Discuss its chemistry along with the diagram.

Ans: *Answer give on pg #* 252 (Topic 7.6)

6. Discuss the redox reactions taking place in the rusting of iron in detail. **(SGD 2017 G-II)**

Ans: *Answer give on pg #* 255 (Topic 7.7)

7. Discuss, why galvanizing is considered better than that of tin plating.

Ans: *Answer give on pg #* 257 (Topic 7.7)

8. What is electroplating? Write down procedure of electroplating?

Ans: *Answer give on pg #* 261 (Electrolytic method)

9. What is the principle of electroplating? How electroplating of chromium is carried out?

Ans: *Answer give on pg # 261* (Electrolytic method)

ADDITIONAL CONCEPTUAL QUESTIONS

Q.3 Differentiate between oxidation and reduction. ***(U.B)***

Ans: **DIFFERENTIATION**

The differences between oxidation and reduction are as follows:

Oxidation	Reduction
• Addition of oxygen	• Removal of oxygen
• Removal of hydrogen	• Addition of hydrogen
• Loss of electrons	• Gain of electrons

Q.6 Does aluminium rust? **(Science, Technology and Society Pg. # 129)(U.B+A.B)**

OR

Compare the process of corrosion of aluminium and iron. **(U.B+A.B)**

Ans: **RUSTING OF ALUMINIUM**

Aluminium corrodes but it does not rust. Rust refers only to iron and steel corrosion. A very hard material aluminum oxide protects the aluminium from further corrosion.

In comparison to that when iron corrodes, its color changes and produces large red flakes known as rust. Unlike aluminium oxide, the expanding and flaking of rust exposes new metal surface to further rusting.

Q.7 What is an alloy? Give an example? **(GRW 2016 G-II)(K.B+A.B)**

Ans: **ALLOY**

"Alloy is a homogeneous mixture of one metal with one or more other metals or non-metals. The process of formation of alloys is called alloying".

Best Example:

The best example of alloying is the 'stainless steel', which is a good combination of iron, chromium and nickel.

Q.3 Why steel is plated with nickel before the electroplating of chromium? ***(U.B+A+B)***

Ans: **STEEL IS ELECTROPLATED WITH NICKLE**

The steel is usually plated first with nickel or copper then by chromium because it does not adhere well on the steel surface. Moreover it also allows moisture to pass through it and metal is stripped off.

Q.4 In electroplating of silver, from where Ag^+ ions come and where they deposit? ***(U.B)***

Ans: **Ag^+ IN ELECTROPLATING**

In electroplating of Ag^+ (Silver) ions come from anode while they deposit at cathode.`1

Q.5 What is the nature of electrode used in electroplating of chromium? ***(K.B)***

Ans: **ELECTRODE IN CHROMIUM PLATING**

In electroplating of chromium, anode is made of antimonial lead while the object to be electroplated acts as cathode.

TERMS TO KNOW

Terms	Definitions
Electrochemistry	The branch of chemistry that deals with the **relationship** between **electricity** and **chemical reactions** is called electrochemistry.
Spontaneous Reactions	Spontaneous reactions are those which take place on their own **without an external agent.**
Non-spontaneous Reactions	Non-spontaneous reactions are those which take place in the **presence of an external agent.**
Oxidation	Addition of oxygen, removal of hydrogen or loss of electrons.
Reduction	Removal of oxygen, addition of hydrogen or gain of electrons.
Valency	The combining capacity of an element with other elements is called valency.
Oxidation Number	The **apparent charge** assigned to an **atom** of an element in a molecule or ion is called oxidation number.
Oxidizing Agent	A **specie** that **oxidizes a substance** by **taking electrons** from it, is called an oxidizing agent.
Reducing Agent	A **specie** that **reduces a substance** by **donating electrons** to it is called reducing agent.
Electrolyte	The substances which **can conduct electricity** in their **aqueous solution or molten state** are called electrolytes.
Strong Electrolytes	The electrolytes which **ionize almost completely** in solution and **produce more ions,** are called strong electrolytes**.**
Weak electrolytes	The electrolytes which ionize to a **small extent** when dissolved in water and **could not produce more ions** are called weak electrolytes**.**
Electrolysis	The **chemical decomposition** of a compound into its components by **passing current** through the **solution** of the compound or in the molten state of the compound is called electrolysis.
Electrolytic Cell	The **type of electrochemical cell** in which **a non-spontaneous chemical reaction** takes place when electric current is passed through the electrolyte, is called an electrolytic cell.

Galvanic or Voltaic Cell	The **electrochemical cell** in which a **spontaneous chemical reaction** takes place and **generates electric current** is called Galvanic or Voltaic cell.
Anode	Anode is an electrode where oxidation takes place.
Cathode	Cathode is an electrode where reduction takes place.
Brine	Concentrated solution of NaCl is called brine.
Corrosion	Corrosion is slow and continuous eating away of a metal by the surrounding medium.
Electroplating	Electroplating is **depositing of one metal over the other** by means of electrolysis.
Galvanizing	The process of **coating a thin layer of zinc** on iron is called galvanizing.
Electrochemical Cell	Electrochemical cell is an energy storage device in which either a chemical reaction takes place by using electric current (electrolysis) or chemical reaction produces electric current.
Salt Bridge	Salt bridge is a **U-shaped glass tube**. It consists of **saturated solution of strong electrolyte** supported in a jelly type material. The ends of the U tube are sealed with a porous material like glass wool.

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. (6×1=6)

1. Which one of the following is not an electrolytic cell?

(A) Down's cell **(B)** Galvanic cell
(C) Nelson's cell **(D)** Both A and B

2. The most common example of corrosion is:

(A) Rusting of tin **(B)** Rusting of aluminium
(C) Rusting of iron **(D)** Chemical decay of plastic

3. The formula of rust is:

(A) $Fe(OH)_3$ **(B)** $Fe(OH)_3.nH_2O$
(C) Fe_2O_3 **(D)** $Fe_2O_3\ nH_2O$

4. Which gas is produced in Down's cell?

(A) O_2 **(B)** O_3
(C) H_2 **(D)** Cl_2

5. Oxidation number of Sulphur in H_2SO_4:

(A) +6 **(B)** +4
(C) +14 **(D)** +7

6. Which metals are corrosion resistant?

(A) Zn, Fe **(B)** Ag, Au
(C) Sn, Cr **(D)** Cr, Hg

Q.2 Give short answers to the following questions. (5×2=10)

(i) Differentiate between strong and weak electrolyte.
(ii) Write comparison of electrolytic and galvanic cell.
(iii) What is salt bridge? Give its function.
(iv) Define oxidizing agents.
(v) Differentiate between valency and oxidation state.

Q.3 Answer the following questions in detail. (5+4=9)

(A) How can we prepare NaOH from brine on commercial scale? Explain working of Nelson's Cell along with the diagram. **(5)**

(B) What is electroplating? Write down the procedure of electroplating. **(4)**

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.