PREFACE

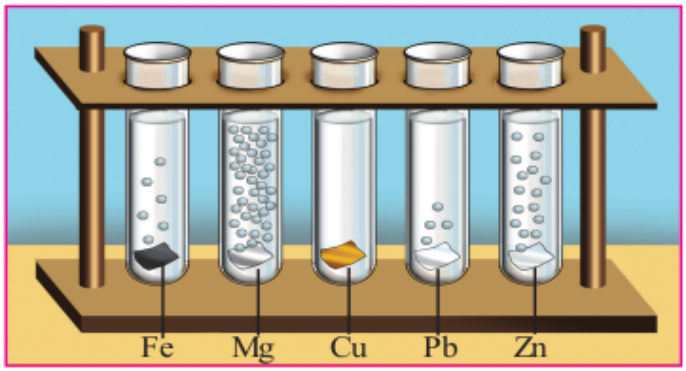
- This is an interactive self learning material exclusively meant for SSLC students of Kerala State Syllabus.
- This work is meant **only for** students appearing SSLC examinations , **march 2021**
- This is strictly in accordance with the Focus points suggested by SCERT
- **Scan the QR codes** given at each section to watch the video, related to the topic.
- You can also watch the videos using mobile,laptop etc by clicking / touching the QR codes. Make sure that the data connection is ON.
- Focus Points are marked as ♥♥♥
- Constructive suggestions for further improvement are always welcome

3 Reactivity series and Electrochemistry

Some metals engage in chemical reactions vigorously, certain others react sluggishly in the same reaction.

Reaction of Metals with Acids

The image given below shows the reaction of some metals with dilute HCl



ARQCKL

This indicates that metals react with dilute HCl at different rates.

1.♥♥♥ What is reactivity series?

The series obtained by arranging the metals in the decreasing order of their reactivity is known as the reactivity series.

Note that hydrogen is also included in this series for the sake of comparison of chemical reactivity.

Potassium	K
Sodium	Na
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Zinc	Zn
Iron	Fe
Nickel	Ni
Tin	Sn
Lead	Pb
Hydrogen	H
Copper	Cu
Silver	Ag
Gold	Au

React with dil acids and displace hydrogen

Do not displace hydrogen from dil acids

♥♥♥Reactivity series and displacement reactions

2.♥♥♥Prepare some $CuSO_4$ solution in a beaker and dip a Zn rod in it. Observe the changes after sometime and write down the observations.

Observation	Before the experiment	After the experiment
Colour of Zinc rod	Grey	Covered with copper
Colour of $CuSO_4$ solution	Blue	**Colourless**

The blue colour of $CuSO_4$ solution is due to the presence of Cu^{2+} ions. When the Zn rod is dipped in $CuSO_4$ solution, the Cu^{2+} ions in the solution get deposited at the Zn rod as Cu atoms. The chemical reaction taking place here is given below.

$$\mathbf{Zn + CuSO_4 \rightarrow ZnSO_4 + Cu}$$

Zinc is more reactive than copper. Hence zinc will displace copper from the solution. As a result, $ZnSO_4$ and Copper are formed. The blue colour of the solution diminishes and disappears. The displaced copper gets deposited at the zinc rod.(The colour of the solution changes to the colour of the newly formed compound(solution).

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow \mathbf{ZnSO_4}_{(aq)} + Cu_{(s)}$$

The ionic form of the above reaction is given below.

$$Zn^{0}_{(s)} + Cu^{2+}SO_4^{2-}{}_{(aq)} \rightarrow Zn^{2+}SO_4^{2-}{}_{(aq)} + Cu^{0}_{(s)}$$

Here Zinc undergoes the following reaction,

$$\mathbf{Zn^{0}_{(s)} \rightarrow Zn^{2+} + 2\,\bar{e}}$$

Each ***Zinc atom loses two electrons*** . That is , ***Zinc undergoes Oxidation .***

At the same time ,Cu^{2+} ions receive two electrons to become Cu atoms

$$\mathbf{Cu^{2+} + 2\,\bar{e} \rightarrow Cu^{0}_{(s)}}$$

Each ***Zinc Copper ion gains two electrons*** . That is , Copper ions ***undergo Reduction.***

Since oxidation and redox reactions occur simultaneously , this is a redox reaction.

3.♥♥♥ A copper plate is immersed in $AgNO_3$ solution,

(a) Identify and record the changes.

Answer: Copper is more reactive than Silver. Hence copper will displace silver from silver nitrate solution. Silver gets deposited at the copper plate. Since copper nitrate solution is formed, the colour of the solution becomes blue.

$$Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Ag_{(s)}$$

(b) Write the reaction in ionic form to show that it is a redox reaction

$$Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Ag_{(s)}$$

$$[Cu^{0}_{(s)} \rightarrow Cu^{2+} + 2\,\bar{e}$$
$$2Ag^{+} + 2\,\bar{e} \rightarrow 2\,Ag^{0}_{(s)}]$$

$$Cu^{0}_{(s)} + 2Ag^{+} + \rightarrow Cu^{2+} + 2\,Ag^{0}_{(s)}$$

Each Copper atom loses two electrons . That is , ***Copper undergoes Oxidation .***

Each Ag^{+} ***ion gains one electron*** . Hence Silver ions ***undergo Reduction.***

Since oxidation and redox reactions occur simultaneously , this is a redox reaction.

♥♥♥ Displacement reactions

Highly reactive metals can displace less reactive metals from their salt solutions . Such reactions are called displacement reactions. **Displacement reactions are redox reactions.**

4.♥♥♥Certain metals and the salt solutions in which they are dipped are given below. Identify displacement reaction occurs.

Metal/ Solution	**Mg**	**Cu**	**Zn**	**Fe**	**Ag**	**Al**
Magnesium sulphate						
Copper sulphate						
Zinc sulphate						
Ferrous sulphate						
Silver nitrate						
Aluminium nitrate						

Answer:

Metal/ Solution	**Mg**	**Cu**	**Zn**	**Fe**	**Ag**	**Al**
Magnesium sulphate	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**
Copper sulphate	**Reaction occurs**	**No reaction**	**Reaction occurs**	**Reaction occurs**	**No reaction**	**Reaction occurs**
Zinc sulphate	**Reaction occurs**	**No reaction**	**No reaction**	പ്രവർത്തനമില്ല	**No reaction**	**Reaction occurs**
Ferrous sulphate	**Reaction occurs**	**No reaction**	**Reaction occurs**	പ്രവർത്തനമില്ല	**No reaction**	**Reaction occurs**
Silver nitrate	**Reaction occurs**	**Reaction occurs**	**Reaction occurs**	**Reaction occurs**	**No reaction**	**Reaction occurs**
Aluminium nitrate	**Reaction occurs**	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**

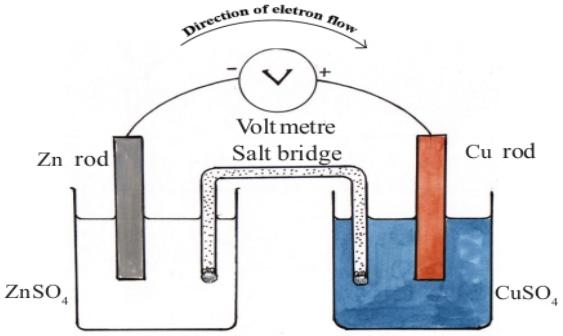
5. ♥♥♥Arrange the above metals in the decreasing order of their reactivity.

Answer: Mg > Al > Zn > Fe > Cu > Ag

♥♥♥ Galvanic cell

We have learned that metals differ in their reactivity. Galvanic cell is an arrangement in which the difference in reactivity of metals is used to produce electricity.

Arrange the apparatus as shown in the picture. Take two beakers, one containing 100mL $ZnSO_4$ solution and the second containing the same amount of $CuSO_4$ solution with the same concentration.



Connection details

Zn rod in $ZnSO_4$ solution , Cu rod in $CuSO_4$ solution.

Negative terminal of voltmeter is connected to the Zn rod and the positive terminal to the Cu rod. Two solutions in the beakers are connected using a salt bridge

(A long filter paper moistened with KCl solution can be used instead of salt bridge).

Observation

The reading of the voltmeter changes. We can produce electricity using such arrangements.

Here electricity is produced due to chemical change.

Galvanic cell or voltaic cell is an arrangement in which chemical energy is converted into electrical energy by means of a redox reaction.

6. ♥♥♥ We have understood from the reactivity series that Zn has higher reactivity than Cu.

a. Which electrode has the ability to donate electrons in a cell constructed using these metals?

Answer: Zn

b. Which one can gain electrons?

Answer: Cu

c. Identify the chemical reaction that takes place at the Zn electrode.

(i) $Zn \rightarrow Zn^{2+} + 2\,\bar{e}$

(ii) $Zn^{2+} + 2\,\bar{e} \rightarrow Zn$

Answer: **(i) $Zn \rightarrow Zn^{2+} + 2\,\bar{e}$**

d. Which reaction takes place here? Oxidation/Reduction

Answer: Oxidation

That is, Zn loses two electrons and becomes Zn^{2+} . This process is known as oxidation.

An electrode at which oxidation occurs is called anode. **Anode has negative charge in this case.**

The electrons liberated from Zn rod reach the copper electrode through the external circuit . These electrons are received by copper ions in the solution changing them into copper.

a. Write the chemical equation for the reaction taking place at the Cu electrode.

Answer: $Cu^{2+} + 2\,\bar{e} \rightarrow Cu$

b. Which reaction takes place here? Oxidation/Reduction

Answer: Reduction

That is, Cu gains two electrons and becomes Cu .

An electrode at which reduction occurs is called cathode. **Cathode has positive charge in this case.**

Normally highly reactive metals donate electrons

*The electrode at which **oxidation** occurs is the **anode** and that at which **reduction** occurs is the **cathode. Anode** attains **negative** charge and **cathode** gets **positive** charge.*

This redox reaction can be written as

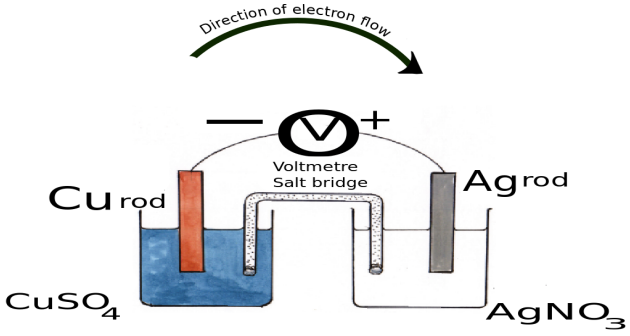
$Zn_{(s)} \rightarrow Zn^{2+} + 2\,\bar{e}$

$Cu^{2+} + 2\,\bar{e} \rightarrow Cu_{(s)}$

♥♥♥ $Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+} + Cu_{(s)}$

Since oxidation and reduction occur at the same time, it is a redox reaction.
The transfer of electrons produced by this redox reaction causes the flow of electric current in the cell. The direction of electron flow is from anode to cathode.

7. ♥♥♥ Construct a galvanic cell using silver and copper electrodes.



Anode	Cu	Cu is more reactive than Ag
Cathode	Ag	
Reaction at anode	**$Cu \rightarrow Cu^{2+} + 2\bar{e}$**	2 Ag^{+}ions receive the two electrons
Reaction at cathode	**$Ag^{+} + \bar{e} \rightarrow Ag$**	

8. ♥♥♥ How many cells can be constructed using Zn , Cu and Ag ?
Find the cathode and anode of the cell.

Answer:

Cell	*Anode*	*Cathode*
Zn – Cu	Zn	Cu
Zn – Ag	Zn	Ag
Ag - Cu	Cu	Ag

♥♥♥ Electrolytic cells

Electrolysis of water is a chemical reaction employing electrical energy. We have learned about this chemical reaction in lower classes.

The process of chemical change taking place in an *electrolyte* by passing electricity is known as electrolysis.

Electrolytes are substances which conduct electricity in molten states or in aqueous solutions and undergo chemical change.

Acids, alkalis and salts are electrolytes in their molten state or in aqueous solution.

In molten state or in aqueous solution, ions of the electrolytes can move freely. These ions are responsible for the conduction of electricity by the electrolytes.

It was Michael Faraday who gave a scientific explanation for electrolysis for the first time. Electrodes are substances which pass electricity to the electrolytes. During electrolysis one electrode is connected to positive terminal of a battery and the other to the negative terminal. The electrode which is connected to the positive terminal of the battery is the anode. The electrode which is connected to the negative terminal is the cathode.

Electrode at which oxidation takes place is anode and electrode at which reduction take place is cathode. In an electrolytic cell oxidation takes place at the positive electrode and reduction takes place at the negative electrode.

9. ♥♥♥ Compare and contrast galvanic cells and electrolytic cells.
Answer:

Galvanic Cells	Electro**lytic** cells.
Chemical energy is converted into electrical energy	Electrical energy is used to bring about a chemical change.
Anode is negative	Anode is positive
Cathode is positive	Cathode is negative
Oxidation occurs at anode	Oxidation occurs at anode
Reduction occurs at cathode	Reduction occurs at cathode

10.♥♥♥ a.To which electrodes are the positive ions attracted during electrolysis?

Answer: During electrolysis, *positive ions are attracted towards negative electrode*(Cathode)

b.To which electrodes are the negative ions attracted during electrolysis?

Answer: During electrolysis, *negative ions attracted towards positive electrode*(Anode)

c.What changes happen to the ions which are attracted to cathode?

Answer: Positive ions are attracted to cathode. They receive electrons to become atoms or molecules . (Positive ions get reduced at cathode)

d.What changes happen to the ions which are attracted to anode?

Answer: Negative ions are attracted to anode. They donate electrons to become atoms or molecules . (Negative ions get oxidised at anode).

The positive ions which are attracted towards the negative electrode are called cations and negative ions which move towards the anode are called anions.

11. ♥♥♥ Electrolysis of molten sodium chloride

Sodium chloride in solid state is not an electrical conductor because its ions have no freedom of movement. But electricity flows through molten sodium chloride. When sodium chloride melts, the positively charged sodium ions (Na^+) and the negatively charged chloride ions (Cl^-) are free to move.

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

- Which ion is attracted to the positive electrode (anode)?

  Cl^-
- What is the chemical reaction taking place there?

  $2Cl^- \rightarrow Cl_2 + 2\,\bar{e}$
- Which is the gas liberated at the anode?

  Cl_2
- Which is the ion attracted to the negative electrode (cathode)?

  Na^+
- Write the change happening to it?

  $Na^+ + \bar{e} \rightarrow Na$
- Which is the metal deposited at the cathode?

  Na