

10 Electrolysis



10.1 Electrolysis

There was a news item of a woman who has been cooking food keeping an aluminum pan on a electric leaky hot plate was struck with an electric shock when she was pouring coconut milk into the curry. She had got the shock even though she was not touching the pan. How would this have happened? The leaking electric current should have passed through coconut milk and entered the woman's body. Your elders must have told you that connecting electric plugs with wet hands is dangerous. The reason for the electric leaks stated above should be the conduction of electricity through a liquid medium.

Let us do activity 10.1 to find out whether electricity is conducted through any substance in liquid state.



Activity 10.1

You will need :- A beaker, two carbon rods, an ammeter, two dry cells (1.5 V), connecting wires, kerosene, salt solution, acidified water, copper sulphate solution, distilled water

Method:-

- Connect the ammeter and the two dry cells to the two carbon rods as shown in the figure. 10.1. Dip the two carbon rods partially in the liquid/solution.
- Pour the liquids/solutions given above into the beaker.
- Observe whether there is a deflection in the ammeter.
- Tabulate your observation.

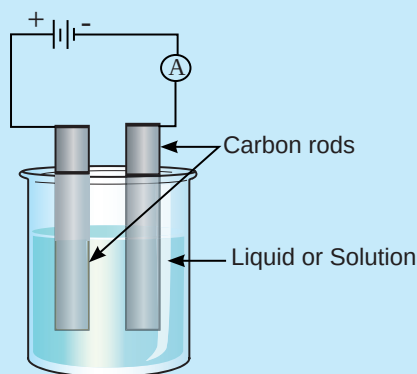


Figure 10.1

It is seen here that the ammeter deflects only when some liquids/solutions are used.

Table 10.1

Liquids/solution causing a deflection in the ammeter	Liquids/solutions not causing a deflection in the ammeter
Salt solution	Kerosene
Copper sulphate solution	Distilled water
Acidified water	

Indicator of the ammeter deflects when a current passes through it. Therefore, a current has passed through the solutions resulting a deflection in the ammeter. The solutions of salt, copper sulphate and acidified water, all contain mobile ions. These solutions conduct electricity through these mobile ions. Liquids or solutions which conduct electricity are called **electrolytes**.

Since kerosene and distilled water do not conduct electricity, they do not bring about a deflection in the ammeter. Such liquids/solutions do not conduct electricity as they do not contain mobile ions. Liquids/solutions which do not conduct electricity are referred to as **non-electrolytes**.

Compounds such as sodium chloride and copper sulphate are known as ionic compounds. They exist in the solid state. They are made up of oppositely charged ions formed by the relevant atoms. You will be able to learn more about them in grade 10.

Although, there are ions in solid ionic compounds they cannot move freely. Hence, those compounds do not conduct electricity in the solid state. But, if an ionic compound is dissolved in water to give an aqueous solution, the ions in it become mobile. Thus, aqueous solutions of ionic compounds are good conductors of electricity.

When an ionic solid is heated and brought to the liquid state, it is called a fused substance. Ions in a fused liquid also can move. Accordingly, Ionic compounds conduct electricity in the fused state.

10.2 Changes caused in a solution by an electric current

When electricity is conducted through an electrolyte, the conductors through which the electric current enters the electrolyte and exits are called electrodes. In the activity 10.1 above the electric current enters the solution by one carbon electrode and exits from the solution through the other carbon electrode.

Let us engage in activity 10.2 to study the changes brought about in a solution by an electric current.



Activity 10.2

You will need :- [A beaker, an ammeter, connecting wires, copper sulphate solution, carbon electrodes, two dry cells (1.5 V)]

Method:-

- Set up apparatus as shown in the figure 10.2 and pass electricity through the copper sulphate solution.
- Note down your observations.

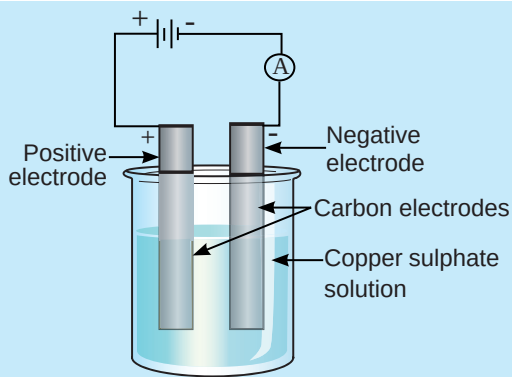


Figure 10.2

The electrode connected to the positive terminal of the external supply of electricity is called the **positive electrode**. The electrode connected to the negative terminal of the external supply of electricity is called the **negative electrode**. In the above activity it can be observed the deposition of a reddish brown substance at the negative electrode and the liberation of gas bubbles at the positive electrode. A gradual decrease in the blue colour can also be observed in the solution. Hence, it is clear that the compounds contained in the beaker undergo a chemical change.

This chemical change is caused by the electric current passed through the solution. Here, copper is deposited on the negative electrode and oxygen gas is liberated at the positive electrode. Copper sulphate undergoing the chemical change has turned into copper, a simpler substance. The chemical change effected by passing an electric current through an electrolyte is known as **electrolysis**. During this process, the electrolyte is converted into more simpler components.

A substance that doesn't react chemically with the electrolyte referred as inert electrodes. Carbon (graphite) and platinum electrodes are such examples.

Electrolysis of acidulated water

By activity 10.2, we learnt that in an electrolysis, an electrolyte is converted into more simpler products. To explore more about this, let us find out the products of the electrolysis of acidulated water. For this let us go ahead with activity 10.3.



Activity 10.3

You will need :- Distilled water with a few drops of a dilute sulphuric acid, a 9 V battery, two carbon rods, a plastic container, connecting wires, two test tubes.

Method:-

- Make two holes on the bottom of a plastic container. Pass two carbon rods through these holes and seal the holes with a substance such as wax.
- Add acidulated water into the container and arrange the apparatus as shown in Figure 10.3.
- Observe well
- Record observations.

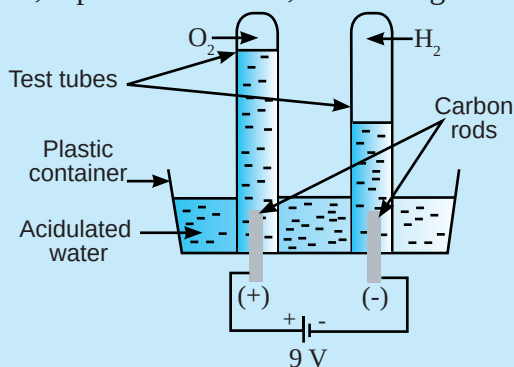


Figure 10.3

In this activity, it can be observed that gas bubbles evolve at the electrodes. The gases evolved get collected in the test tubes. The volume of the gas collected at the negative electrode is approximately twice the volume of the gas collected at the positive electrode.

It can be examined that hydrogen gas (H_2) evolves at the negative electrode and oxygen gas (O_2) evolves at the positive electrode.

If the gas evolved at the positive electrode is collected and tested with a glowing splint is put into it, the splint reignites. This verifies that the gas evolved at the positive electrode is oxygen. Similarly, if the gas evolved at the negative electrode is separated and a lighted splint is put into it, the gas burns with a squeaky "pop" sound. This confirms that the gas evolved at the negative electrode is hydrogen.

Thus, during electrolysis, water is splitted into more simpler substances, hydrogen and oxygen.

Applications of electrolysis

Electrolysis is frequently used in various industries.

- Extraction of various metals e.g. sodium, aluminum
- Industrial manufacture of caustic soda (sodium hydroxide)
- Electroplating

Let us now study electroplating which is an application of electrolysis.

10.3 Electroplating

Recall the observations of activity 10.2. you would have observed the deposition of copper on the negative electrode. By engaging in the activity 10.4, let us investigate whether copper can be deposited on a certain object.



Activity 10.4

You will need :- Aqueous copper sulphate solution, a clean copper plate, a cleaned iron nail, a beaker, connecting wires, two dry cells of 1.5 V

Method :-

- Connect dry cells to the copper plate and the iron nail as shown in figure 10.4 and dip them at once in the copper sulphate solution.
- Record your observations.

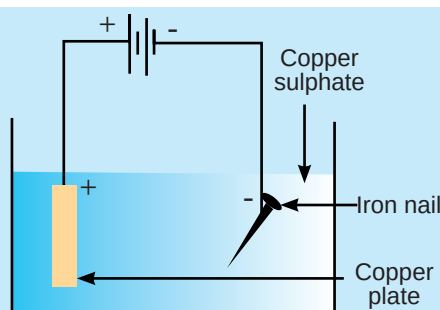


Figure 10.4

In the activity 10.4, you can observe that the copper plate gradually dissolves and copper is deposited on the iron nail. The plating of a certain metal on another surface using electricity is referred to as **electroplating**.

For electroplating, the metal that needs to be plated should be used as the positive electrode and the object that is plated should be used as the negative electrode. Further, the electrolyte used needs to be a solution of a salt of the metal that should be plated.



Assignment 10.1

1. Electroplating silver on an iron plate
2. Electroplating gold on a copper ring

Draw figures of suitable apparatus (as in figure 10.4) for no 1 and 2 instances stating the positive electrode, negative electrode and the electrolyte in each case.

Take the iron nail you used in activity 10.4 to your hand and touch its plating with your fingers. You will observe that the copper plating will get removed from the nail and comes to your finger tips.

This shows that the plating occurred in this way is not in good quality.

Let us consider the characteristics of a high quality electroplating.

- The coating should firmly adhere to the surface subjected to plating.
- The coating should be of confirm thickness.
- The coating should be shiny.

Such a high quality plating occurs when the electrochemical change take place very slowly. The electrolyte (salt solution) used for this has to be very dilute.

The chemical change occurring can also be slowed down by passing a very low current through the solution. This can be effected by applying a low potential difference.

In chemical industries, high quality electroplating is done by controlling the conditions appropriately.

Plating of metals like nickel and chromium on iron trays is an example. This gives a beautiful silver appearance to the tray.

Applications of electroplating

Pay your attention to vases, trays, cutlery and door locks offering a golden or silvery lustre which are being used at home. Very often the luster of these objects is due to a metal layer deposited on them. In order to prevent rusting of the parts of motor vehicles, they are coated with a thin metallic layer by electroplating. Mostly metals like copper (Cu), silver (Ag), gold (Au), nickel (Ni) and chromium (Cr) are plated like this. In such instances, the metal plate has a certain property which is lacking in the metal which is subjected to plating. Resistance to **corrosion, attractive colour, luster and good finish** are some of such properties.

- Electroplating nickel metal on iron tray protects it from rusting and also gives it an attractive appearance.
- Electroplating a copper jewellery with gold adds value to it and gives it a rich look.



Figure 10.5 - Some copper jewellery subjected to electroplating



Figure 10.6 - Some electroplated kitchen equipment



Figure 10.7 - Some electroplated spare parts



Summary

- Liquids/ solutions which conduct electricity are called electrolytes.
- The reason for the electrical conductivity of electrolytes is the presence of mobile ions in them.
- Liquids/solutions which do not conduct electricity are called non electrolytes. They do not contain mobile ions.
- Though ionic compounds contain ions, they cannot move in the solid state. Therefore, solid ionic compounds do not conduct electricity.
- Aqueous solutions and fused liquids of ionic compounds conduct electricity.
- The chemical changes taking place at the electrodes when an electric current is passed through an electrolyte is referred to as electrolysis.
- During electrolysis, chemical compounds are splitted into more simpler compounds or elements.
- By electrolyzing acidulated water, water can be turned into the elements, hydrogen and oxygen.
- Coating one metal with another metal by passing an electric current is called electroplating.
- When electroplating, always the metal that is subjected to plating should be kept as the negative electrode.
- During electrolysis the metal that is plated is kept the anode while a solution of a salt of that metal is used as the electrolyte.
- A high quality plating occurs when the chemical changes at the electrodes occur very slowly.
- To obtain a high quality plating in chemical industry, conditions are appropriately controlled.
- In electroplating, it is expected that the metal that is plated possesses superior qualities to that of the surface being plated.

Exercises

(01) Select the correct or most suitable answer.

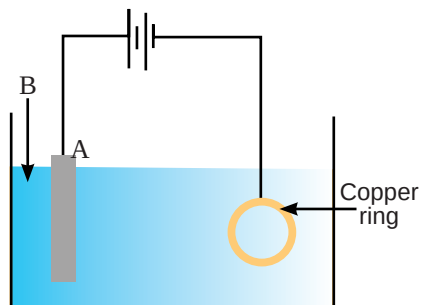
- What is the electrolyte, from the given liquids or solutions?
 - Distilled water
 - Sugar dissolved in distilled water
 - Sodium chloride dissolved in distilled water
 - Grease dissolved in kerosene
- Petrol is not an electrical conductor because,
 - It does not contain mobile electrons
 - It does not contain mobile ions
 - Its density is very low
 - It is highly volatile
- Select the correct statement, from the following statements.
 - Solid sodium chloride (NaCl) is an electrical conductor
 - Fused sodium chloride (NaCl) does not conduct electricity
 - An aqueous solution of sodium chloride (NaCl) conducts electricity
 - Solid sodium chloride (NaCl) consists of mobile ions.
- Which of the following statement is correct about electroplating?
 - To make a high quality electroplating, the concentration of the electrolyte must be high
 - To electroplate a copper ring with silver, the copper ring must be kept as the positive electrode,
 - To electroplate a copper ring with silver, a copper salt must be taken as the electrolyte
 - When electroplating a copper ring with silver, the positive electrode erodes gradually
- You are required to coat a silver bangle with gold. Which of the following set of substances is most suitable for it?
 - A silver rod, a very dilute solution of a silver salt
 - A gold rod, a very dilute solution of a silver salt
 - A gold rod, a very dilute solution of a gold salt
 - A gold rod, a concentrated solution of a gold salt
- Which of the following is **not** an observation of the electrolysis of a copper sulphate solution?
 - Decaying of the positive electrode
 - Reducing the blue colour of the solution
 - Deposition of copper on the negative electrode
 - Liberation of gas bubbles at the positive electrode

(02) Give short answers.

1. Name three electrolytes.
2. Name three non-electrolytes.
3. Write three observations when electrolysis of a copper sulphate solution occurs using inert electrodes.
4. Name the gases liberated at the positive and negative electrodes during the electrolysis of acidulated water.
5. In addition to the liberation of gas bubbles at the electrodes, write an observation that can be made during this electrolysis.
6. Write a simple test to identify the gas liberated at each electrode.

(03) The diagram shows an electrolytic cell used to electroplate a copper ring with silver.

1. Name a metal that can be used as electrode A.
2. What is the sign of the electrode A? positive or negative?
3. Which solution of a salt of which metal can be used as solution B which, is the electrolyte?
4. What precautions can be taken to obtain a plating of high quality ?



Technical Terms

Electrolysis	- විද්‍යුත් විච්ඡේදනය	- மின்பகுப்பு
Electrolyte	- විද්‍යුත් විච්ඡේදකය	- மின்பகுபொருள்
Non-electrolyte	- විද්‍යුත් අවිච්ඡේදකය	- மின்பகாப்பொருள்
Positive electrode	- ධන ඉලෙක්ට්‍රෝඩය	- நேர்மின்வாய்
Negative electrode	- ඍණ ඉලෙක්ට්‍රෝඩය	- மறைமின்வாய்
Electroplating	- විද්‍යුත් ලෝහාලේපනය	- மின் முலாமிடல்
Inert electrodes	- අක්‍රීය ඉලෙක්ට්‍රෝඩ	- சடத்துவ மின்வாய்