CHAPTER 12

The Effects of Electricity in Liquids

Electricity is one of the most important forms of energy known to us. It can provide light from bulbs and warmth from electric heaters. It can generate sound in a radio and produce pictures on a television set. It can power the huge engines of a high speed electric train and turn a piece of iron into a magnet. This is not all! In this chapter, we will learn more about the effects of electricity.

Exercise 1

In this list of substances, underline the ones that are good conductors of electricity.

copper rod, iron nail, glass tumbler, silver chain, rubber gloves, plastic spoon, aluminium foil, wooden ruler, steel spoon, safety pin, metal frame of spectacles, gold earrings

You already know that most metals are good conductors of electricity. Even mercury, the only liquid metal shows this property. What about other liquids and solutions? Do they too conduct electricity like mercury?

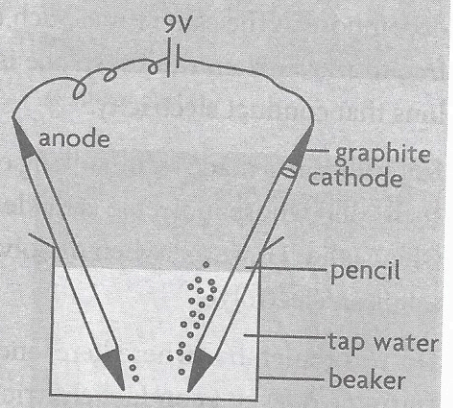
Exercise 2

Name a non-metal that conducts electricity.

Activity 1 To Find out if Liquids Conduct Electricity

You will need: a beaker, wires, a 9V battery, pencil lead or carbon rods (cut open used-up dry cells to get them), a torch bulb, some tap water

Work in groups, set up the apparatus as shown in the figure. Make sure that the insulation at each end of the copper wires is removed and wrap them firmly around the carbon rods as shown.



▲ electrolysis of Water

The two carbon rods, called **electrodes**, are used to carry the electricity into the liquid. These electrodes are made of **inert** substances which will not react with other substances.

Complete the circuit and watch the electrodes carefully. Do you notice bubbles collecting at the two electrodes? Is there any difference in the amount of bubbles forming at each electrode? Can you say what the bubble formation at the electrodes indicates? Where do the gases come from? (Hint: What are the gases that make up a water molecule?)

Clearly, tap water allows electricity to flow through it. It conducts electricity and in the process, the water breaks down into hydrogen and oxygen. **The breakdown of a chemical compound by electricity is called electrolysis.**

Now, repeat the activity with **distilled water**. What difference do you notice now?

Dissolve some common salt in the distilled water. Can electricity flow through it now?

Distilled water is pure water. Water on its own is a very poor conductor of electricity. However, some solutions made by dissolving a substance in water are good conductors of electricity. These substances are called **electrolytes**. The water in rivers, seas, lakes, as well as tap water, conducts electricity because all of them always contain several dissolved salts. Distilled water, which does not contain any dissolved salts, is a poor conductor of electricity.

Exercise 3

Why are we advised not to touch electrical appliances with wet hands?

Activity 2

Try the above activity again using other liquids like sugar solution, lemon juice, vinegar, honey, vegetable oil and kerosene. What do you find? Which ones conduct electricity? Do you notice anything happening at the electrodes?

Not all liquids conduct electricity. Some solids conduct electricity when dissolved in water and they decompose at the same time. Such solids contain **ions**, which are charged particles. The ions become free to move when the substance is dissolved and electricity is passed through the solution. It is the ions that conduct electricity.

Salt solution is made by dissolving common salt (sodium chloride, NaCl) in water. Common salt is one such solid whose molecule is made up of negatively and positively charged ions. It is a non-conductor when solid. However, when dissolved in water, it can conduct electricity. Thus, a solution of common salt is an electrolyte.

Do you remember where kerosene is obtained from? It is a hydrocarbon. You must have found that kerosene does not conduct electricity. Hence it is a **non-electrolyte**.

Is lemon juice an electrolyte? Remember lemon juice is an acid.

Conductors like silver, copper, mercury and other metals are elements, and remain unchanged when they conduct electricity. Electrolytes are compounds that conduct electricity when they are in solution or in the molten state. During electrolysis they decompose. Many acids, bases and salts dissolved in water are electrolytes.

Exercise 4

Find out the name of the electrolyte used in car batteries.

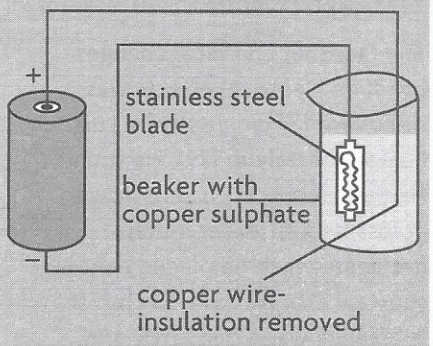
Uses of Electrolysis

Activity 3 Electroplating a Blade

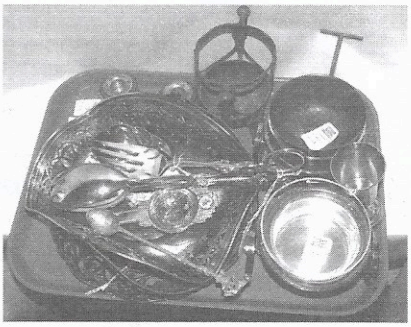
You will need: copper sulphate solution, beaker, a new stainless steel blade, some copper wires, a fresh 1.5V battery

Make the connections as shown. Wait for a few minutes. Take out the blade and look at it carefully. What do you notice? You will see a reddish-brown deposit on the blade. This reddish-brown substance is copper. The blade gets coated with copper. Which terminal was the blade connected to?

On passage of the electric current, the positively charged copper ions from the solution go to the negatively charged blade and get deposited there.



Electrolysis is often used to coat one metal with another. **This process of coating one metal over another with the help of electricity is called electroplating.** This is usually done to make the object more attractive, or to prevent it from rusting. Electroplating is used a great deal in industry. For example, steel is electroplated with tin, to make containers for food. Silver cutlery that you may have seen, is usually made of less expensive and stronger brass which is electroplated with silver.



▲ silver cutlery

The bumpers and door handles of motor cars, bicycle handlebars, towel rails and taps are coated with a silvery layer of chromium. Chromium does not corrode easily. It can be polished to give it a bright look. It also forms a hard layer which does not wear out or scratch easily.

▲ chrome alloy wheels

Electrolysis is used in purifying metals. Copper, for example, is purified by electrolysis. Copper which is used in electrical wires must be very pure.

Metals like sodium and aluminium are obtained from their ores by the process of electrolysis. Aluminium is extracted from alumina, Al_2O_3. Electricity is passed through molten alumina.

During electrolysis, the alumina is split up into its elements, aluminium and oxygen. Liquid aluminium collects at the negative electrode and oxygen is released at the positive electrode. The liquid aluminium is collected from time to time.

Did you know?

The fact that chemical changes produce electrical effects was discovered accidentally by Luigi Galvani of Italy in 1791. He found that an electrical current flowed across two different metals between which he placed a moist substance. In his case, the moist substance was a dead frog and the passage of electrical current was detected by the twitching of its leg.

Activity 4 Electrolysis of Potassium Iodide

You will need: filter paper, a 9V battery, carbon electrodes, connecting wires, potassium iodide, water

Soak the filter paper in potassium iodide solution. Here potassium iodide is the electrolyte. Take the paper out and place it on a glass sheet to drain. Connect the wet filter paper to the negative terminal of a 9V battery. Connect a wire to the positive terminal of the battery. Switch on the circuit and write on the wet paper with the free end of the wire connected to the positive terminal. When the positive electrode touches the wet paper blue-black colour appears.

Exercise 5

Paper contains starch. What part of the electrolyte, potassium iodide, gives blue-black colour at the positive electrode?

Exercise 6

In the electrolysis of potassium iodide solution, scientists found hydrogen gas being collected at the negative electrode. Where did the hydrogen come from?

Electrolytes do not just let electricity pass through them, they undergo some changes too. Sometimes bubbles of gas can be seen at one or both electrodes, and sometimes a solid or a liquid appears around an electrode. New substances are being formed.

Electrolytes let electricity pass through them and, at the same time, are chemically changed by it. Thus, electrical energy can cause chemical changes.

For some electrolytes, the new substances formed at the electrodes come from the dissolved solid. The copper deposited on the blade from the electrolysis of copper sulphate must come from the copper sulphate itself.

Exercise 7

In the electrolysis of a solution of magnesium nitrate, the oxygen that was to be formed at the positive electrode could not be detected at the positive carbon electrode. Instead, carbon dioxide was formed. Can you say how?

Exercise 8

Here are some results of passing electricity through solutions of salts in water. Study the table, then recapitulate what you have learnt about the Reacivity Series and answer the questions that follow.

Salt	Substance Formed at Negative Electrode
i. lead nitrate	lead
ii. magnesium nitrate	hydrogen
iii. sodium chloride	hydrogen
iv. silver nitrate	silver
v. potassium iodide	hydrogen
vi. zinc sulphate	hydrogen
vii. copper chloride	copper

The electrolysis of some solutions gives rise to hydrogen at the negative electrode. In these cases, the electricity is breaking down the water into its elements.

Reactivity Series (or Activity Series) of Metals

These metals are more reactive than hydrogen.	**potassium**	**K**
	sodium	Na
	calcium	Ca
	magnesium	Mg
	aluminium	Al
	zinc	Zn
	iron	Fe
	tin	Sn
	lead	Pb
	[hydrogen]	**[H]**
These metals are less reactive than hydrogen.	copper	Cu
	platinum	Pt
	silver	Ag
	gold	Au

(most reactive metal)

decreasing chemilcal reactivity

(least reactive metal)

a. Write the chemical formulae of the salts listed in the table.

b. Classify the salts into a group that forms a metal at the negative electrode and a group that forms hydrogen.

c. What is the connection between the metal salts that form hydrogen at the negative electrode and their position in the metal reactivity series? Study the reactivity series before answering.

d. What is likely to be formed at the negative electrode when electricity is passed through calcium nitrate solution? Explain your answer.

Exercise 9

Will mercury be a conductor or an electrolyte?

CHECK IT OUT

1. copper rod, iron nail, glass tumbler, silver chain, rubber gloves, plastic spoon, aluminium foil, wooden ruler, steel spoon, safety pin, metal frame of spectacles, gold earrings **2.** *graphite* ***Activity 1:*** *The bubble formation at the electrodes indicates the formation of gases. Water decomposes into hydrogen and oxygen when an electric current is passed through it. Since water has two hydrogen atoms for every oxygen atom, twice as much hydrogen is formed at the electrode connected to the negative terminal. Distilled water does not give the same reaction. When salt is added, it again conducts electricity.* **3.** *The water may conduct electricity and give us a shock.* ***Activity 2:*** *Only lemon juice and vinegar conduct electricity. Kerosene and sugar solution do not conduct electricity.* **4.** *A car battery contains lead plates placed in sulphuric acid. The sulphuric acid is the electrolyte.* **5.** *Brown iodine turns blue-black in the presence of starch. This shows that iodine is formed at the positive electrode.* **6.** *During the electrolysis of some solutions, hydrogen is formed at the cathode and oxygen at the positive electrode even though the solid dissolved in the water may not contain these elements. In these cases, the electricity must be breaking down the water present in the solution into its elements.* **7.** *The oxygen that was formed by the decomposition of water in the solution combined with the carbon in the electrode to form carbon dioxide.* **8. a.** *i. lead nitrate, $Pb(NO_3)_2$ ii. magnesium nitrate, $Mg(NO_3)_2$ iii. sodium chloride, $NaCl$ iv. silver nitrate, $AgNO_3$ v. potassium iodide, KI vi. zinc sulphate, $ZnSO_4$ vii. copper chloride, $CuCl_2$* **b.** *Salts that form metal at the negative electrode — lead nitrate, silver nitrate, copper chloride; Salts that form hydrogen at the negative electrode — magnesium nitrate, sodium chloride, potassium iodide, zinc sulphate* **c.** *Metals whose salts form hydrogen at the negative electrode are found high in the reactivity series. In the case of the salts of the metals that are lower down in the series, the metal is deposited on the cathode.* **d.** *Hydrogen will be formed at the negative electrode. As calcium is high up in the reactivity series, it is a very reactive metal.* **9.** *Mercury will be a conductor.*