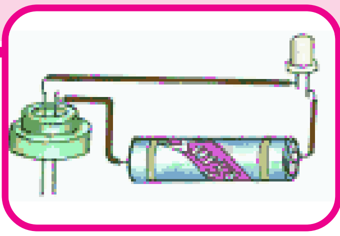
# Lesson 8

# ELECTRICAL CONDUCTIVITY OF LIQUIDS



Sometimes we read in news about farmers getting electric shocks while starting water pumps of the wells, especially because of contacts made with switches or starters by wet hands. Do you know the reason behind getting electric shock while working with wet hands?

Our elders caution us about touching electric heater immersed in water. Why do they instruct us to stay away from it? How does the electric current flow through water?

In the earlier class you have learnt that electric current can pass easily through metals like copper, aluminum, etc. Do you recall some other materials which conduct electric current? Let us revisit the activity and do it now.

## Activity-1

### Testing the material to know which allows electric current to pass through it

Take a torch bulb or LED (Light Emitting Diode), a dry cell, Wooden sheet, two drawing pins, a key (safety pin) and pieces of connecting wires. Set up the electric circuit as shown in the figure-1.

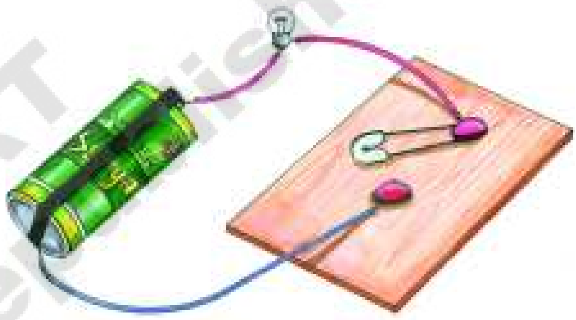


*Fig-1 : Testing conductivity of material*

Place the key on drawing pin. The bulb begins to glow as soon as the key touches the drawing pin. Now replace the key by a nail. Does the bulb glow?

Repeat the activity using different types of materials instead of the nail, say a strip of paper, a piece of chalk, a drinking straw, a piece of plastic, a paper clip, a rubber eraser, etc.

Note in each case whether the bulb glows or not and enter your observations in Table-1.

## Table 1

| S.No. | Object | Material | Bulb glows Yes/No | Good conductor/ Bad or Poor conductor |
|---|---|---|---|---|
| 1 | Nail | Iron | Yes | Good conductor |
| 2 | Eraser | Rubber | No | Bad/Poor Conductor |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Take care that whenever the bulb glows, it should not be kept in the 'ON' position for a long time to avoid the early discharge of dry cell.

From the above activity, we conclude that some materials allow electric current to pass through them. We call them as good conductors of electricity.

In general, all metals are good conductors of electricity. On the other hand, the materials that do not allow current to pass through them are called bad or poor conductors of electricity.

### Think and discuss

Why some material allows electric current to pass through them and why some do not?

**Electric conductivity** is a property of any given material. We can say that a material has good electrical conductivity if it allows electric current to pass through it easily.

## Electrical conductivity of liquids

In the activity-I, we have tested conductivity of objects like nail, paper strip, chalk, etc. All of these are solids. What about liquids? Do the liquids allow electric current to pass through them?

Let us do another activity to find out whether a given liquid allows electric current to pass through it or not.

### Activity-2

### Testing the electric conductivity of liquids

Take a LED, dry cell, metal pins, rubber cap of injection bottle and wires for making connections. Set up an electric circuit as shown in the figure 2.

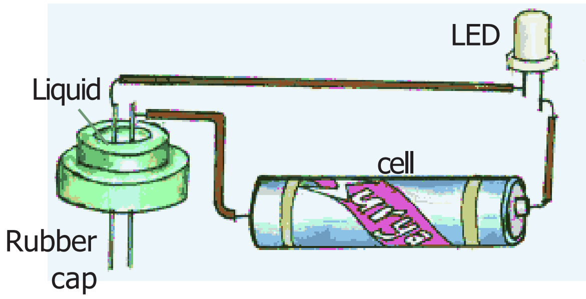



*Fig. 2: Testing conductivity of liquids*

See that the two metal pins, pass through the cap and should have a very small gap (around 2 mm) between them so that the pins are fairly closer but not touching each other. The LED should not glow when pins are separated by the small distance.

Now, join the free ends of the pins together by pressing them for a moment and make sure that the LED glows. Release the pins they get separated and LED should not glow. This becomes our tester. We will use this tester to check the conductivity of liquids.

Fill the rubber cap with different liquids, one after another and in each case, check whether the LED glows or not. Start with distilled water (you can get distilled water from battery stores or from medical shop). Pour distilled water in the rubber cap till the two metal pins come in contact with it. Check whether the LED glows or not.

Then take water that you drink in school and repeat the procedure. Do this activity with liquids like coconut oil, kerosene, lime juice, mustard oil, sugar solution, etc. After testing each of the liquids, carefully wipe and dry the cap and the pins before filling in the next liquid. In each case, note your observations in Table2.

From your observations, decide which liquids are good conductors of electricity and which are poor or bad conductors. Note your inference also in Table 2.



**Table 2**

| S.No. | Liquid | LED glows Yes/No | Good conductors/ poor or bad conductors |
|---|---|---|---|
| 1 | Distilled Water | No | bad conductor |
| 2 | Drinking water | Yes | good conductor |
| 3 | Coconut oil | | |
| 4 | Lemon juice | | |
| 5 | Vinegar | | |
| 6 | Kerosene | | |
| 7 | Vegetable Oil | | |
| 8 | Sugar solution | | |
| 9 | | | |
| 10 | | | |

Let us think about the above table.

- Why doesn't the LED glow in all the cases? Or why doesn't the LED remain off in all the cases?

In Activity 1, we said that when current flows through the object inserted in the gap, the bulb glows. Similarly, we can say that when the liquid between the two pins of the tester allows electric current to pass through, the circuit is completed (closed) and the LED glows.

On the other hand, when the liquid does not allow the current to pass through, the circuit is incomplete (Open) and the LED does not glow.

Thus, some liquids are conductors of electricity and some are bad or poor conductors of electricity.

*List out the good conductors from table 2.*

In the above activity, you may have observed that in all those cases where the LED glows, its brightness (intensity) is not the same. Sometimes it may be brighter and sometimes it may be relatively dimmer. Why is that so?

The intensity of the glow of the LED depends on the flow of electric current through the circuit. Although a liquid may be a conductor, it may not allow current through it as easily as a metal does.

As result, although the circuit is completed and the LED glows, due to weak current in cases of some of the liquids, the intensity of glow would be lower compared to other liquids.

## Do you know?

Why do we use LED in the tester instead of a bulb?

LED glows even when a very weak current is passing through the circuit. Thus, it helps in testing flow of electricity in conductors when meager current is passing through the circuit.

Since LEDs glow even with a very little current passing through them, they are used as 'indicators' in electrical appliances like mobile phones, televisions, transformers, etc. to indicate whether the device is working or not.

There are two wires called leads attached to an LED. One lead is slightly longer than the other. See figure 3.

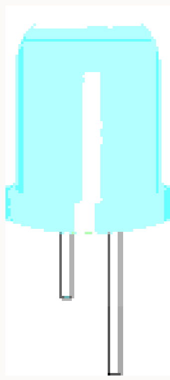


*Fig. 3 (LED)*

While connecting to the LED to the circuit, the longer lead is always connected to positive terminal of the battery and the short lead is connected to the negative terminal of the battery.

## When do liquids conduct electricity?

In the last activity we observed that distilled water does not conduct electricity. Can we make poor conductors like distilled water to conduct electricity? Let us try it out.

### Activity-3

### Transforming a poor electric conductor into a good conductor

Take same amount of distilled water in three different containers. Dissolve small quantity of common salt in the water of first container. Dissolve the Copper Sulphate (Mylatuttam), lemon juice in 2nd and 3rd containers respectively.

Use the tester that we used in Activity 2, and repeat the activity 2. Note your observations in Table 3.

(Caution: Wash and wipe the pins of tester dry after testing with each liquid.)

**Table 3**

| S.No. | Material | Does the LED glow? Yes/No | Good conductor/ bad or poor conductor |
|---|---|---|---|
| 1 | Distilled water | No | Bad conductor |
| 2 | Dist. Water + salt | | |
| 3 | Dist. Water + $CuSO_4$ | | |
| 4 | Dist. Water + leman juice | | |

From Table 3, what can we infer? Distilled water does not allow the electric current to pass. Water in its pure (distilled) form is a bad conductor of electricity. But when water contains salts or acids, it allows passage of electric current and turns into a good conductor of electricity.

The water that we get from sources such as taps, hand pumps, wells and ponds is not pure like distilled water. It contains some salts and minerals dissolved in it. Some of these minerals are useful for our health. This water is a good conductor of electricity.

On the other hand distilled water is free of all salts, minerals, acids, etc. and is a poor conductor of electricity.

- Do you now understand why you are advised not to touch electric appliances with wet hands?

Water with salts is a good conductor of electricity and the current flowing through house hold electric appliances is very high. Therefore, we should never touch the electrical appliances with wet hands.

Like water in the above activity, most liquids that conduct electricity are solutions of acids, bases or salts.

## Chemical effect of electric current

If solutions of different salts and acids conduct electricity, what do vegetables and fruits do? Let us try to find that out.

### Activity-4

### Testing the effect of electric current on potato

Take a potato. Cut in into two halves and take one half of it. Construct tester with LED bulb. Insert two copper wires of the tester into the potato leaving some distance (around 1 cm) between them. See figure 4.

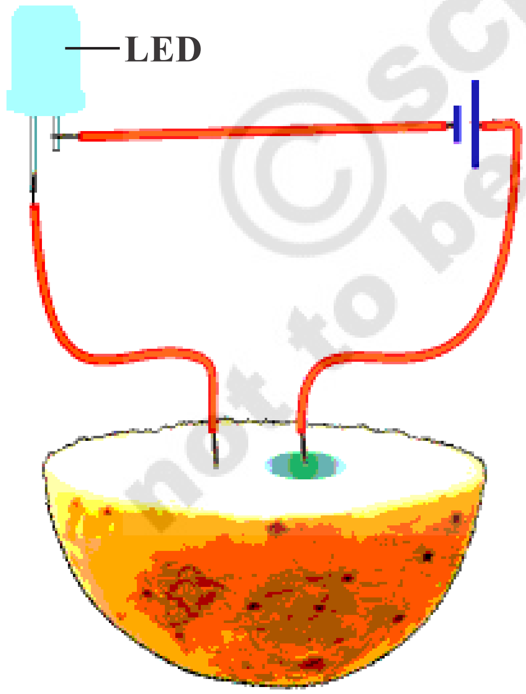



*Fig. 4*

- Does the LED glow?

Leave the inserted wires for 20-30 minutes.

- What do you observe the surface of the potato?

A greenish blue spot is seen on the potato around the wire connected to the positive terminal of the battery. But no such spot is seen around the other wire connected to the negative terminal. This greenish spot is due to chemical change in the potato.

- What could be the cause behind this change?
- Will other vegetables also show such an effect?

Try it out with vegetables like carrot, beetroot, cucumber, radish, brinjal, sweet-potato, etc.

### Think and discuss

If a battery is packed in a box and if only two wires from two terminals are given out, how can we decide the positive and negative terminal of the battery?

## Electrolytic cell

In all the above activities, the battery we have used is made up of dry cells. In lower classes you have studied about dry cell.

- Can you produce electric current in another way?
- Do you know, how was the first cell made?

## How the first cell was made?

People in Europe began experimenting with electricity around 400 years ago. They generated electricity in different ways and conducted various experiments. However, they faced one major problem which prevented them from understanding electricity in depth. They did not have a stable and permanent source of electricity. This may sound like a minor problem today, but it took scientists nearly 200 years to find a solution.

That solution came in the year 1780. And it came almost by chance. A biologist named Luigi Galvani from Bologna, Italy, once saw a frog's leg hung from a copper hook twitching violently when it touched another metal. It seemed as if the frog's leg had suddenly come to life.

Galvani did many more experiments with the legs of dead frogs. He finally came to the conclusion that frog's legs twitched every time electricity flowed through them. Galvani thought he had discovered living or biological electricity. He presented his theory to the world, saying that all living beings contained electricity and it was this electricity that was their main source of life.

Galvani's experiments took the whole of Europe by storm. Many scientists began performing similar experiments with various species of animals. Among them was Alessandro Volta of Italy. He, too, performed experiments with frog's legs. However, he discovered that if a frog's leg hung from an iron hook is touched with another iron rod, it does not twitch. Volta was a bit puzzled..

If the reaction in a frog's leg is due to the electricity in its body, why are two different metals required to make it twitch, he wondered? After a lot of thinking he arrived at the conclusion that electricity does flow through the frog's leg when two different metals touch it. However, this electricity is not contained in the leg of the frog but is generated by some other process.

Volta repeated his experiment using different liquids instead of frog's legs. He found that it did not require an animal's body to generate electricity. It is possible to generate electricity if two different metals are placed in some liquids.

These experiments showed the way to a steady source of electricity. Volta made his first cell in 1800 using zinc and copper plates dipped in sulphuric acid. His discovery made him famous in the realm of science. The cell he made is called a Volta cell in his honour. The word voltage is also derived from his name.

Let us make a cell with the same metals and chemicals used by Volta.

## Activity-5

### Make your own cell

Collect two injection bottles. Cut two 5 cm-long bits of thick copper wire. Use sandpaper to scrape about 1 cm of the coating off both ends of the wires.

Break open a exhausted dry cell and remove its outer metal covering (made of zinc). Cut two 2 mm-wide and 5 cm-long strips from this zinc plate. Insert the copper wires and zinc strips into the rubber caps of the injection bottles as shown in figure5. Ensure that the copper wire and zinc strips do not touch each other.

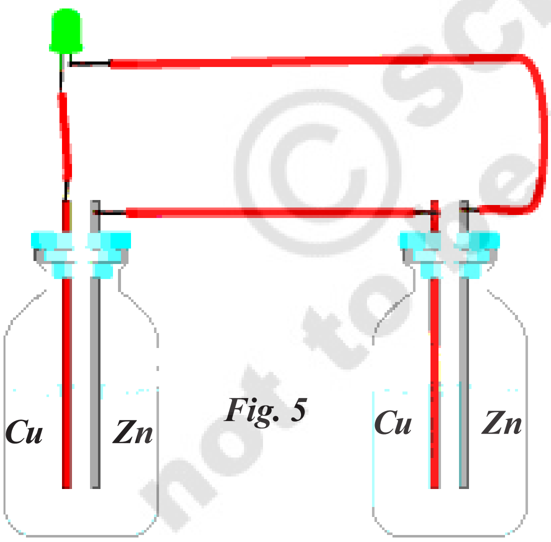


*Fig. 5*

Now take a wire and connect the copper wire of one bottle with the zinc plate of the other bottle. Fill both bottles with dilute Sulphuric acid. Carefully close the bottles with the caps in which the copper wires and zinc strips are inserted. Your cell is ready.

How will you test it?

Take an LED. Attach two wires to its two terminals. Touch the wire from one terminal to the zinc plate and the wire from the other terminal to the copper wire. Did the LED light up? If not, change the connections vice-versa. Did the LED glow?

Repeat the above activity using lemon juice, tamarind juice and tomato juice one by one instead of sulphuric acid to make your cells.

- What other liquids can be used to make the cell?
- Will detergent solution be useful?

  Find it out for yourself.
- How does the above cell function?

After a few seconds of immersion of zinc and copper wires into dilute sulphuric acid, zinc slowly begins to dissolve in the sulphuric acid. We can see bubbles getting formed on the copper rod.

The current is passed from copper rod to zinc rod. These rods are known as **electrodes** and dilute sulphuric acid is known as **electrolyte.**

Here the chemical energy is converted into electric energy by "electrolysis method".

Can you compare this cell with dry Cell?

Which is good one? Why?

## Think and discuss

What is electrolysis?

Discuss with your teacher or collect the information about electrolysis method form your school library books.

## Electroplating

Can you list some objects around you that keep shining? For example, the clip of your writing pad or rim of a newly bought bicycle.

However, if these objects are scratched deliberately or accidently, their shine diminishes. Scratching of such objects removes some coating from their surface and we can see a relatively dull surface below the coating. Safety pins, when they are new, shine brightly. However, with repeated use, they lose the brightness of shining. Repeated handling makes the coating of the pins wear off and the non-shiny metal beneath is exposed.

In the above examples, the material underneath contains a coating of another metal. How is this achieved? Is the shining metal melted and then poured on the dull object or is there any other way?

Well, let us try doing it ourselves.

### Lab Activity

**Aim:** Coating an iron key with copper by electroplating method.

**Required material:** Copper plate of size 2 cm x 5 cm, crystals of copper sulphate (blue vitriol), a key made by iron, glass beaker, water, sulphuric acid, Battery Cell and some connecting copper wires. (You may take a thick copper wire and hammer it to flatten it instead of the above mentioned copper plate.)

**Procedure:**

Dissolve crystals of copper sulphate in pure water to prepare concentrated solution (deep blue in colour). Pour the solution in a beaker and add a few drops of dilute sulphuric acid to it. (Acid helps in increasing the conductivity of electricity.)

Tie one end of a connecting copper wire to the iron object (key) to be coated with copper. Connect its other end to the negative terminal of a battery. Suspend the tied iron object into the copper sulphate solution. Suspend the copper plate into copper sulphate from positive end of the battery through a switch as shown in fig-6.

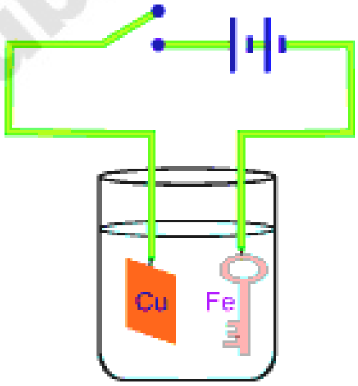


*Fig. 6: Copper plating*

Care should be taken that the key and plate do not touch each other and are a little away from one another. Put the switch on for about 10 minutes. Switch the circuit off and take the iron key out.

**Observations**

- Does the iron key get coated with a shiny, brown colour?
- What is the colour due to?
- What will happen if you interchange the battery terminals?

- Why does copper get deposited on the iron key?

When electric current is passed through the copper solution, in which the copper sulphate is present in the form of copper and sulphate ions. The free copper ion gets drawn to the electrode connected to the negative terminal of the battery and gets deposited on it.

Thus one metal is coated with another material. This process is known as electroplating.

$$CuSO_4 \longrightarrow Cu^{+2} + SO_4^{-2}$$

(goes to –ve terminal) (goes to +ve terminal)

If the key is to be coated with zinc or aluminium instead of copper, what changes do we need to make in the above experiment?

In electroplating, an inferior metal (metals which are effected by the atmospheric humidity, carbondioxide, etc.) is coated with a superior metal (metals which are not effected by the humidity or carbondioxide). The following are the requirements for fine coating.

(a) The object to be electroplated should be free from greasy matter.

(b) The surface of the article should be rough so that the metal deposited sticks permanently.

(c) The concentration of the electrolyte should be so adjusted as to get smooth coating.

(d) Current must be the same throughout.

## Electroplating – uses

Electroplating is widely used in industry for coating metal objects with a thin layer of different metals.

For example, metals like iron which are easily corroded by atmospheric air, moisture and carbon dioxide are coated with deposits of nickel or chromium which are most resistant to such corrosion by electro plating method. Machinery parts are often chromium plated to protect them from corrosion and at the same time to give them good polish. (see Figure 7)

*Fig. 7*

Sometimes, electroplating is done with a view to repairing worn out parts of machinery. In such cases the suitable metal is deposited on the affected parts of the machinery by electro plating method.

Electroplating is also done for ornamentation and decoration purposes. For example several articles made of copper or its alloys, such as table wares, decoration pieces are coated with silver or gold. (see Figure 8)

*Fig. 8*

*Fig. 9*

In general the processed food items are preserved in tin coated iron cans. Tin is less reactive to the food than iron. So the cans are made by electroplating tin on iron. (see Figure 9)

When iron is coated with zinc metal, iron becomes more resistive to corrosion and formation of rust. So, zinc coated iron is used for bridges and in automobiles.



## Key words

*Good conductors, Poor conductors, Electrodes, Electrolyte, Electrolysis, Electroplating*

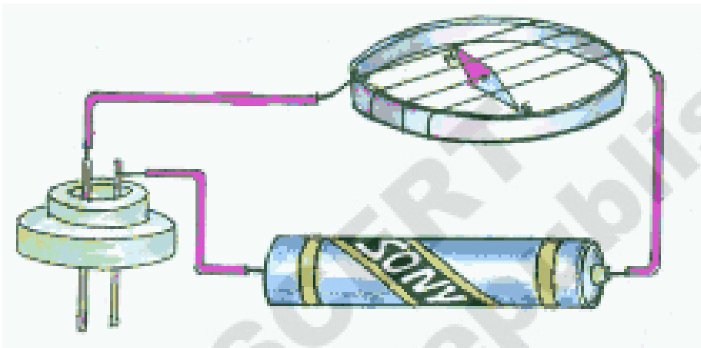
## What we have learnt?

1. Some liquids also conduct electricity as some solids do.
2. Some liquids are good conductors of electricity and some are poor conductors.
3. Distilled water does not allow the current to pass through it.
4. Most Liquids that conduct electricity are solutions of acids, bases and salts.
5. Electrolyte is a solution of a substance through which electric current can pass.
6. Electroplating is possible through electrolysis.

## Improve your learning

1. Give examples for good conductors solid and liquid. ($AS_1$)
2. Give examples for poor conductors solid and liquid. ($AS_1$)
3. What do you add to distilled water for making it to conduct electricity. ($AS_1$)
4. Explain the process of coating copper on iron key. Draw the circuit diagram. ($AS_3$)
5. What is an electrolyte? ($AS_1$)
6. Which energy is cause for glowing of bulb in electrolytic cell? ($AS_1$)

7. Write the uses of electroplating. ($AS_1$)
8. In case of a fire, before the fire men use the water, they shut off the main electrical supply for the area. Explain why they do this? ($AS_1$)
9. Collect the information and make list of good conductors and bad conductors. How do you use this information in your daily life works. ($AS_1$)
10. In many of the activities in this chapter, we have used a tester made up of LED. Can we avoid LED and use something else as a tester? Magnetic compass needle could be an alternative tester. We know that when we take a current carrying wire near magnetic compass needle, it shows deflection. Use this property to make a tester of magnetic compass needle. You may refer to the following figure. ($AS_5$)




11. We get some items made from iron wire in which iron wire is coated with plastic. Is plastic coated by the process of electroplating? Why plastic cannot be coated on a metal by the process of electroplating? ($AS_1$)
12. Make a battery from four lemons and test it with a LED in the circuit. ($AS_3$)
13. Refer to the Activity 3 in the chapter. Start with distilled water. The LED would not glow. Add two drops of some acid to distilled water and check the glow of LED. Add two more drops and check the intensity of the glow. Repeat the activity 5 to 6 times by adding 2 drops of the same acid each time. Do you see any difference in the intensity of glow with increasing acid content of water? What can be inferred from the above observations? Repeat the entire activity by taking a solution of baking soda and adding drops of it to distilled water instead of acid. Write differences and similarities. ($AS_3$ , $AS_1$)
14. How do you appriciate the efferts of Luigi Galvani and Alissondro Volta in discovering a cell and making a stored Electric energy available to human beings ? ($AS_6$)
15. Kavya observed that a discharged dry cell which kept in sun light by her father for few hours got ability to glow LED. She got many doubts and questions to raise. Can you guess those questions or doubts? ($AS_2$)