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MASTI KI PRAYOGSHALA- CHEMISTRY

Metals Lesson plan

Concepts covered through this module:

1. *Physical properties of metals*
2. *Chemical properties of metals (Activity for each property)*
3. *Electrolysis (Activity)*
4. *Formation of Alloys (Activity)*

Start the session by taking them through the previous module. Check if they can remember what was taught to them previously.

Main Script:

Today we are going to learn about various properties of metals.

What are metals? What makes you say that a particular substance is a metal or a nonmetal?

(Keep certain objects on the demo table to help differentiate between metals and nonmetals. They can consist of a wooden scale, bell, plastic bottle, metal scale, spoon, copper wire, aluminum wrapper, etc. Try to bring out the properties of metals with the help of these examples)

There are certain properties or features which help us identify metals. By just looking at a substance, we can say if it's a metal or a nonmetal. These are called as physical properties. Let us list out these properties one by one.

- All metals are solid in nature. Exception to this property is mercury which is liquid at room temperature.
- Metals are hard. It is not easy to break them. Example is iron. Exceptions to this property are sodium and potassium. It is very easy to cut these metals with a knife.

Inquisitive Question: Why are gold, silver and platinum used to make ornaments? (*Volunteers need to let the students think before they can answer this question. Inquisitive questions are meant to be answered by students. Give them sufficient time (and hints if required) and let them come up with answers.* ***DO NOT*** *give the answer immediately).*

Value Content: *If a student answer any of the questions, ensure he/she is appreciated by rest of the students. Encourage students to appreciate each other. This boosts the morale and*

encourages the students to speak out.

Answer: This is because these metals are lustrous. (*Explain what lustre is, this is the next physical property)*

- Metals reflect light because of which they appear shiny and attractive. They have a shining surface. This is called as lustre. Gold and silver can be the best examples of metals which are shiny. These are used to make ornaments.
- Metals can be stretched and made into form of wires. This is called as ductility. For example, copper can be drawn into a wire.
- Metals can be made into the form of sheets. This is called as malleability. Have you come across any such metals in day-to-day life? Aluminum foils are used for packing medicines. We have plates made up of aluminum.
- Metals are good conductors of heat. For example, copper, silver. Cooking vessels are made up of metals.
- Metals are good conductors of electricity. This is the reason why electric wires are coated with rubber to prevent shock.
- Metals produce ringing sound. Best example for this is the school bell. When you strike the bell, it produces loud ringing sound. If you strike a wooden table, it doesn't produce the same sound as wood is not a metal. This property of metal is called as sonorous.
- Metals have high melting and boiling points. Tungsten filament is used inside a bulb because it doesn't melt even at high temperatures.

Interesting Aside!

You would have to heat tungsten to 6,192°F before it would melt!

These are the physical properties of metals. Now, let us investigate the chemical properties. We cannot determine the chemical properties just by viewing or touching the substance. We must make it undergo a change in its molecular structure with the help of chemical reactions. When the metal reacts with different substances and undergoes change, we can determine its chemical properties.

1) Metals react with oxygen to form metal oxides. For example, Magnesium, when reacts with oxygen gives magnesium oxide.

$2Mg + O_2 \rightarrow 2MgO$

Suggested Activity:

A strip of Magnesium ribbon is already placed at each table. Tell the students to hold the ribbon end with a pair of tongs and heat the other end in blue color of the flame till it ignites. It should be held at arm's length away from the burner. (Volunteer must ensure that the student holds the ribbon away from the table).

Value Content: *Ensure the instructions are given step by step and the students follow the instructions. Emphasize on the importance of being disciplined inside a chemistry lab as well as outside, generally.*

The magnesium ribbon, which is silver-grey in color combines with oxygen in the atmosphere, in the presence of heat to produce a white dazzling light. The white powdery substance produced is Magnesium Oxide.

Day To Day Relevance: In day-to-day life, we see formation of rust on iron windowpanes and benches. This is because the iron reacts with oxygen in the presence of moisture to form iron oxide, which is nothing but rust.

Reactivity Series: Before going into the 2nd chemical property of metals, let us try to understand the reactivity series.

An atom has electronic shells consisting of one or more electrons. The electrons in the outer-most shell are called as the valence electrons. The atoms either lose or gain electrons to achieve stability and reach octet level. Metals tend to lose their valence electrons. Some metals may lose very easily whereas some may require energy to do so. Those metals which can lose their valence electrons very easily can react easily with other substances which accept electrons from these metals. Those which cannot lose electrons easily are less reactive metals. Based on the ability to give away electrons, metals are ordered from highest reactivity to lowest reactivity in a series. This is called as the reactivity series of metals. It goes as follows (Po So Ca M Al Z I T L Hy Co M)

- Potassium
- Sodium
- Calcium
- Magnesium
- Aluminum
- Zinc
- Iron
- Tin
- Lead
- Hydrogen
- Copper
- Manganese
- Silver
- Gold
- Platinum

Decreasing order of reactivity

From this series, we know that potassium is the highest reactive metal, and the reactivity decreases as we go further down. All those which are above hydrogen are considerably good in their reactivity.

Inquisitive Questions:

1) Why are food cans coated with Tin and not with Zinc? (*Volunteers need to let the students think before they can answer this question. Inquisitive questions are meant to be answered by students. Give them sufficient time (and hints if required) and let them come up with answers.* ***DO NOT*** *give the answer immediately).*
   Answer: Zinc is more reactive than tin and hence food cans are coated with tin. Tin does not react with the food whereas zinc can react with food making it poisonous for consumption.

2) Why are sodium, potassium and lithium stored under oil? *(Again, volunteers are requested not to provide the answer to them immediately)*
   Answer: They are stored under oil because they are extremely reactive and can react with oxygen in the atmosphere and explode. They are stored under oil where there is no oxygen.

Let us consider water whose molecular formula is H_2O. It has H^+ positive ions and OH^- negative ions. When a metal whose reactivity is higher than hydrogen is brought in contact with H_2O, it will tend to displace H from H_2O as its ability to give away electrons is more than hydrogen and hence can easily combine with the OH^- ions.

Similarly consider hydrochloric acid, whose molecular formula is HCl. It has H^+ positive ions and Cl^- negative ions. When you bring a metal which is more reactive than hydrogen, in contact with HCl, it will take the place of H as it reacts better with Cl^- ions. It displaces H^+ ions.

This happens only with the metals which are more reactive than hydrogen. The metals which are less reactive than hydrogen cannot displace hydrogen as their tendency to give away electrons is less as compared to hydrogen.
Now, let us look at the other chemical properties of metals.

1) Metals react with water to produce metal hydroxides and hydrogen gas.

$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2\uparrow$
$Zn + 2H_2O \rightarrow Zn(OH)_2 + H_2\uparrow$
$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2\uparrow$
$2Al + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2\uparrow$

2) Metals react with acid to form metal salts and hydrogen gas

$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$
$2Fe + 6HCl \rightarrow 2FeCl_3 + 3H_2\uparrow$

Inquisitive Question: Aluminum is a highly reactive metal, yet it is used to make utensils for cooking. Why? (*Again, let the students think, volunteers are requested to give hints if the students are unable to answer, but let the students answer)*

Answer: This is because aluminum reacts with oxygen to form an aluminum oxide layer on top which is very stable. The oxide layer does not react with anything else further, thus forming a non-reactive layer. Hence aluminum was used to make utensils, though now it is no longer used as aluminum leaches into food causing harm in the long run.

Suggested Activity:

There are three different metals, Copper strips, Zinc pellets and Iron nails, placed at the demo table. Make three chits numbered from one to three. Let each student from the group (of three) pick a chit. The one who gets 1 should come forward first with a test tube and pick any one metal of his choice and put in the test tube. Similarly, the one who picks 2 will come next with a test tube and pick another metal of his choice and the 3rd person picks the remaining metal and puts in his test tube. Once they get back to their places, go around with a beaker of hydrochloric acid (1:1 ratio of water and HCl) and make the students pour the acid carefully

into the test tubes. The acid should be poured in such a way that it just covers the metal completely. Once this is done, ask the students to carefully stretch and put the balloon over the top of the test tube.

Value Content: *Ask the students to **focus** on what is happening in the test tubes. It is of utmost importance that they observe and focus on the changes happening in the test tube to make a conclusion.*

Explanation: The test tube containing zinc will show a vigorous reaction with acid. Hydrogen gas can be seen bubbling off due to which the balloon starts to blow up. The more reactive the metal is, more is the blowing up of the balloon. We can see small bubbles of hydrogen gas at the surface of iron nails. We can see that copper does not react at all. This is because copper falls below hydrogen in the reactivity series and hence does not react with HCl. By looking at the sizes of the balloons, we can easily find out the order of reactivity of these metals.

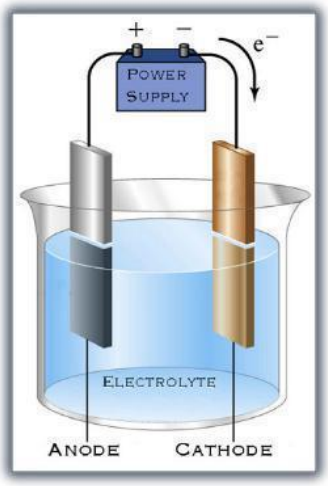
So far, we discussed the physical and chemical properties of metals. Now, we will study a very important topic of this chapter.

It is electrolysis. How can you obtain a pure metal? Are there any methods you know of obtaining a pure metal without any impurities?

Electrolysis is a process of refining and obtaining pure form of metal from the impure metal. It is used in various manufacturing industries. In this, electricity is used to bring about a chemical reaction. This chemical reaction results in pure metal being deposited.

Let us try to get a pure coating of copper on a coin by using an impure copper strip and copper sulphate solution.

Look at the following diagram.



Anode and cathode are electrodes. An electrode is any conductor through which electricity can pass. The electrode to which the positive terminal of the power supply is connected is called as anode. The other electrode to which negative terminal is connected is called as the cathode. In this process, we take an impure copper plate as the anode and a coin as the cathode. The solution in the beaker is called as the electrolyte. Usually, salt solution of the metal that has to be plated is taken as the electrolyte. In this case, since the metal to be plated is copper, we take copper sulphate solution as the electrolyte. It has several freely moving ions. We have a 9V battery as a power source. The power source provides sufficient potential difference between the two electrodes. This completes the circuit. The electrons which move in the external circuit is compensated by the ions moving inside the electrolyte. Let us see what happens at each electrode once the closed circuit is set up.

At the anode, the copper metal starts to ionize, i.e., Cu loses two electrons and becomes Cu^{2+} ions which go into the solution.

$Cu \rightarrow Cu^{2+} + 2e^-$

The two electrons travel through the external circuit and move towards the coin. The coin gets negatively charged as it now has excess of electrons. From the solution, the copper ions which are positively charged get attracted towards the coin and take up the excess electrons at the coin to form copper metal.

$Cu^{2+} + 2e^- \rightarrow Cu$

This pure copper metal gets deposited on the coin. Thus, we obtain pure form of copper metal from an impure strip of copper. The impurities from the strip settle as mud under the copper electrode. This is called as the anode mud.

Suggested Activity: *Each group has a 100mL beaker of copper sulphate solution, copper strip, coin, 9V battery, two copper wires to which the alligator clips are attached on both ends and filter paper. Go around to each group and pour about 2-3 drops of ethanol on the coin placed on the filter paper. This removes any dust particles, impurities on the coin. Ask the students to wipe the coin using the filter paper. Then, ask them to connect the two terminals of the battery to the two copper wires with the help of alligator clips. Tell them that the other end of the copper wire which is connected to the + terminal must be connected to the copper strip and the other end of the wire connected to – terminal must be connected to the coin. Then, tell them to carefully dip the coin and the copper strip inside the beaker containing copper sulphate solution in such a way that they don't touch each other. Ask them to leave it aside and observe after a while.*

After some time, we start to observe something getting deposited on the coin. The color of the

coin changes to pinkish brown. This is nothing but the copper deposit. As explained, the copper ions from the solution take up electrons from the coin and deposit as copper metal on the coin.

Thus, the current source helps in setting up a potential difference due to which current flows, due to which there is a chemical reaction and deposition of pure copper on the coin.

Main Script:

Alloys

An alloy is a homogeneous metal composed of two or more elements. One of the elements in the alloys is essentially a metal, while the other element or elements may be metals or non-metals.

Alloy = Metal + metal/non-metal (Carbon, Silicon, Sulphur, Boron)

Pure metals have poor mechanical properties. Hence, they are not used in their pure form in industry. Their properties are modified by adding other elements.

Alloys are stronger than the metal which they are made and are more resistant to corrosion.

Suggested Activity: *(The set up for this activity must begin while the students are doing the electrolysis experiment) Take a copper plate and cut out a piece in the shape and size of a coin. Rub the copper coin with sandpaper to remove dirt. Place a tripod stand and a wire gauge over it on the demo table. Place a spirit lamp over an inverted beaker below the tripod stand. (This is done to ensure the flame reaches the wire gauge. This set up is done in schools where there are no Bunsen burners) Take a 250mL beaker and fill half of it with distilled water. Put about 8-10 spatula of Sodium Hydroxide pellets in the beaker and place it over the tripod stand. Light the spirit lamp. Leave the NaOH solution to boil for 5 mins and then put about 2 spatula of Zinc powder and 3-4 pellets of Zinc granules into the beaker. Let the solution boil for another 10mins. (**NOTE: If bunsen burner is used in place of spirit lamp, the solution must be boiled only for 5 mins or less overall! If it is left to boil for longer, there is a possibility of it getting spilled out**). Wait to see tiny bubbles being formed on the sides of the beaker. Once the bubbles are seen, turn off the spirit lamp. From here, the students are advised to observe the demo. Explain to them what was done until then. Boiling of solution is started during the electrolysis experiment as it is time consuming. Once the students gather around the table, begin the next part of the experiment. (Ensure that students stand a little away from the demo table as the hot, NaOH solution is extremely hazardous!!) Dip the copper coin inside the solution with the help of a pair of tongs. The coin must touch the Zinc granules inside the solution. Wait for about two mins*

and then remove the coin. The copper coin would have gotten a coating of silver! Wash the coin under running tap of water. Light the spirit lamp and move the coin gently over the flame, to and fro for few seconds. (Ensure you move the coin over the flame and NOT just place it over the flame continuously. Placing it continuously will turn the coin black). After few seconds, it will be seen that the silver coin has turned into gold! A copper coin just got converted into silver and then into gold!

Explanation:

When copper coin is put inside the beaker, there is a deposition of Zinc. Hence the coin gets the colour of Zinc, which is silver. When it then heated in flame, the zinc coating combines with copper underneath and turns into brass, the colour of which is gold. Thus, zinc and copper combine to form an alloy, brass.

Interesting Aside!

The tallest free-standing structures in the world are primarily made of the alloy steel. They include the Dubai skyscraper Burj Kalifa, the Tokyo television tower Skytree, and the Shaghai Tower skyscraper!

Examples of alloys:

- Duralumin is an alloy of Al, Cu, Mg, Mn
- Steel is an alloy of C, Fe
- Stainless steel is a mixture of Fe, Cr, Ni. It is very strong and does not rust. It is used in making cooking utensils, surgical instruments, dairy industry etc.
- Brass is a mixture of Cu and Zn.
- Bronze is a mixture of Cu and Tin. It is tough, resistant to corrosion, used to make statues, coins, medals, utensils.

Revise all concepts from the beginning.