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Science is Fun- CHEMISTRY

Types of Chemical Reactions

If a module has already been done previously, ask them about it and if they remember what they learnt and if they liked it.

Start the session by stating various examples in our daily life like formation of milk to curds, blossoming of a flower, growing of a tree, burning of paper, melting of ice, etc. Ask what is common in all of them. In every situation, there was something initially, and something else in the end, i.e., in each case there has been some_____? Continue till you get the answer that there is a change involved in all of them. The outcome is not the same as the initial. Then go on as follows:

Main script:

There are two types of changes, or all the changes in the world can be classified into two types:

1) Physical change
2) Chemical change

A physical change is that which involves a change in the shape or form. It does not change the identity or the chemical formula of the substance. For ex, an apple remains an apple when cut into pieces, it doesn't turn into an orange. There is a change in the shape and size of the apple, but no change in its identity. Thus, the apple is said to have undergone a physical change. Another example of a substance undergoing a physical change is melting of ice. The ice becomes water on melting, but the content, or molecular formula (H_2O) remains the same.

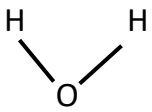
Sometimes, when a substance undergoes a physical change, it is possible to get back the starting material. This is called reversible **Change.**

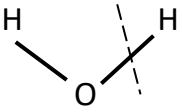
A B 

Day to day relevance: Melting of ice to water and boiling of water to steam are examples of reversible changes. It is possible to get back water by condensing the steam and ice on freezing water.

Main script: A chemical change is that which involves a change in the identity of a substance by changing its chemical formula, leading to new substances being formed.

The molecular formula of water is H_2O.

It can be symbolized as 

When the O --- H bond breaks, 

the resultant is one H^+ ion and one OH^- ion.

The two ions react with some other substances to form new compounds. Thus, in a chemical change, a new compound is formed as the atoms rearrange themselves to form new chemical bonds. It is not possible to get back the H_2O molecule again.

Suggested Activity: *Pick any two students. Ask one of them to pick up the rough sheet from the table and the other to light a match and carefully burn the sheet. Ask the class to observe. The paper burns to give ash. Ask the students if it is possible to get back the paper from the ash. Thus, the conclusion follows as:*

Burning of paper is an example of a chemical change and these chemical changes are **irreversible changes,** i.e., the original material cannot be obtained. Other examples of substances undergoing chemical changes are formation of curds, cooking, etc.

Main script:

As focus of today's session, we will learn about the different ways of classifying chemical changes. The first way is to classify reactions based on whether they take in or give out heat:

Category -1 INVOLVING HEAT

1) Exothermic reaction: An exothermic reaction is one in which heat is given out by the system into the surrounding environment. Exo means external, therm is heat. Exothermic means heat is given out of the system. Therefore, a chemical reaction which produces/gives out heat, increasing the temperature of the surroundings, is said to be an exothermic reaction.

Day to day relevance:

1) *Ask the students to breathe out on the back of the palm. Ask them what they feel. Wait for the students to say that it feels warm as they exhale on the back of the palm. Then go on to say as follows:*

What are we breathing out? CO_2. Why is it warm? It is because of the process of respiration. We first breathe in O_2. The O_2 undergoes various reactions in our body which produce energy and CO_2 from the food we eat. The energy is used in our body, and the CO_2 is given out. Because this entire process inside our body is exothermic, so the CO_2 which comes out feels warm on the back of our palm.

2) Burning of fossil fuels produces heat- It is hot near the vehicle exhaust.
3) When you keep detergent powder on your hand and add very little water, it becomes slightly warm.

All these are some of the day-to-day examples of exothermic reactions.

Endothermic reaction: An endothermic reaction is one in which heat is taken into the system. It requires heat to form the product. Endo means internal and therm is heat. Therefore, a chemical reaction which takes in heat and thus cools the surroundings is said to be an endothermic reaction.

Day to Day Relevance

1) Sweating:

When we feel hot, why does our body sweat? What is the use of this process? When we sweat and a wind blow, do we feel cooler than normal? Why?

When we have sweat on our skin, and the wind blows, the sweat evaporates. This process of evaporation is endothermic, which means the system absorbs heat from the environment. What is the environment in this case for the sweat? Our skin. So the sweat takes away the heat from our skin while evaporating, thus making our skin feel cool.

2) Similarly, when we use a nail polish remover, we would feel cold on our nails. This is because the nail polish remover takes in the heat from the fingers and evaporates thus giving a cooling sensation.

(A volunteer can take a hand sanitizer to the class and demonstrate the cooling sensation).

Suggested Activity:

Ask two students from each group to come forward with two test tubes. The two chemicals, Sodium Hydroxide pellets and Ammonium chloride are already arranged on the table along

with two spatulas. Tell the students that NaOH with water is an exothermic reaction, and NH_4Cl with water is an endothermic reaction. Ask two students from each group to come forward, with one test tube each. NaOH pellets and NH_4Cl powder are placed separately on two sides of the table, without telling the students which is which. A volunteer on each side of the demo table assisting the students in taking the substances in their test tube (about 7-8 pellets of Sodium Hydroxide in one test tube and about 2 spatulas of Ammonium Chloride in the other test tube). The students must take the substances by themselves. However, the volunteer must make sure that the students don't touch these chemicals with their bare hands, especially NaOH, as it is a highly corrosive chemical which can severely irritate and burn the skin when brought in contact. Tell the students to return to their places once they have taken both the chemicals. There is already a beaker of distilled water kept at each table. Tell the students to fill the test tube with the water, just enough to dissolve the chemical. They must shake the test tube until the chemical is completely dissolved. Then ask each one from the group to touch both the test tubes. One test tube feels hot and the other cold. Based on their observations, they must answer which of the pellets and the powder is NaOH and which is NH_4Cl.

The test tube containing NaOH pellets becomes hot due to exothermic reaction and the one containing ammonium chloride becomes cold due to endothermic reaction.

Category-2 FORMATION AND BREAKAGE OF BONDS:

Now we move on to the second way of classifying all chemical reactions, based on how the chemical bonds break and are re-formed.

1) **Combination Reaction:** Combining means two separate 'things' coming together to form a single 'thing'. A chemical reaction where two or more substances combine to form a single, new substance is called a combination reaction.

$$A + B \rightarrow AB$$

Day to Day Relevance: Iron combines with oxygen in the presence of moisture to form a brown layer on it. This is called rust.

Iron combines with Oxygen to gives Iron Oxide

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Remember that oxygen can never exist as a single atom 'O'. It takes two atoms of 'O' to form a molecule, O_2. Hence 2 atoms of Mg combine with O_2 to give rise to 2MgO.

Suggested Activity: Light the spirit lamps. Take the iron filings in a spatula and slowly tap it over the flame to sprinkle the filings over the flame. You can see that sparks are produced as the filings encounter the flame.

This is an example of an exothermic reaction as sparks are produced. It is also a combination reaction as Iron combines with oxygen in the air, in presence of the heat to give iron oxide.

Interesting Asides:

Metals and Metal salts combined with oxygen give out different coloured flames. This principle is used in manufacturing fireworks. E.g., Strontium Salts give out Red Colour while Copper salts give out blue colour.

2) Single displacement reaction:

Value Content:

Call three students in front. Take three A-4 sheets, with the letters 'A', 'B', 'C' written on them and hand over one to each student. Make them stand in a line facing the class, with sheets held such that the alphabets are shown to the class. Let 'A' stand a little apart from 'B' and 'C' who are standing together. Proceed as follows:

Let us assume that 'C' has a bad habit 'B', which is "talking too much". 'C' is unable to get over his bad habit. He can get over his bad habit only by imbibing a good habit, say, talking when necessary. 'A' is a good habit. Hence, 'C' acquires a good habit only by replacing his bad habit 'B' with 'A'. *(Exchange places of 'A' and 'B')*

$A + BC \rightarrow AC + B$

This is called displacement, where A displaces B and takes its place. Let us see some examples.

Suggested Activity: *Give each group an iron nail (to be scraped clean with sandpaper if rusted), thread and a test tube. Ask 1 person from each group to come forward with 1 test tube and put 2 spatulas of copper sulphate powder in the test tube (students to take themselves under supervision). Instruct the students to do the following: Tie the thread around the head of the nail. Fill distilled water up to one-fourth of the test tube containing copper sulphate powder and shake it well in order to dissolve the copper sulphate. Once it dissolves, insert the iron nail into the test tube by the thread in such a way that half the nail is dipped inside the copper sulphate solution, and the thread hangs out. Leave it aside for a while for the reaction to occur. (Proceed with the next reaction and come back to this after 15-20 mins)*

After some time, remove the nail carefully using the thread. Two important observations are to be noted:

1. *It will be observed that there is a reddish-brown coating of copper on the part of the iron nail that was dipped in the solution. This is the copper from the copper sulphate solution. (Make sure that the students understand that it is a copper deposit and **not rust**. It is highly likely that the students tend to misunderstand this concept).*
2. *Also, the solution of copper sulphate turns from deep blue to light green. This is due to the displacement of iron from the nail into the solution, forming iron sulphate from the copper sulphate.*

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

A is Fe
B is Cu
C is SO_4

Suggested Activity:

Pop sound experiment

Do a demonstration before the can students do the hands-on for this activity.

Take a test tube and add 1-2 granules of Zinc. Pour about 10 mL of HCl (1:1 ratio of conc. HCl and water) into the test tube. Cover the mouth of the test tube with the thumb for a few seconds to collect sufficient Hydrogen gas. Bubbles can be seen on the surface of the metal due to the formation of Hydrogen gas. Once you feel enough pressure of the gas, ask another volunteer to light a match using the spirit lamp, and place it at the mouth of the test tube as soon as you remove the thumb. The gas burns with a 'pop' sound which is a characteristic nature of hydrogen gas. After the demo, ask the students to add the zinc granules in one of their test tubes. Ask the volunteers to go around at each table with the common beaker of HCl and ensure that the students carefully pour the acid in the test tube. Ensure that the students bring the lighted matchstick near the test tube only when the volunteer is with the group. After the match is placed and the popping sound heard, the student holding the test-tube can again block the mouth of the test-tube, building up the hydrogen gas being formed. Once the pressure builds up, another student can try to get the popping sound using another lit matchstick. This can be repeated by each of the students in the group till the hydrogen gas stops being produced enough to give the popping sound.

$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

A is Zn
B is H
C is Cl
Zinc reacts with Hydrochloric acid to give Zinc Chloride and Hydrogen gas.

Interesting Asides:

Displacement reaction is used in joining of railway tracks. A mixture of Al and Fe2O3 reacts to produce molten iron that is used to join railway rails together.

$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

Aluminium is more reactive than Iron, it displaces Iron from the Mixture. The process is called Thermite Welding. (Show a picture with your phone if possible)

3) Double displacement reaction:

Place two different colored bottles along with their caps on the table. Call the cap of the 1st bottle as A and its base as B. Call the cap of the 2nd bottle as C and its base as D. So the cap and base of 1st bottle can be called as AB and similarly the 2nd bottle as CD. (Label them if needed). Tell the students that we now have AB + CD. Now, interchange the caps of the 2 bottles. Ask them to tell what it now represents (CB + AD). To help remember, tell them to note that the bases haven't moved, only the caps have changed i.e., in AB + CD, B and D remain in their places. The caps A and C interchange to give CB and AD. (This is as students often get confused while interchanging the symbols).

From this small activity, we see that there is a displacement of two, i.e., A and C. Each takes the place of the other. Hence, this is called a double displacement reaction.

$AB + CD \rightarrow CB + AD$
Let us investigate some examples.
$HCl + NaOH \rightarrow NaCl + H_2O$
A is H
B is Cl
C is Na
D is OH
This is what we learn in acids, bases and salts as Neutralization Reaction.

Another example is where lead nitrate reacts with potassium iodide to give lead iodide and potassium nitrate.

$Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 + PbI_2 \downarrow$

The downward arrow (↓) represents precipitate formation. A precipitate is a solid that is formed after a reaction and is insoluble in the solution. Here, the lead iodide formed is a precipitate.

Suggested Activity:

Golden Sprangles experiment

Ask two students from every group to come forward with a test tube each. Each group should add half a spatula of lead nitrate in one test tube and half a spatula of potassium iodide in the other. Once finished, tell them to take their seats.

Fill up to one-fourth of the test tubes with distilled water and shake them well to dissolve the powder. Two colorless solutions are obtained. Now, slowly pour the contents of one test tube into another completely. Keep the test tube in the stand for a while and allow the mixture to settle down. You will observe that a yellow insoluble solid is formed which settles down in the solution. This solid is the lead iodide precipitate and the solution is potassium nitrate. Do not allow the contents to mix. Once the solid has completely settled, take the test tube and carefully decant the solution, i.e. drain the liquid into another test tube. Once this is done, fill half of the test tube containing the solid lead iodide with distilled water. Hold the test tube with a test tube holder and heat it, while shaking the test tube to mix the contents. After thorough heating, leave the test tube in the stand to cool. After some time, you will observe golden crystals of lead iodide formed in the test tube. These are called golden spangles.

This reaction involves patience, cooperation and awareness. Do encourage the students to observe and listen to the procedure before they execute them within their groups.

Interesting Asides:

- Marble statues get eroded during Acid Rain (Containing HNO_3)

$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

Main script:

4) Decomposition reaction: Decomposition means breaking down into simpler substances. So, in a decomposition reaction, a complex substance breaks into two or more simpler substances.

$AB \rightarrow A + B$

Decomposition reactions occur in the presence of heat, light, chemicals or electricity. Now let us investigate one such reaction.

The formula for hydrogen peroxide is H_2O_2. What do you think are the two substances that you get when H_2O_2 is decomposed? One can be H_2O and the other O_2.
$2H_2O_2 \rightarrow 2H_2O + O_2\uparrow$

Hydrogen peroxide is very stable and does not decompose easily and does not get decomposed by itself easily. However, with an external helping hand, it gets decomposed quickly in a few seconds. This is called a catalyst. E.g., Pundit carrying out wedding ceremonies for bride and groom. A catalyst helps the reaction happen faster, without itself undergoing change. In this case, the catalyst is potassium iodide.

Suggested Activity:

Elephant Toothpaste Experiment (Demonstration only)

Take a 50 mL measuring cylinder and place it inside a 500mL beaker. Carefully, pour about 5 mL of 35% hydrogen peroxide into the measuring cylinder.
(The volunteer is advised to put on safety gloves for this demonstration. The hydrogen peroxide used in this reaction is a 35% solution. It is corrosive and can cause severe itching when it encounters the skin. The hydrogen peroxide that is available in medical stores is a 2% solution.) Add a few drops of liquid soap (Preferably Pril) into the measuring cylinder and shake it well. Then add 2-3 drops of food coloring agents on the walls of the measuring cylinder. More than one colour can be added. (This is just to make the rising foam more visible and colorful to observe). Add 5-10 mL of potassium iodide, all at once, straight into the solution (not along walls).

You can observe that the froth gushes out of the measuring cylinder and falls into the beaker. This is because, in the presence of potassium iodide, hydrogen peroxide decomposes into water and oxygen in a few seconds. The froth, formed when the water produced mixes with the soap added initially, traps the oxygen gas produced in the reaction and rises with the rising oxygen. The froth is multi-colored due the food coloring agents on the walls. Also, the reaction is exothermic. So, the measuring cylinder will become warm and once the froth starts falling into the beaker, the beaker will become warm too.

Conclusion: All the reactions may belong to more than one category of reactions. For eg., just as you are both a 9th standard student and a boy/girl, in the same way breaking up of hydrogen peroxide into water and oxygen is both a decomposition reaction and an exothermic reaction. (Unity in Diversity)

(Revise all the types of reactions and corresponding activities done from the beginning)

Types of Chemical Reactions

Heat intake/outtake	**Formation/breakage of bonds**
1) Exothermic Reactions	1) Combination Reactions
2) Endothermic Reactions	2) Single displacement Reactions
	3) Double displacement Reactions
	4) Decomposition Reaction

Thus, we have seen different kinds of chemical reactions along with examples and experiments. Doubts?