

Chapter 1 : Chemical Reactions and Equations

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Chemistry - class X

Chapter 1: Chemical Reaction and Equation.

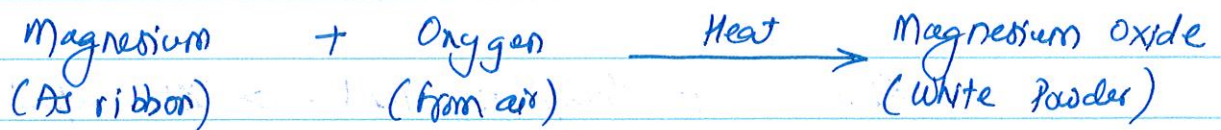
Introduction

Chemical reactions are the process in which new substances with new properties are formed. Chemical reactions involve breaking of old chemical bonds which exist between the atoms of reacting substances, and then making of new chemical bonds between the rearranged atoms of new substances. During a chemical reaction, atoms of one element do not change into those of another element. Only a rearrangement of atoms takes place in a chemical reaction.

Reactants: The substances which take part in chemical reaction are called reactants.

Products: The substances which are formed in a chemical reaction are called products.

The burning of magnesium in air to form magnesium oxide is an example of a chemical reaction.



Examples of chemical reactions.

- (i) Digestion of food
- (ii) Respiration
- (iii) Rusting of iron
- (iv) Burning of magnesium ribbon
- (v) Formation of curd.

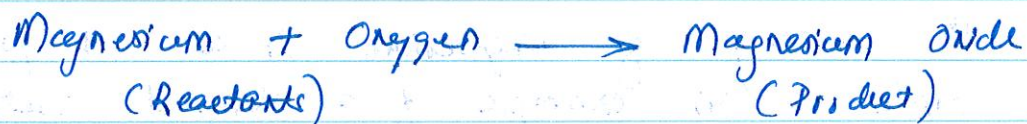
A chemical reaction can be identified by either of the following:

- (i) Change in state
- (ii) Change in colour
- (iii) Evolution of gas
- (iv) Change in temperature
- (v) Formation of a precipitate.

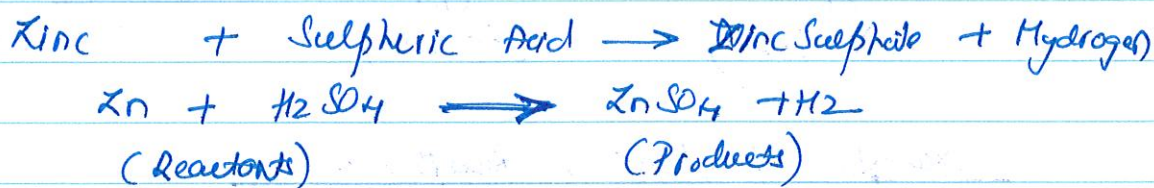
Chemical Equations

The method of representing a chemical reaction with the help of symbols and formulae of the substances involved in it is known as a chemical equation.

When a magnesium ribbon is burnt in oxygen, it gets converted to magnesium oxide.



This is known as word equation.



The arrowhead points towards the products, and shows the direction of the reaction.

Writing a chemical Equation

- (i) The symbols of elements and the formulae of reacting substances are written on the left hand side with a plus (+) sign between them.
- (ii) The symbols and formulae of the substances formed are written on the right hand side with a plus sign (+) between them.
- (iii) An arrow (\longrightarrow) sign is put between the reactants and the products.
- (iv) The physical states of the reactants and products are also mentioned in a chemical equation.



This equation is unbalanced because the mass is not the same on both sides of the equation. Such a chemical equation is a skeletal chemical equation for a reaction.

Balanced Chemical Equation

According to the law of conservation of mass, total mass of the elements present in the products of a chemical reaction has to be equal to the total mass of the elements present in the reactants.

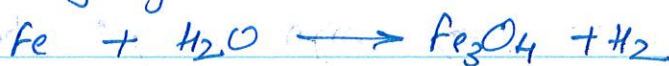
Thus, the equation in which atoms of various elements on both sides of a chemical equation are equal in accordance with the law of conservation of mass, is called balanced equation.

The process of making atoms of various elements equal on either side of an equation is called balancing of chemical equation.

Hydrogen burns in oxygen to form water.



Balance the following equation:

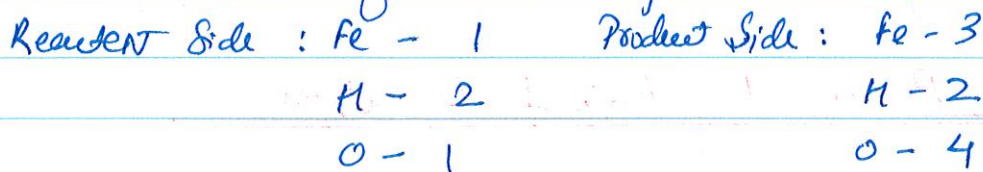


Step 1: Write the chemical equation and draw boxes around each formula.

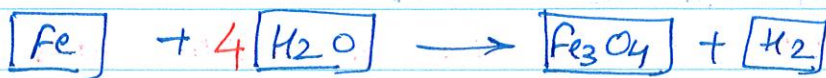


Do not change anything inside the box

Step 2: Count the number of atoms of each element on both sides of chemical equation.



Step 3: Equilibrate the number of atoms of element which has maximum number by putting in front of it.



Balance oxygen atoms.

Step 4: Try to equalize all the atoms of elements on reactant and product side by adding coefficient in front of it.



Now all the atoms of elements are equal on both side.

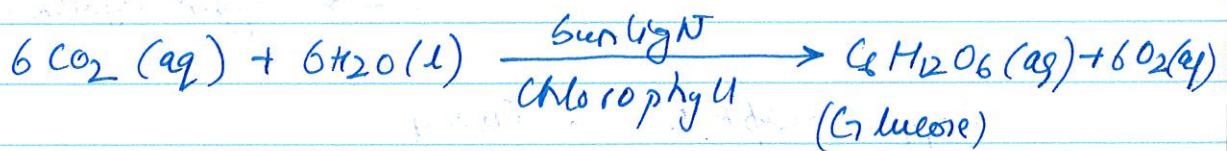
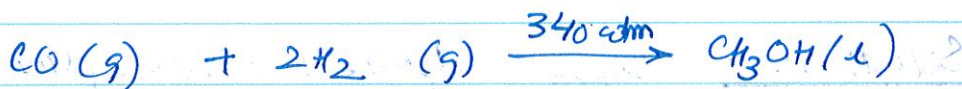
Step 5: Write the physical states of reactants and products



To make a chemical equation more informative, the physical states of the reactants and products are mentioned along with their chemical formulae.

The word (aq) is written if the reactant or product is represented as a solution in water.

Sometimes the reaction conditions, such as temperature, pressure, catalyst etc., are indicated above and/or below the arrow in the equation.



Q) Write a balanced equation for the following reaction:

Methane burns in oxygen to form carbon dioxide and water.

Solution: This reaction can be written as:

Methane + Oxygen \longrightarrow Carbon dioxide + Water.



Q) Write the balanced equation for the following reaction:

On adding an aqueous solution of sodium hydroxide to an aqueous solution of copper sulphate, copper hydroxide is precipitated and sodium sulphate remains in solution.

Solution: Copper Sulphate + Sodium Hydroxide
 \longrightarrow Copper Hydroxide + Sodium Sulphate

Copper Sulphate \longrightarrow CuSO_4

Sodium Hydroxide \longrightarrow NaOH

Copper Hydroxide \longrightarrow $\text{Cu}(\text{OH})_2$

Sodium Sulphate \longrightarrow Na_2SO_4





Oxides of iron metal

(i) Iron (II) oxide, FeO : This is called iron (II) oxide because the valency of iron in it is II (two). The common name of iron (two) oxide, FeO , is ferrous oxide.

(ii) Iron (III) oxide, Fe_2O_3 : This is called iron (III) oxide because the valency of iron in it is III (three). The common name of iron (three) oxide, Fe_2O_3 is ferric oxide.

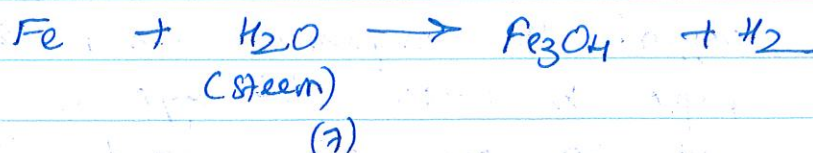
(iii) A third oxide of iron is Fe_3O_4 is named as iron (II, III) oxide. Common name is magnetic iron oxide.

Q.3) Write a balanced chemical equation with state symbols for the following reaction :

Heated iron metal reacts with steam to form iron (II, III) oxide, Fe_3O_4 and hydrogen.

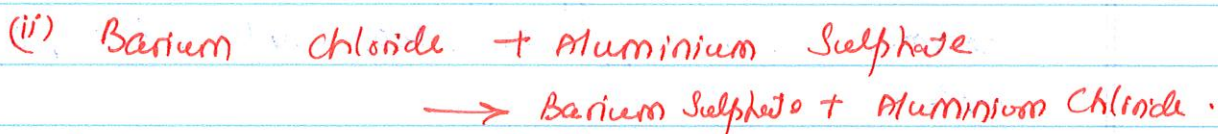
Solution : This reaction can be written as :

Iron + Steam \longrightarrow Iron (II, III) oxide + Hydrogen

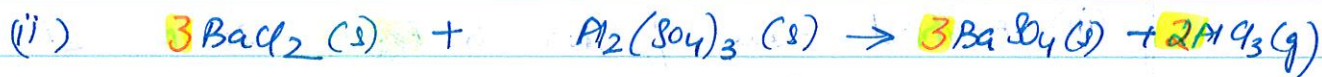




Q) Write the balanced equation for the following chemical reactions:



Solution:



Q) Why should a magnesium ribbon be cleaned before burning in air?

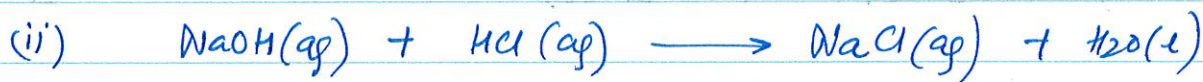
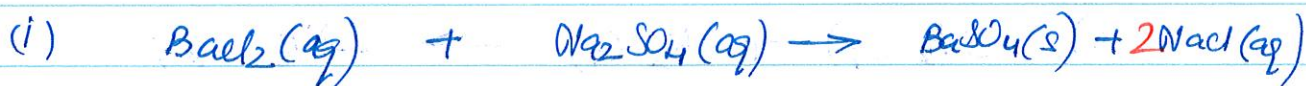
Solution: Magnesium is very reactive metal. When stored it reacts with oxygen to form a layer magnesium oxide on its surface. This layer of magnesium oxide is quite stable and prevents further reaction of magnesium with oxygen. The magnesium ribbon is cleaned by sand paper to remove this layer so that the underlying metal can be exposed into air.

Q.) Write a balanced chemical equation with state symbols for the following reaction.

(i) Solutions of barium chloride and sodium sulphate in water react to give insoluble barium sulphate and the solution of sodium chloride.

(ii) Sodium hydroxide solution (in water) reacts with hydrochloric acid solution (in water) to produce sodium chloride solution and water.

Solutions:



Q.) What is a balanced chemical equation? Why should chemical equations be balanced?

Solution:

A reaction which has an equal number of atoms of all elements on both sides of the chemical equation is called a balanced chemical equation. The law of conservation of mass states that mass can neither be created nor destroyed. Hence, in a chemical reaction, the total mass of reactants should be equal to the total mass of the products. It means that the total number of atoms of each element should be equal on both sides of a chemical equation. Hence, it is for this reason that chemical equations should be balanced.

Q) Translate the following statements into chemical equations and then balance them.

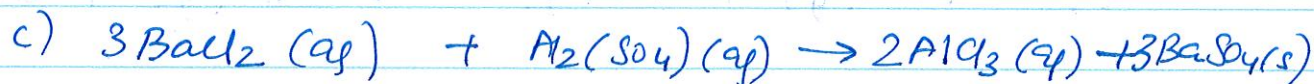
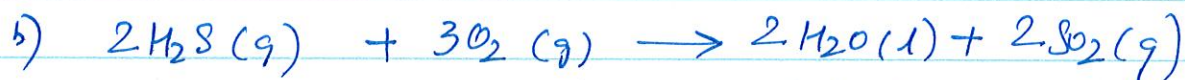
(a) Hydrogen gas combined with nitrogen & form ammonia.

(b) Hydrogen sulphide gas burns in air to give water and sulphur dioxide.

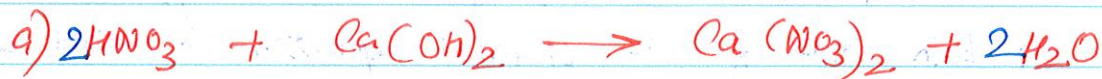
(c) Barium chloride reacts with aluminium sulphate to give aluminium chloride and a precipitate of barium sulphate.

(d) Potassium metal reacts with water to give potassium hydroxide and hydrogen gas.

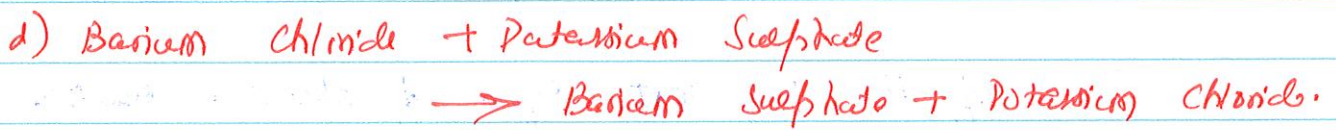
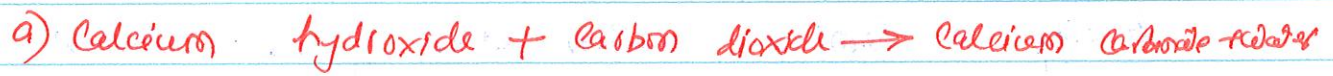
Solution :



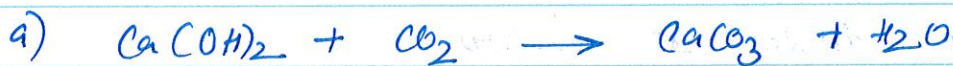
Q) Balance the following chemical equations.



Q) Write the balanced chemical equations for the following:



Solution:



Types of Chemical Reaction

During a chemical reaction atoms of one element do not change into those of another element. Nor do atoms disappear from the mixture or appear from elsewhere.

Chemical reactions involve the breaking and making of bonds between atoms to produce new substances.

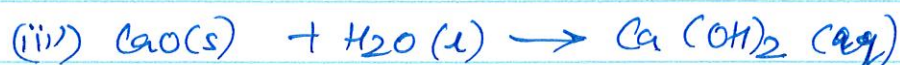
Some of the important types of chemical reaction are:

1. Combination reaction
2. Decomposition reaction
3. Displacement reaction
4. Double displacement reaction
5. Oxidation and Reduction reaction.

Combination Reaction

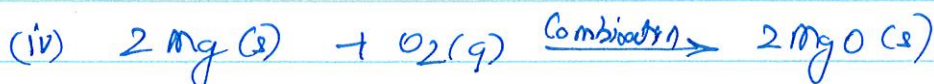
Those reactions in which two or more substances combine to form a single substance, are called combination reactions.

Example,



Quick lime

Slaked lime



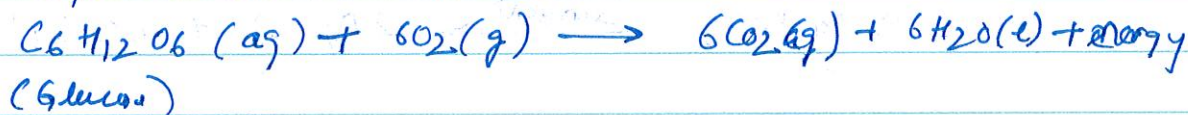
Exothermic Chemical Reaction:

Reactions in which heat is released along with the formation of products are called exothermic chemical reactions.

Example, (i) Burning of natural gas



(ii) Respiration is also an exothermic reaction.



(iii) The decomposition of vegetable matter into compost is also an example of an exothermic reaction.

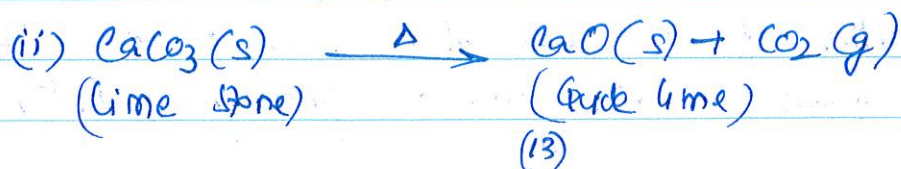
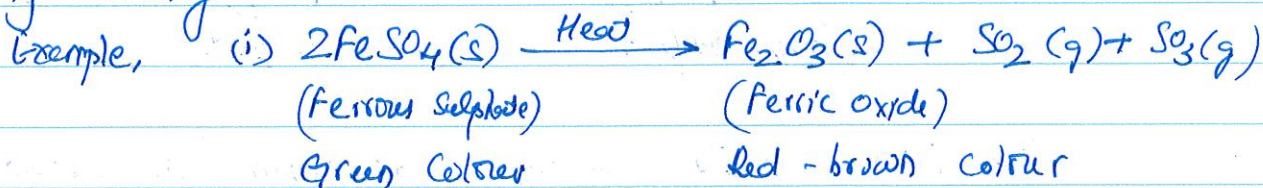
Decomposition Reaction

These reactions in which a compound splits up into two or more simpler substances are known as decomposition reactions.

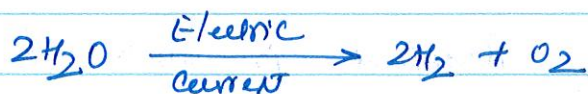
The decomposition reactions are carried out by applying heat, light or electricity. A decomposition reaction is just the opposite of a combination reaction.



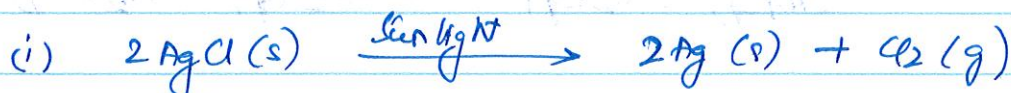
Thermal decomposition: When decomposition is carried out by heating.



Electrolytic Decomposition : When decomposition is carried out by passing electricity.



Photolytic Decomposition : When decomposition is carried out in presence of sunlight.



Above reaction is used in black and white photography.

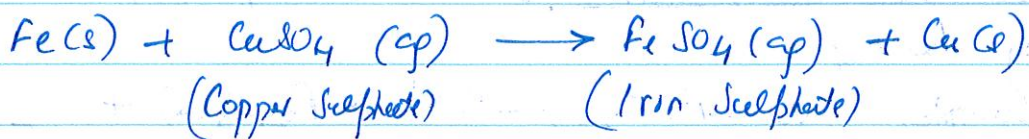
Endothermic Reaction :

The reactions which require energy in the form of heat, light or electricity to break reactants are called endothermic reactions.

(Reactions in which energy is absorbed are known as endothermic reactions)

Displacement Reaction :

Those reactions in which one element takes the place of another element in a compound, are known as displacement reactions. In general, a more reactive element displaces a less reactive element from its compound.



The iron nails become brownish in colour by decomposition of Cu and blue colour of CuSO_4 changes to dirty green colour due to formation of FeSO_4 .



Zn is more reactive than copper.

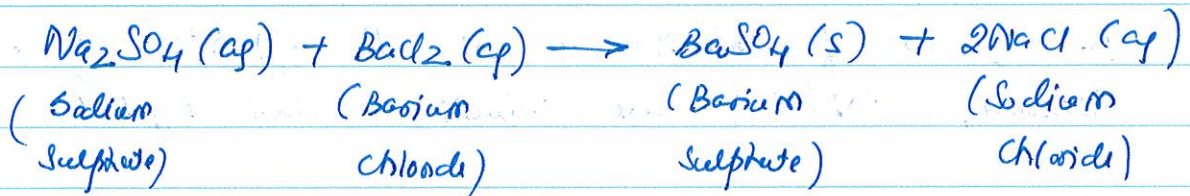


Lead is more reactive than copper.

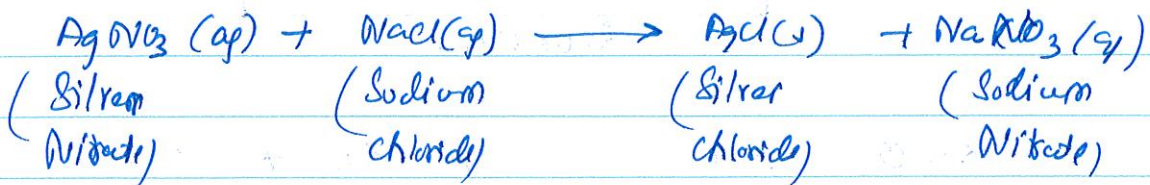
So, Zinc and lead are more reactive elements than copper. They displace copper from its compounds.

Double Displacement Reaction

Any reaction that produces a precipitate can be called a precipitation reaction. precipitate - insoluble substance.



Those reactions in which two compounds react by an exchange of ions to form two new compounds are called double displacement reactions.



When silver nitrate solution is added to sodium chloride solution, then a white precipitate of silver chloride is formed along with sodium nitrate solution:

Oxidation and Reduction

In terms of oxygen or hydrogen, oxidation and reduction can be defined as follows:

Oxidation:

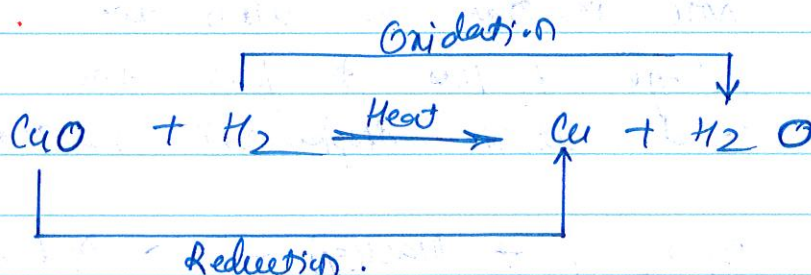
- (i) The addition of oxygen to a substance is called oxidation.
- (ii) The removal of hydrogen from a substance is also called oxidation.

Reduction:

- (i) The removal of oxygen from a substance is called reduction.
- (ii) The addition of hydrogen to a substance is called reduction.

The process of reduction is just the opposite of oxidation. Moreover, oxidation and reduction occur together.

The oxidation and reduction reactions are also called redox reactions.

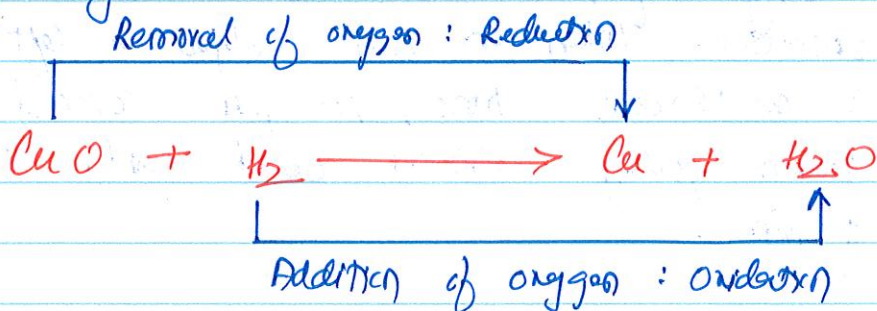


Oxidising agent :

- (i) The substance which gives oxygen for oxidation is called an oxidising agent.
- (ii) The substance which removes hydrogen is called an oxidising agent.

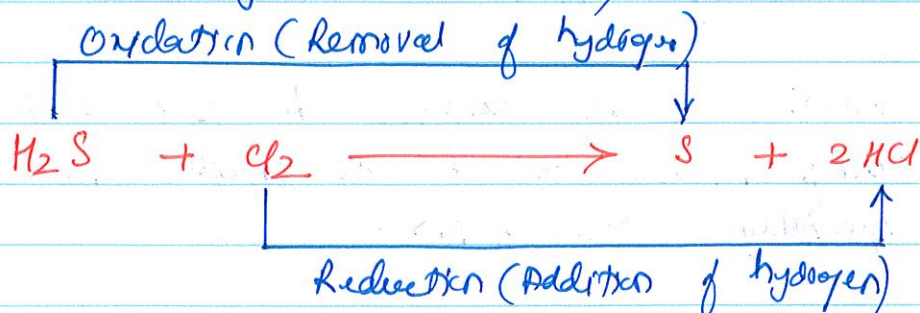
Reducing agent :

- (i) The substance which gives hydrogen for reduction is called a reducing agent.
- (ii) The substance which removes oxygen is also called a reducing agent.



- (i) Substance oxidised : H_2
- (ii) Substance reduced : CuO
- (iii) Oxidising agent : CuO
- (iv) Reducing agent : H_2

Substance which gets oxidised (H_2) is the reducing agent.
Substance which gets reduced (CuO) is the oxidising agent.



Effects of Oxidation reactions in everyday life

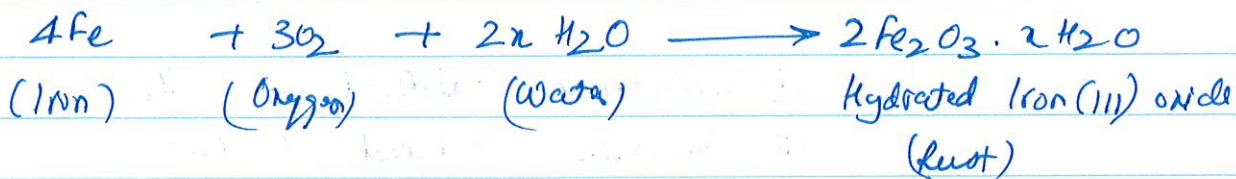
Oxidation has damaging effect on metals as well as on food. There are two common effects of oxidation reactions which are observed in daily life.

- 1) Corrosion of metals
- 2) Rancidity of food.

Corrosion:

Corrosion is the process in which metals are eaten up gradually by the action of air, moisture or a chemical (such as an acid) on their surface.

Rusting of iron metal is the most common form of corrosion. When an iron object is left in damp air for a considerable time, it gets covered with a red-brown flakey substance called 'rust'. This is called rusting of iron.



Please note that the number of water molecules (x) in the rust varies. The rusting of iron is a redox reaction.

The black coating on silver and the green coating on copper are examples of corrosion.

Corrosion causes damage to car bodies, bridges, iron railways, ships and to all objects made of metals, specially those of iron.

Rancidity

Oxidation also has damaging effect on foods containing fats and oils. When the fats and oils present in food material get oxidised by the oxygen (of air), their oxidation products have unpleasant smell and taste. "The condition produced by aerial oxidation of fats and oil in foods marked by unpleasant smell and taste is called rancidity".

- a) Keeping food in air tight containers help to slow down oxidation.
- b) Rancidity can be prevented by adding anti-oxidants to foods containing fats and oils.
- c) Rancidity can be prevented by packaging fat and oil containing foods in Nitrogen gas.
- d) Rancidity can be retarded by keeping food in a refrigerator.
- e) Rancidity can be retarded by storing foods away from light.

Prevention of Rusting

- (i) The iron articles should be painted.
- (ii) The machine parts should be oiled and greased.
- (iii) Galvanised iron pipes are used for water supply.
- (iv) Iron can be coated with chromium to prevent rusting.

Q5) A solution of a substance 'X' is used for white washing.

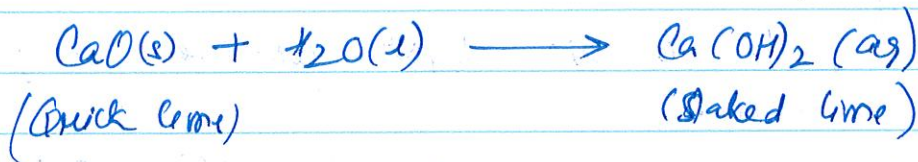
(i) Name the substance 'X' and write its formulae.

(ii) Write the reaction of the substance 'X' name above with water.

Solution:

(i) The substance 'X' is calcium oxide - CaO .

(ii) Calcium oxide (CaO) reacts vigorously with water to form calcium hydroxide (slaked lime).



Q6) Why is double the amount of gas collected in one of the test-tubes in the electrolysis of water experiment.

Name this gas.

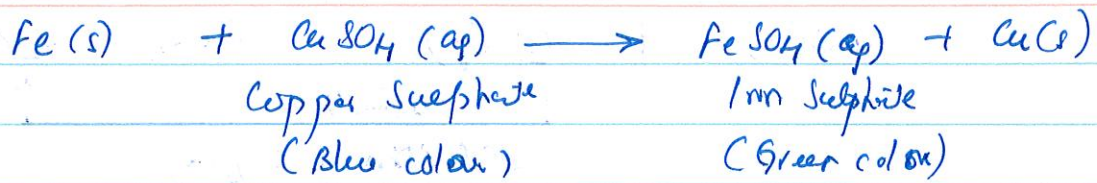
Solution: The gas which is collected in double the amount in the electrolysis of water experiment is hydrogen. This is because water (H_2O) contains 2 parts of hydrogen element (as compared to only 1 part of oxygen element).

During electrolysis, since H_2 goes to one test tube and O_2 goes to another, the amount of gas collected in one of the test tubes is double of the amount collected in the other.

Q7) Why does the colour of copper sulphate solution change when an iron nail is dipped in it?

Solution:

When an iron nail is placed in a copper sulphate solution, iron displaces copper from copper sulphate solution forming iron sulphate, which is green in colour.

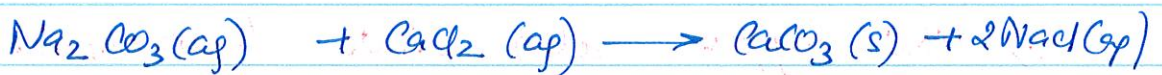


Therefore, the blue colour of copper sulphate solution fades and green colour appears.

Q.) Given an example of a double displacement reaction other than the one given activity 1.10.

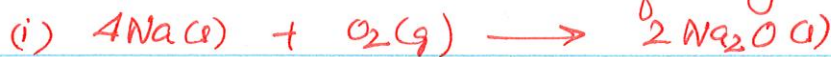
Solution:

Sodium carbonate reacts with calcium chloride to form calcium carbonate and sodium chloride.

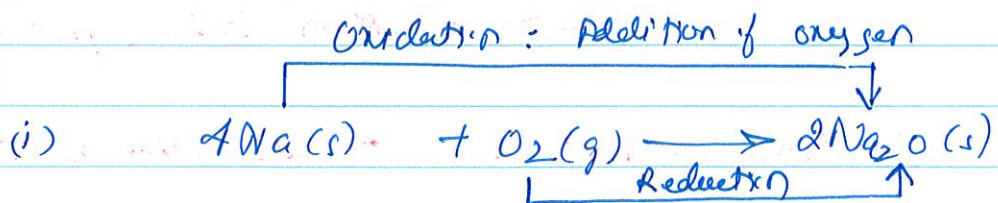


In this reaction, sodium carbonate and calcium chloride exchange ions to form two new compounds. Hence, it is a double displacement reaction.

Q.) Identify the substances that are oxidised and substances that are reduced in the following reactions:



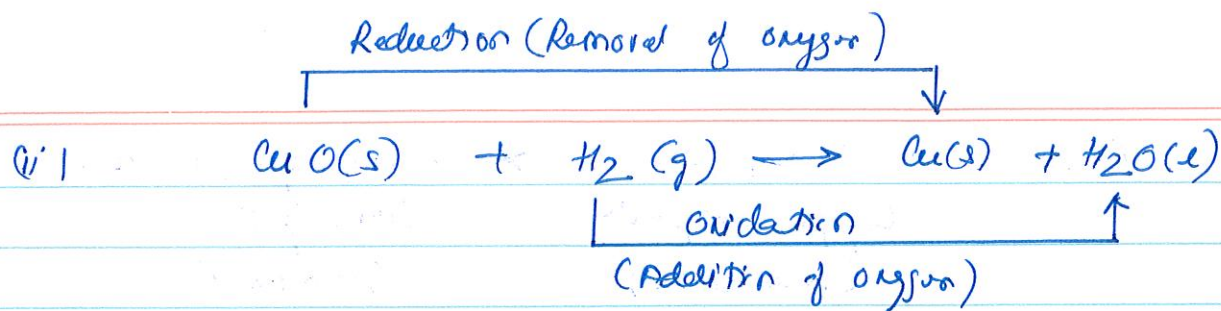
Solution:



Substance oxidised : Na(s)

Reducing agent : Na(s)

(Sodium is oxidised as it gains oxygen and oxygen gets reduced).



Substance oxidised : H_2

Substance reduced : CuO(s)

Oxidising agent : CuO(s)

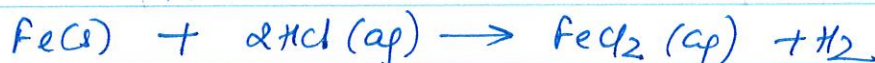
Reducing agent : H_2

Q2) Give an example of displacement reaction.

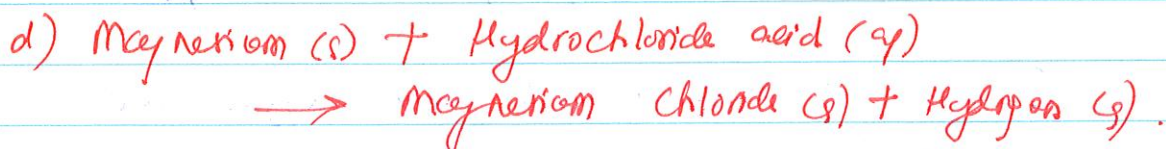
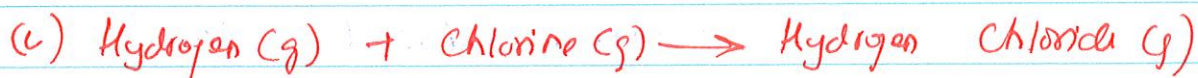
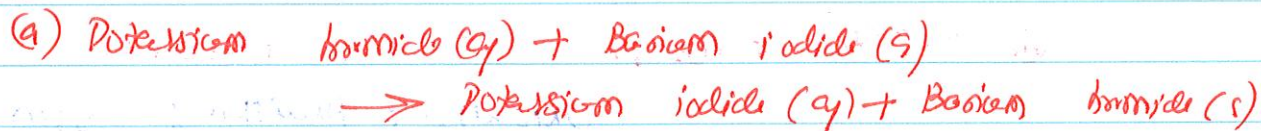


Q3) What happens when dilute hydrochloric acid is added to iron filings?

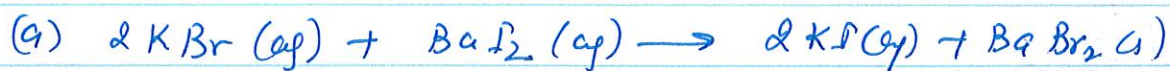
Solution: Hydrogen gas and iron chloride are produced.



Q4) Write the balanced equation and identify the reaction type.



Solution:



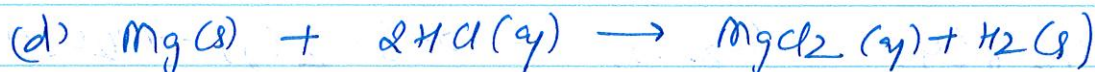
Double displacement reaction.



Decomposition reaction.



Combination reaction



Displacement reaction.

Q. What does mean by exothermic and endothermic reaction.
Give example.

Solution:

Chemical reactions that release energy in the form of heat, light, or sound are called exothermic reactions.

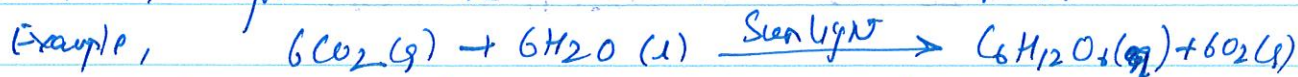
Example,

mixture of sodium and chlorine to yield table salt.



In other words, combination reactions are exothermic.

Reactions that absorb energy or require energy in order to proceed are called endothermic reactions.

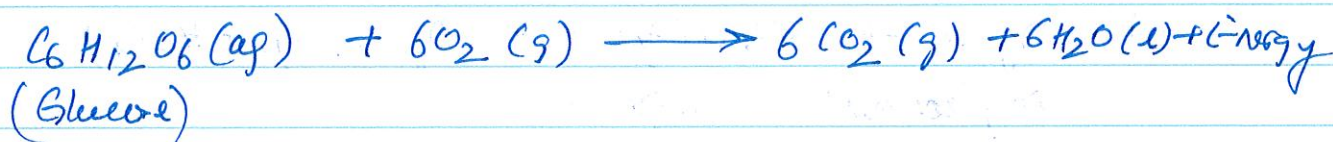


During photosynthesis, plants use energy from sun to convert CO_2 and water to glucose and O_2 .

Q. Why is respiration considered an exothermic reaction. Explain.

Solution:

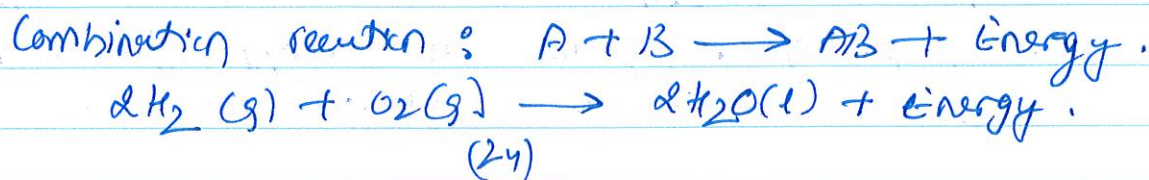
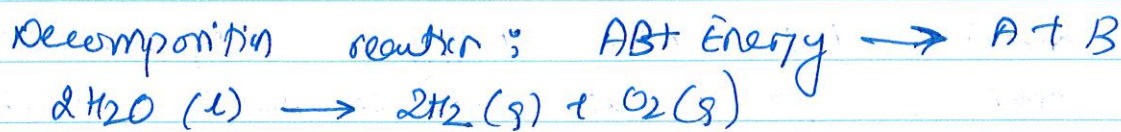
Energy is required to support life. Energy in our body is obtained from the food we eat. During digestion, large molecules of food are broken down into simpler substances such as glucose. Glucose combines with oxygen in the cells and provides energy. The special name of this combustion reaction is respiration. Since energy is released in the whole process, it is an exothermic process.



Q. Why are decomposition reactions called the opposite of combination reactions? Write equations for these reactions.

Solution:

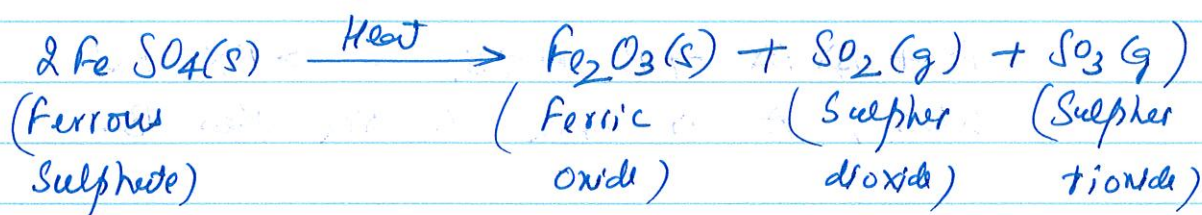
Decomposition reactions are those in which a compound breaks down to form two or more substances. These reactions require a source of energy to proceed. Thus, they are exact opposite of combination reactions in which two or more substances combine to give a new substance with the release of energy.



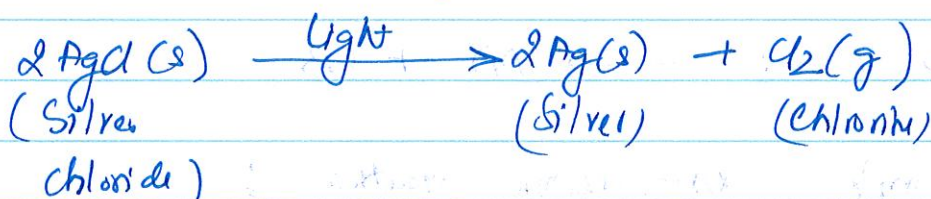
Q.) Write one equation each for decomposition reactions where energy is supplied in the form of heat, light or electricity.

Solutions:

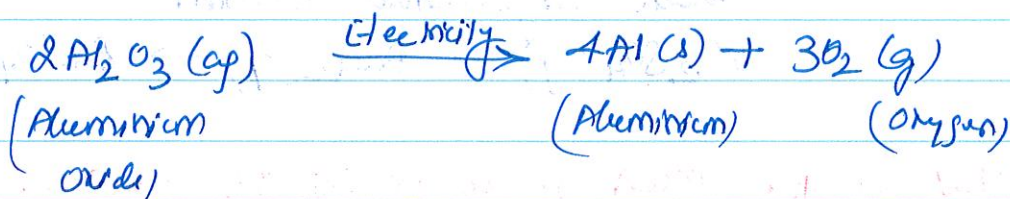
(a) Thermal decomposition :



(b) Decomposition by light :

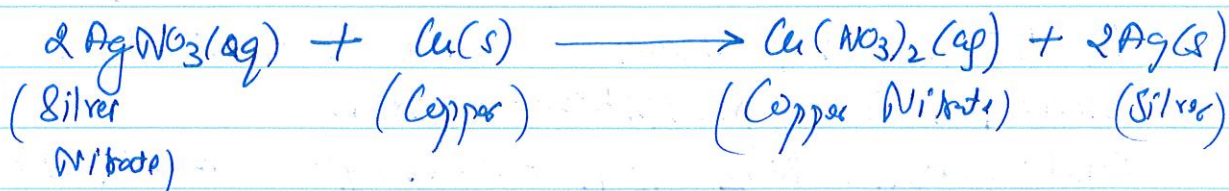


(c) Decomposition by electricity :



(Q.) In the refining of silver, the recovery of silver from silver nitrate solution involved displacement by copper metal. Write down the reaction involved.

Solution :



Q) What is the difference between displacement and double displacement reactions? Write equations for these reactions.

Solution:

In a displacement reaction, a more reactive element replaces a less reactive element from a compound.



where, A is more reactive than B.

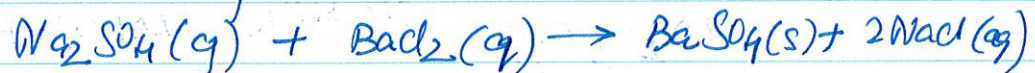
In a double displacement reaction, two atoms of a group of atoms switch places to form new compounds.



for example, displacement reaction:



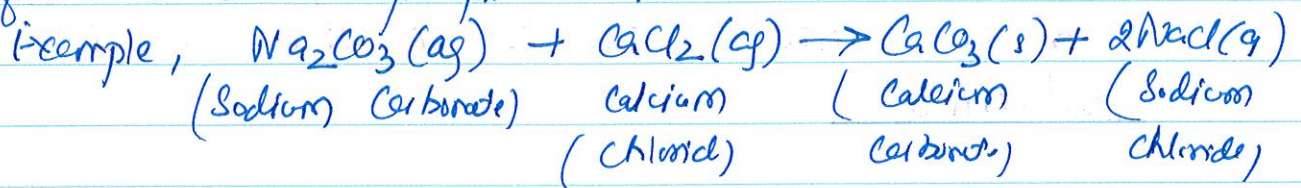
Double displacement reaction:



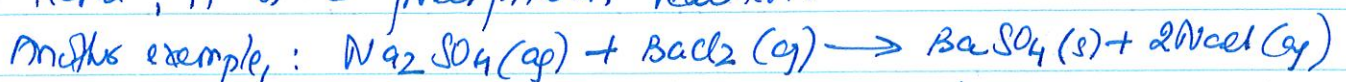
Q) What do you mean by a precipitation reaction? Explain.

Solution:

A reaction in which an insoluble solid (called precipitate) is formed is called a precipitation reaction.



In this reaction, calcium carbonate is obtained as a precipitate. Hence, it is a precipitation reaction.

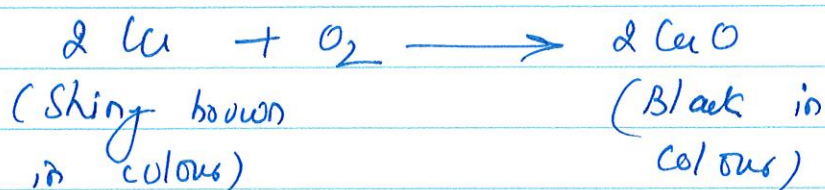


In this reaction, barium sulphate is obtained as a precipitate.

Q.) A shiny brown-coloured element 'X' on heating in air becomes black in colour. Name the element 'X' and the black coloured compound formed.

Solution:

'X' is copper (Cu) and the black-coloured compound formed is copper oxide (CuO). The equation of the reaction involved on heating copper is given below:



Q.) Why do we apply paint on iron articles?

Q.) Oil and fat containing food items are flushed with nitrogen. Why?

Q.) Explain the following terms with one example each.

a) Corrosion b) Rancidity.