

COMBUSTION

&

FLAME

INTRODUCTION

- In the stone age, people were unaware of the use of fire, they used to eat raw food.
- They found that fire can be produced by rubbing two stones.
- Slowly, they started using wood, coal, kerosene and gas to make fire.
- These substances on burning not only produce heat but also light.
- Burning of a substance to give heat and light is called Combustion.



COMBUSTION

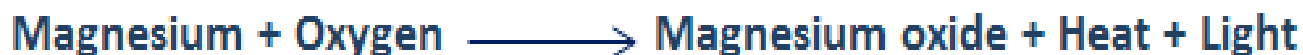
- The process of burning substances in the presence of air or oxygen with the evolution of heat and light is called combustion.
- The substance which undergoes combustion is said to be combustible.
Eg :- paper, wood , cloth, kerosene and LPG.
- A substance that does not burn in air or oxygen is called non-combustible substance.
Eg :- stone, glass piece and metal.



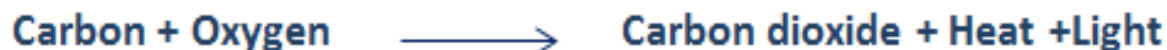
SOME EXAMPLES OF COMBUSTION :

- Burning of magnesium ribbon in the presence of oxygen produces heat and light.

This can be represented in the form of an equation -



- Similarly, when we burn a piece of charcoal which has mainly carbon, it combines with oxygen to form carbon dioxide. It also liberates heat and light.



So, we can say that magnesium and charcoal are combustible substances.



SUPPORTER OF COMBUSTION :-

Oxygen is the supporter of combustion and is a necessary condition for combustion to happen.

To show that oxygen is necessary for combustion:

Light a candle and invert a glass tumbler over it. It burns for a little while and then it is put out. This is because the air or oxygen which was present in the tumbler was used by the candle and then due to the absence of air, the candle could not continue to burn.

So, the candle burns by taking the oxygen present in the air. Once, the oxygen is over, it is extinguished as the remaining gases like N_2 and CO_2 do not support combustion.

NOTE :

Electric bulbs are filled with non combustible gases like nitrogen and argon to prevent the filament from burning.



IGNITION TEMPERATURE

In order to burn a substance, it must be heated to a certain temperature. A substance will not catch fire until its temperature is raised to a certain minimum temperature and this temperature is called Ignition Temperature.

Ignition Temperature: The lowest temperature at which a combustible substance starts burning in the presence of air or oxygen is called its ignition temperature or kindling temperature.

For E.g. :- Ignition temperature of phosphorus is 35°C . So, if the temperature of air is 35°C or more, phosphorus will catch fire without heating. And if it is less than 35°C , it will not catch fire. Similarly, Kerosene oil and wood do not catch fire on their own at room temperature. However, if both are heated a little, then kerosene oil will catch fire and not wood. This shows that ignition temperature of wood is more than that of kerosene oil and more heat energy is required to burn wood.

INFLAMMABLE SUBSTANCES

- Substances that have a very low ignition temperature and catch fire easily are **called Inflammable Substances**.
For eg:- Kerosene, LPG, alcohol, petrol etc.
- Few substances which have high ignition temperature are wood, charcoal, cow dung cakes etc. These substances cannot be burnt easily by a lighted matchstick.

NOTE -

A matchstick does not catch fire on its own at room temperature because **the ignition temperature of a matchstick is much higher than the room temperature.**



HISTORY OF MATCHSTICK

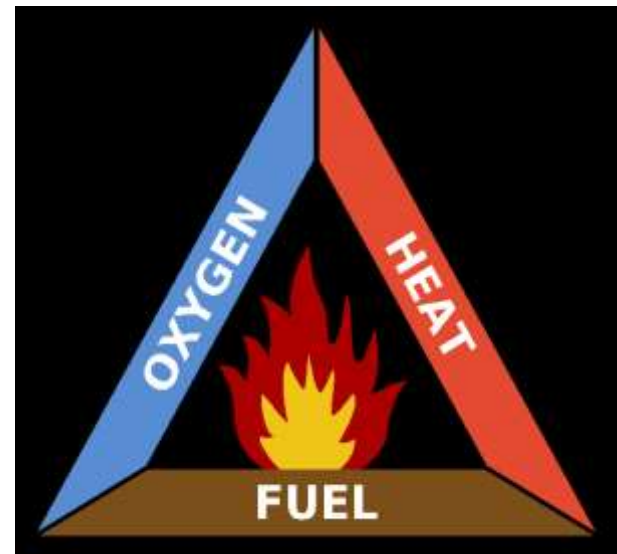
- The history of matchstick is very old. Since ages, matchsticks are in use. Small pieces of pinewood dipped in sulphur were used as matches in the ancient Egypt more than 5000 years ago.
- Around 200 years ago, the modern safety matches consisting of a mixture of antimony trisulphide, potassium chlorate and white phosphorous with some glue and starch applied on the head of the match were developed. However, these were not considered to be safe due to the presence of white phosphorous which creates toxic fumes.
- Nowadays, the head of matchstick contains antimony trisulphide and potassium chlorate and the rubbing surface has powdered glass and a little red phosphorous.
- When the head of a matchstick strikes against rough surface of the match box, red phosphorous gets converted into white phosphorous and it reacts with potassium chlorate to ignite antimony trisulphide and therefore, combustion takes place.
- So, it is because of the heat produced due to friction which rises the temperature of the chemical present in it and helps it in burning.



CONDITIONS NECESSARY FOR COMBUSTION:

Burning cannot happen until a combustible substance is present. Thus, the conditions necessary for combustion to take place are-

- Presence of oxygen.
- Presence of combustible substance.
- Attainment of ignition temperature.



CONTROLLING FIRE

We all are aware of the three conditions required for fire which are presence of oxygen, combustible substance and attainment of ignition temperature. If we want to extinguish or control the fire we need to control these conditions.

- Break the contact of the combustible substance with the fire.
- Stop the supply of the supporter of combustion.
- Cool the burning substance below its ignition temperature.



HOW TO EXTINGUISH FIRE.?

Sand and **Water** are usually thrown on burning matter to extinguish fire.

- Sand covers the fire and cuts off the supply of air and water cools the object and brings the temperature of the combustible substance below its ignition temperature. Water also cuts off the supply of air, the supporter of combustion.
- However, water cannot be used to control the fire caused by electricity because water is a good conductor of electricity and the person trying to do so can get an electric shock.
- Water also cannot be used to put off the fires caused by oil. This is because water being heavier than oil settles down and oil being lighter floats on the surface of water and keeps burning.



FIRE EXTINGUISHERS

Fire Extinguishers are devices used to put off an accidental fire. Now a days, the fire extinguishers which have carbon dioxide in them are available in the market and help to extinguish fires.

For electrical and oil fires, it is best to use carbon dioxide as an extinguisher.

Carbon dioxide being heavier than oxygen covers the fire like a blanket due to which the contact between the fuel and oxygen is cut off.

The most simplest fire extinguisher is the soda acid type fire extinguisher.

Note: Fire Extinguishers are painted red for easy identification.



SODA ACID TYPE FIRE EXTINGUISHER

The container of a fire extinguisher is cylindrical in shape. It contains sodium bicarbonate solution.

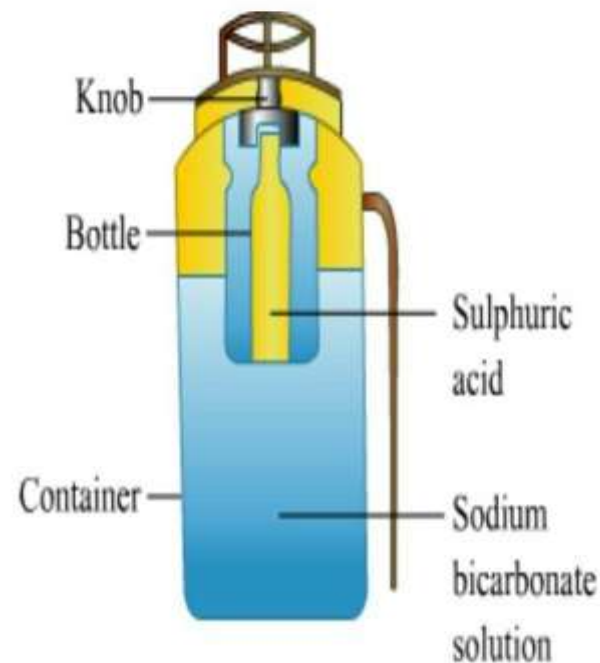
A small bottle containing concentrated sulphuric acid is attached to the knob.

For a chemical reaction to occur, the knob is struck. The bottle breaks and sulphuric acid reacts with sodium bicarbonate liberating large amount of CO₂ gas with great force.

The following reaction takes place:



It forms the blanket around the fire , cutting off the air supply.



A soda-acid type fire extinguisher

TYPES OF COMBUSTION

1.Rapid Combustion :

The combustion that takes place at a very fast rate is called rapid combustion.

For e.g. You must have seen that a paper or LPG in the kitchen burns quickly releasing lot of heat. Such kind of combustion is called rapid combustion.

Even, the burning of dry grass is an example of rapid combustion.

2.Slow Combustion :

Combustion that takes place at a slow rate with steady production of heat and light is called slow combustion.

For e.g. Burning of coal and rusting of iron involve slow combustion. In fact, respiration and digestion are also slow combustion.



3.Spontaneous Combustion:

The combustion that occurs without the supply of external thermal energy is called Spontaneous combustion

Spontaneous combustion takes place at room temperature. The heat required for spontaneous combustion is produced inside the substance by its slow oxidation. It occurs in those substances which have very low ignition temperature.

For E.g. :- If white phosphorous is kept in open air for some time, it catches fire. Such kind of combustion is called Spontaneous Combustion.

Spontaneous combustion also occurs in a haystack fire. The bacteria present in the hay cause slow oxidation of the organic material of the hay resulting in the release of heat. When ignition temperature is reached, the hay catches fire.

Other examples of spontaneous combustion are Forest fires and fire in coal mines.



4. Explosion :

Sometimes, a large volume of gas is liberated in combustion besides the production of heat and light. The sudden evolution of large quantities of gas creates excess of pressure that produces a loud noise. Such a combustion is known as an Explosion.

For E.g. :- Bursting of crackers and the shot of a gun.

When fire crackers are burnt, the chemicals present in it undergo a sudden combustion producing large amount of heat, light and a large volume of gases. The gases produced are heated by the heat evolved in the reaction due to which they expand and cause explosion producing sound.

5. Incomplete Combustion :

Burn a candle and hold a china dish over it, a deposit of soot is formed. This soot is carbon which has not undergone combustion.

For e.g. Incomplete Combustion takes place when camphor is burnt.

Incomplete combustion results in the formation of poisonous gas- Carbon Monoxide (CO) and deposition of soot.



FLAME

- A flame is a region where combustion of fuel takes place.
- Only those substances which vaporize on burning produce flame. If a substance does not get vaporized, it does not produce flame.
- An ignited matchstick heats the wick of the candle and melted wax is quickly absorbed by the wick and moves upwards by the capillary action. The heat causes the melted wax to vaporize and burn in the presence of oxygen.



BLUE & YELLOW FLAME

- ❖ When the supply of oxygen is low or insufficient, then the fuel or the substance burns with a yellow flame. This is mainly caused by the glow of unburnt carbon particles produced due to incomplete combustion. This flame is also called luminous flame.
- ❖ When the supply of oxygen is very high then the substance burning produces a blue coloured flame. It is produced by the complete combustion of the substance. Such kind of flame is called Non-Luminous flame.

NOTE -

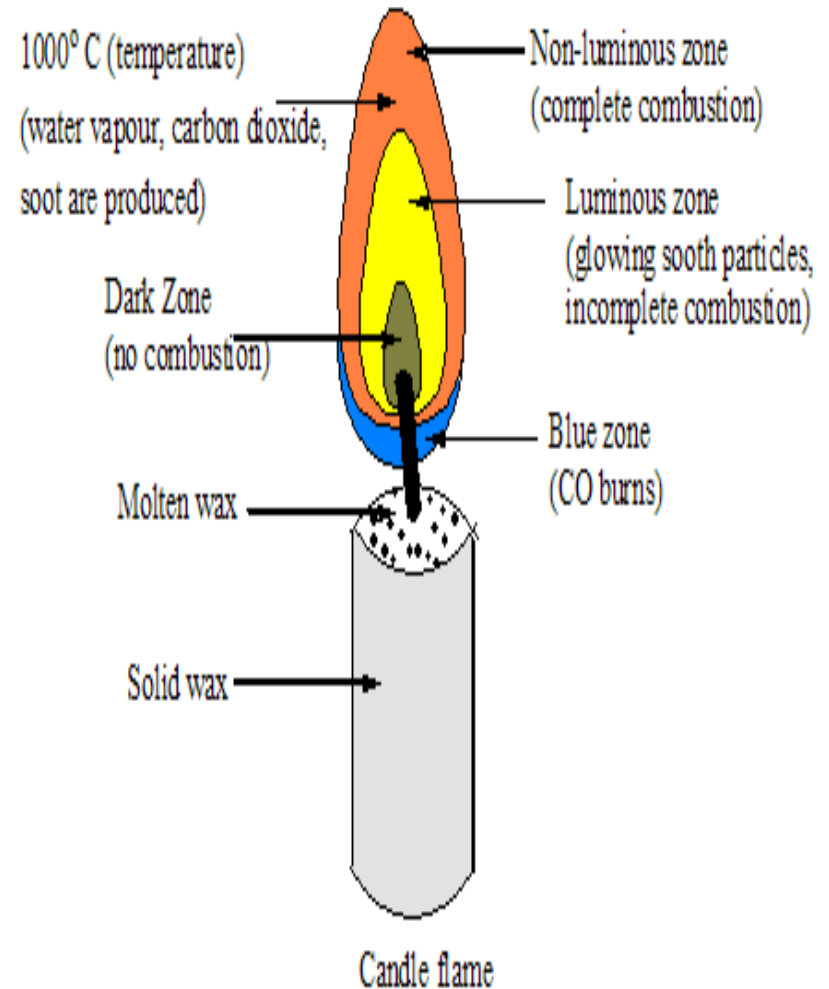
The blue coloured flame produced by the burning of LPG in your kitchen stoves is due to the complete combustion.



STRUCTURE OF A FLAME

In order to understand the structure of a flame, light a wax candle and carefully observe the different coloured zones in the flame. Starting from the base of the flame, a flame has the following four zones:

- I. BLUE ZONE**
- II. DARK INNER ZONE**
- III. LUMINOUS ZONE**
- IV. NON- LUMINOUS ZONE**



The different zones of a candle flame can be described as follows:

(i) Blue Zone: This zone is present near the base of the flame. In this zone, vaporised wax gets oxidised to carbon monoxide and carbon monoxide burns completely with a blue flame.

(ii) Dark innermost zone: The innermost zone is the least hot of all the zones. This is also called the zone of no combustion or dark zone of the flame. This zone is formed just around the wick of the candle flame as the candle burns. It consists of hot, unburnt vapours of the combustible material. No combustion takes place in this zone as wax vapours do not come in contact with oxygen and hence, do not burn.

(iii) Luminous/Middle zone: The middle zone is moderately hot with limited supply of oxygen. The wax vapours do not burn completely due to less amount of oxygen. Thus, the carbon particles produced due to incomplete combustion glow, giving this zone its bright yellow colour. So, this zone is also known as luminous zone. The carbon particles then leave the flame as smoke and soot. The major part of the flame comprises of this zone.

(iv) Non- Luminous/outermost zone: The outermost zone is the zone of complete combustion and is the hottest zone of the candle flame. It is also known as non-luminous zone as it does not produce much light. This zone appears slightly blue in colour. The presence of adequate amount of oxygen aids in complete combustion.

FUELS

- Fuels are great source of energy. They are the substances which burns in air at moderate rate, producing a large amount of heat energy without leaving behind any undesirable residue.
- Different kinds of fuel are used for various purposes at home, in industry and for running automobiles.
- The fuel may be in solid, liquid or gaseous state.
Solid fuels are solid in state like wood, coal, charcoal.
Liquid fuels are liquid in state like petrol, kerosene and diesel.
Gaseous Fuels are gaseous in state like CNG and LPG.



HOW IS A FUEL DIFFERENT FROM COMBUSTIBLE SUBSTANCE.?

Combustible Substances are those substances which can burn. It is not necessary that they will produce a large amount of heat energy without leaving any residue. However, fuel is a substance that is used to produce energy.

Therefore, all fuels can be referred to as combustible substances but not all combustible substances are fuels.

For example, wood and LPG are fuels and also combustible substances whereas wax is a combustible substance but not fuel.



FUEL EFFICIENCY

All fuels do not burn efficiently and at the same rate. For e.g. petrol will burn more quickly and efficiently than wood. Fuel efficiency is determined by its calorific value.

Calorific Value :

The amount of heat energy released on complete burning of 1Kg of a fuel in pure oxygen is called the Calorific Value of a fuel.

Calorific value of fuel = Heat generated / Mass of fuel used.

The calorific value of the fuel is expressed in kilojoules per kilogram (kJ/kg).



CHARACTERISTICS OF AN IDEAL FUEL

A fuel is considered to be a good ideal fuel if it has the following characteristics:

- Low ignition temperature
- Produce large amount of heat
- High calorific value
- Does not cause pollution
- Leaves behind no residue
- Cheap and easily available
- Easy to store
- It should burn at a slow rate and its combustion should be Controllable.

NOTE –

There is probably no fuel which can be considered as an ideal fuel.

Calorific Value of fuels	
Fuel	Calorific Value(KJ/Kg)
Cow dung cake	6000-8000
Wood	17000-22000
Coal	25000-33000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	55000
Biogas	35000-40000
Hydrogen	150000



EFFECTS OF BURNING FUELS

1. All fuels on incomplete burning produces harmful gases in the environment like carbon monoxide, oxides of nitrogen and oxides of sulphur etc.

2. Carbon monoxide being a poisonous gas even at low concentrations can lead to suffocation and even death. Thus, carbon containing fuels such as wood, coal should not be burnt in a closed room.

3. Apart from the emission of harmful gases from vehicles, lot of emission of smoke takes place from factories which increases the carbon content in the atmosphere leading to global warming.

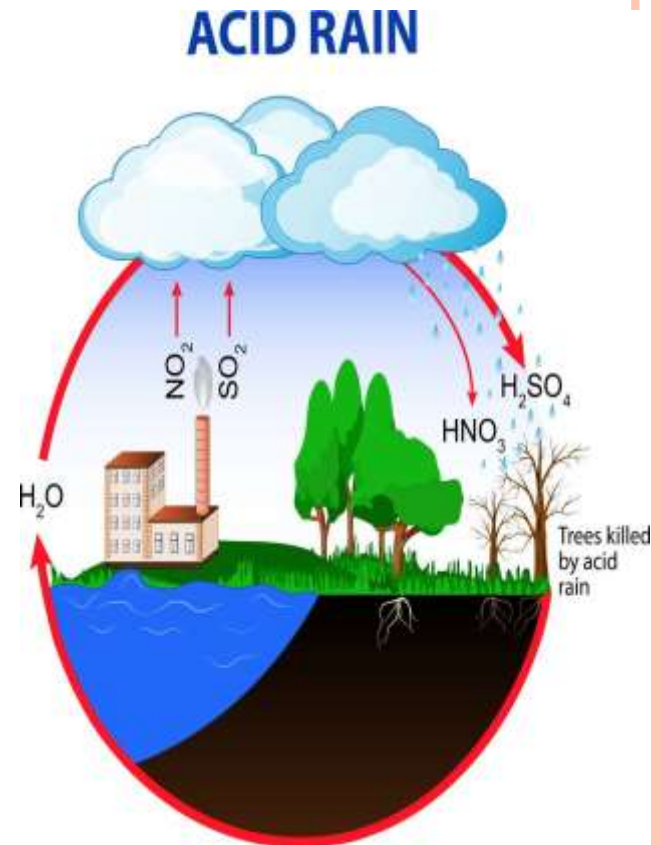


4. Oxides of nitrogen and sulphur also leads to ACID RAIN. These gases when come in contact with moisture present in air get dissolved to produce nitric and sulphuric acid. When it rains ,the acid present in it damages buildings, plants and trees.

5. The burning of fuels containing carbon such as wood, coal, petroleum etc. release unburnt carbon particles in the air.

These particles cause respiratory diseases like asthma. Also, the cutting of trees for obtaining wood leads to deforestation.

6. Carbon particles of smoke or the ash get suspended in the air. Excessive amount of these particles in the air cause several breathing disorders.



**THANK
YOU**

