

COMBUSTION & FLAME

Key Points

"Combustion, as Lavoisier theorized, is the process by which some material combines with oxygen."

1. INTRODUCTION

People generally use wood, cow dung cakes, crop residues, kerosene oil, coke or LPG gas to cook food. For running vehicles, we use petrol or diesel oil. In factories, we use coal or fuel oil or natural gas.

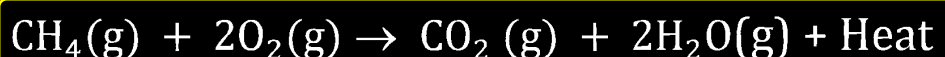
2. Combustion

- Air or oxygen which helps in burning is called supporter of combustion and the chemical reaction which takes place with the release of heat and light energy is called combustion.
- A chemical process in which a substance reacts with oxygen to give off heat is called combustion.
- The substances which undergo combustion are known as combustible substances. It may also be called a fuel.
- Sometimes, heat is accompanied by light, either as a flame or as a glow, during combustion.
- Fuel may be solid, liquid or gas. A combustion reaction may be written as-

(a) Charcoal burns in air to give carbon dioxide and heat.



(b) Methane burns in air forming carbon dioxide, water and heat.

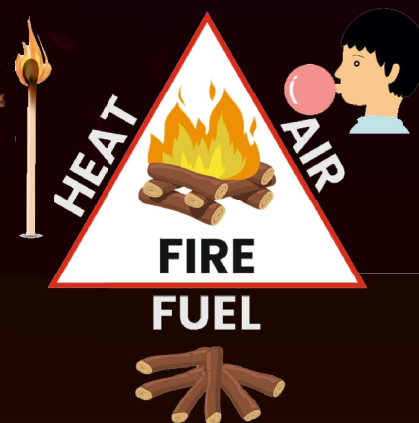


- (c) Glucose burns in presence of oxygen forms carbon dioxide, water and energy. In combustion of food, energy releases in the form of ATP (Adenosine triphosphate).



3. CONDITIONS REQUIRED FOR COMBUSTION

We know that there are three conditions necessary for producing and sustaining combustion



- Presence of a combustible substance.
- Presence of a supporter of combustion.
- Attainment of ignition or kindling temperature.

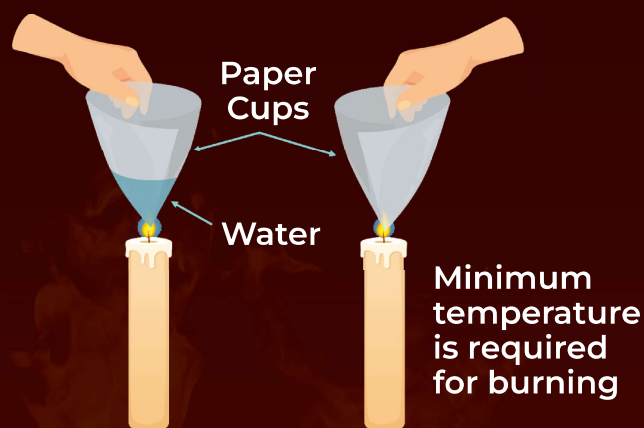
Ignition temperature

It is the minimum temperature to which a combustible substance must be heated, before it catches fire.

Example :

- (i) Ignition temperature of phosphorus is 35°C . So, unless phosphorus is heated to 35°C , it will not catch fire. However, if temperature of air is 35°C or more, phosphorus will catch fire without heating.

- (ii) In case of empty paper cup, the temperature of paper rises sharply, till a stage comes when it catches fire. In case of paper cup with water, the ignition temperature of paper is not reached because the heat supplied to paper is transferred to water by conduction. Hence, it does not burn.



Heating water in a paper cup

4. How do we control fire?

Generally, water is used to control fire. Water brings down the temperature of the combustible substance below its ignition temperature. The water vapour surrounds the combustible material, thus helping in cutting off the supply of air. So, that the fire is extinguished.



Fire can be extinguished by using fire extinguisher properly

- We know that there are three conditions necessary for producing and sustaining combustion.

Combustible Substance

Ignition or kindling temperature

Supporter of Combustion.

Thus, fire can be controlled by removing one or more of these requirements of fire control.



Note

Fire produced by the burning of oil or petrol cannot be controlled by throwing water on it because water being heavier than oil, settles down the oil and oil continues to burn.

- In the case of fires caused by burning liquid fuels, such as kerosene oil can be controlled by throwing sand or soil over it.

- The fire extinguisher also try to cut off the supply of air or bring down the temperature of the fuel or both, to control the fire. The combustible substance as such cannot be eliminated in most of the cases from the place of fire.
- There are various types of fire extinguishers used for controlling a fire. The job of a fire extinguisher is to cut off the supply of air or bring down the temperature of the fuel.

Soda-acid fire extinguisher

- Carbon dioxide is liberated by the reaction of sulphuric acid with sodium bicarbonate solution comes out with a stream of liquid water at high pressure.
- Water puts off the fire by lowering the temperature of the combustible material below its ignition temperature and carbon dioxide cut off the supply of air to the combustible substance.



- CO_2 is the best extinguisher because CO_2 being heavier than O_2 , covers the fire like a blanket. Since the contact between the fuel and oxygen is cut off, the fire is controlled. The additional advantage of CO_2 is that in most cases it does not harm the electrical equipment.

ALLEN® To operate a fire extinguisher



Why is the person caught in fire, is covered with a blanket ?



- If the clothes of a person catch fire, he is immediately wrapped in a thick blanket. The blanket cuts off the supply of air i.e. the supporter of combustion and hence the fire is put off.



Blankets during fire, cuts off the supply of oxygen

5. Types of combustion

Combustion is mainly of three types

1. Rapid combustion

- The combustion in which the gas burns rapidly and produces heat and light energy is called rapid combustion.
- **Example :** when a burning matchstick is brought near a gas burner and the gas tap is opened, the gas immediately starts burning with the production of heat and light energy. For example, Petrol, LPG, spirit, etc.

2. Spontaneous combustion

- The combustion in which no external heat is given is known as spontaneous combustion.

Example: Burning of white phosphorus in air.

3. Explosion

- The combustion in which large amount of gases are evolved with the production of a tremendous amount of heat, light and sound is called explosion.

Example : When a cracker is ignited, a sudden reaction, oxidation process takes place, and in which at high speed large amount of gas is evolved with the production of tremendous amount of heat, light and sound.

6. Flame and Its Structure

- **Flame :** A region of burning gases is called flame.
- A substance will burn with a flame, only if some gaseous substance is there to burn.

Structure of a flame

In order to understand the structure of a flame, light a wax candle and watch its flame. Carefully note the different coloured zones in the flame. Starting from the base of the flame, a flame has three zones.

- Inner most zone :** It is cooler than outer zones and it is dark.
- Middle zone :** It is the largest zone of candle flame. This zone gives soot and smoke.
- Outermost zone :** This zone of the flame is thin and blue in colour. This is the hottest zone of the flame. The temperature of this zone is maximum around 1800°C .



Why do goldsmiths use the outermost zone of the flame for melting gold and silver?



- Goldsmiths, use the outermost zone or non-luminous part of the flame for melting or shaping gold and silver ornaments. They direct the non-luminous part of the flame of candle on the gold with the help of a blow pipe. As the temperature of this part of the flame is around 1300°C , it is sufficient to melt gold at specific point and thus helps goldsmiths to give proper shape to the gold ornaments.



Goldsmith blowing flame through a metallic pipe

7. Fuel

- Any substance which is easily available and burns in air at a moderate rate, producing a large amount of heat energy, without leaving behind any undesirable residue is called fuel.
For example, wood, charcoal, petrol, kerosene, etc.

Ideal Fuel

- There is probably no fuel that could be considered as an ideal fuel. We should look for a fuel which fulfils most of the requirements for a particular use.

Characteristics of a good fuel

- It should be cheap and readily available.
- It should be easy to store.
- It should burn at a slow rate and its combustion should be controllable.
- It should have moderate ignition temperature.
- It should produce very small amount of residues such as ash.
- It should have large calorific value.
- It should not produce gases which pollute the air.
- It should not produce any hazards during transportation

Types of Fuels

- On the basis of physical state, fuels are classified into three parts.
 - Solid fuels- wood, coal, coke, charcoal etc.
 - Liquid fuels-kerosene, petrol, diesel etc.
 - Gaseous fuels- LPG, CNG, coal gas, water gas etc.

8. Fuel efficiency

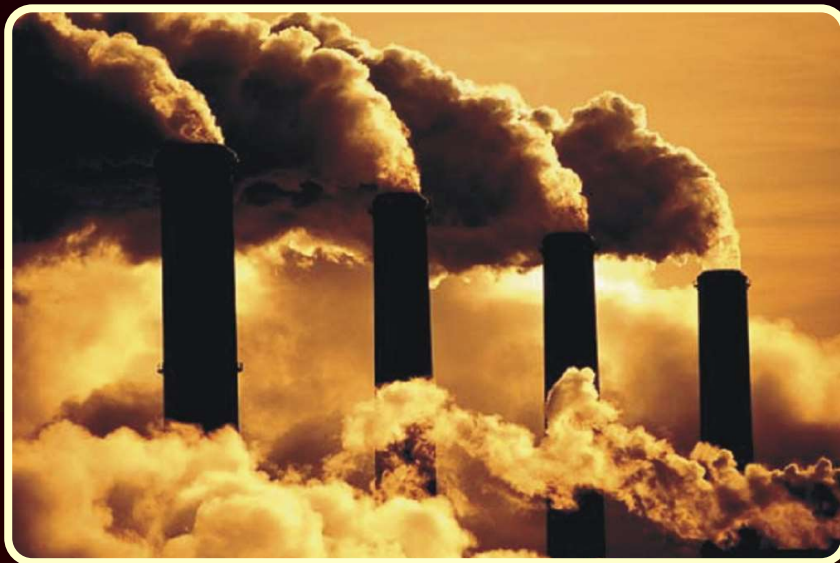
- The amount of heat energy produced on completely burning of one kilogram of fuel (in presence of O_2) is called the calorific value of a fuel. The calorific value of the fuels is expressed in kilojoules per kilogram (kJ/kg) or kilojoules per gram (kJ/g).

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

Calorific values of different fuels

9. Harmful effects of burning fuels

- » The increasing fuel consumption has harmful effects on the environment. The main products formed during the fuel combustion which produce harmful effect are



Combustion of fuel causes a lot of pollution

- » Fine particles produced on burning of carbon fuel are dangerous pollutants, causing respiratory problems.
- » Carbon monoxide is poisonous gas which produces during incomplete combustion of fuels. It can kill persons sleeping in a closed room.
- » Increased concentration of CO_2 can cause global warming.
- » Oxides of sulphur and nitrogen dissolve in rain water and form acids. Such rain is called acid rain. It is harmful for buildings and monuments.
- » Burning of wood gives a lot of smoke which causes air pollution and is also very harmful for humans. It may lead to many respiratory problems. Cutting of trees for obtaining wood leads to deforestation which is quite harmful to environment.
- » Carbon particles of smoke or the ash get suspended in the air. Excessive amount of them in the air causes breathing problems.