1. **Combustion**: A chemical process in which a substance reacts with oxygen to give off heat and light.

   Examples of Combustion: Burning of wood, coal, and LPG.

1.1 Types of Combustion

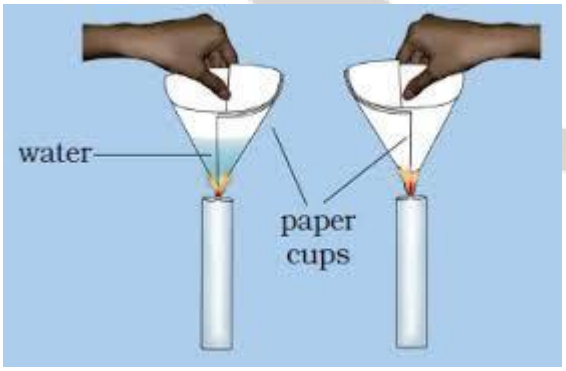
a) Rapid Combustion: Combustion in which a substance burns rapidly and produces heat and light (e.g., burning of LPG in a gas stove).
b) Spontaneous Combustion: Combustion which occurs on its own without external heat (e.g., phosphorous catching fire at room temperature). Spontaneous combustion of coal dust has resulted in many disastrous fires in coal mines.
c) Explosion: Sudden and violent combustion with the production of heat, light, sound, and gases (e.g., firecrackers). Explosions can also result from applying pressure.

1.2 Conditions for Combustion

i. Combustible substance: A substance that undergoes combustion. Any material that undergoes combustion is called a combustible substance. It is also called as fuel. Some examples of fuels are petrol, diesel, etc. The fuel may be in solid, liquid or gas state.
ii. Supporter of combustion like Oxygen. Combustion requires air. In absence of air, combustion will stop. Carbon dioxide and nitrogen are non supporters of combustion.
iii. Attainment of Ignition Temperature:(Ignition Temperature: It is the minimum temperature at which any material catches fire).

If the temperature of combustible substance is lower than the ignition temperature then the substance will not burn. It has to be heated to its ignition temperature. This is the reason why If kerosene oil is heated a little, it will catch fire. But if wood is heated a little, it would still not catch fire. Kerosene has a lower ignition temperature. Cooking oil catches fire when a frying pan is kept for long on a burning stove because it attains its ignition temperature.

We have to use paper or kerosene oil to start fire in wood or coal because paper has a lower ignition temperature than wood and coal.



Try this,

Make two paper cups by folding a sheet of paper . Pour about 50 mL of water in one of the cups. Heat both the cups separately with a candle. We observe that the paper cup without water starts burning while the one with water does not.

This is because in the paper cup with water, heat is getting transferred to the water(which will heat up), and its ignition temperature is not reached.

1.3. Some special cases:

- In cells, oxygen is also combined with fuel molecules to release the stored energy in the fuel, our food. However, this is a slower and more controlled process in cells. The process is slower so the cell can use the energy that is released to do work. Just remember that there are similarities but important differences in the way furnaces and cells “burn” fuel. In the furnace the process is called **combustion**. In the cell the process is called **cellular respiration**.
- Sun produces a large amount of energy in the form of heat and light. It uses nuclear reactions to do so. There is no oxygen in space so combustion cannot take place.
- Forest fire : forest fires are more frequent in summer as the leaves are dry and they have a lower ignition temperature. Any spark, a lit cigarette carelessly thrown , or even the heat from the sun can sometimes cause a forest fire. During extreme heat of summer, at some places dry grass catches fire. Spontaneous forest fires are sometimes due to the heat of the sun or due to lightning strike. However, most forest fires are due to the carelessness of human beings. It is important to remember that the campfires must be completely extinguished before leaving a forest after a picnic, or a visit.
- How a Matchstick works : More than five thousand years ago small pieces of pinewood dipped in sulphur were used as matches in ancient Egypt. A mixture of antimony trisulphide, potassium chlorate and white phosphorus with some glue and starch was applied on the head of a match made of suitable wood. When struck against a rough surface, white phosphorus got ignited due to the heat of friction. White phosphorus proved to be dangerous both for the workers involved in the manufacturing of matches and for the users.

  These days the head of the safety match contains only antimony trisulphide and potassium chlorate. The rubbing surface has powdered glass and a little red phosphorus (which is much less dangerous). When the match is struck against the rubbing surface, some red phosphorus gets converted into white phosphorus. This immediately reacts with potassium chlorate in the matchstick head to produce enough heat to ignite antimony trisulphide and start the combustion.

2. Fuel

A substance that undergoes combustion is called a fuel.

2.1 Types of Fuel-

On the basis of physical state :

Solid	wood, coal
liquid	Petrol, diesel,kerosene
gas	LPG, CNG, Hydrogen

On the basis of their use, fuels are classified as Renewable and Non renewable fuels.

Renewable fuels	Non-renewable fuels
Can be used over a longer time and are never exhausted	Present in a finite amount. Replenished very slowly. Get exhausted over a period of time
Wood from forests, animal waste like cowdung	Fossil fuels like coal, petroleum, natural gas

2.2 Efficiency of fuels and Calorific value:

Efficiency of a fuel is determined by its Calorifuc value.

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 Value: the heat/energy liberated when one kilo gram of fuel burns completely. It is measured in Kilo joules per Kg.

Example: kerosene has a calorific value of 45000 kJ/kg . that means that on burning one kg of kerosene, we get 45000 kJ of energy.

Calculate the heat produced by burning 2 kg of LPG if its calorific value is 55,000 kJ/kg. (Heat produced = 2 kg × 55,000 kJ/kg = 110,000 kJ.)

Compare the calorific values of fuels given in the table here.

Why do you think LPG is preferred over wood as a fuel?

2.3. Characteristics of a good fuel:

a) It should have a high calorific value
b) Ignition temperature should be moderate
c) It should be readily available and economical
d) It should be easy to store and transport
e) It should be eco-friendly. Should not give out undesirable gases or residue.

2.3.1

Combustible Substances- substances that can catch fire or burn . eg wood, paper, oil, coal, alcohol

Incombustible substances- substances that do not catch fire eg stone, glass .

2.3.2

Inflammable substances : Materials which have a low ignition temperature and catch fire easily are termed as inflammable substances. Example includes petrol, LPG, alcohol, red phosphorous etc. containers of such substances usually have a warning sign.

3.Controlling Fire

To control fire we can remove any one of the three necessary conditions. We can either cut off the supply of oxygen or cool the material so that the ifnition temperature is no longer achieved.

The combustible substance which is already burning is not removed so easily. If a building is on fire, we cannot remove it.

Putting out fire is called Extinguishing the fire.

3.1 Extinguishing fire

a. **Water** as fire extinguisher : water cools the substance and also cuts off the supply of air

Water cannot be used for electrical fires as it is a conductor and can cause electric shocks
Water is not used for oil fires as oil is less dense than water and floats over it. Oil will therefore continue to burn.

b. When we place a piece of burning wood or charcoal on an iron plate or Tawa and cover it with a glass jar . It stops burning after sometime as the oxygen gets used up.
c. When the clothes of a person catch fire, the person is covered with a **blanket** to extinguish fire, the blanket cuts off the supply of air, the supporter of combustion.
d. Throwing **sand** over a burning substance cuts off the supply of air and extinguishes the fire.
e. **Carbon dioxide** as a fire extinguisher.- Carbon dioxide is heavier than air, it covers the burning substance like a blanket and cuts off the supply of air

3.2 Fire Extinguisher

It is a portable apparatus that can be used to put out accidental fires.

3.2.1 Carbon dioxide fire extinguisher- can be used for oil and electric fires also. For fires involving electrical equipment and inflammable materials like petrol, carbon dioxide (CO_2) is the best extinguisher.CO_2 , being heavier than oxygen, covers the fire like a blanket. Since the contact between the fuel and oxygen is cut off, the fire is controlled. The added advantage of CO_2 is that in most cases it does not harm the electrical equipment. We can get a steady supply of carbon dioxide by storing it at high pressure as a liquid in cylinders, Just like LPG. When released from the cylinder, CO_2 expands enormously in volume and cools down. So, it not only forms a blanket around the fire, it also brings down the temperature of the fuel. That is why it is an excellent fire extinguisher.

3.2.2 Soda acid fire extinguisher – the apparatus contains Sodium bicarbonate(baking soda) or Potassium bicarbonate in a metallic container and concentrated sulphuric acid in a glass bottle. When the knob is struck, the bottle

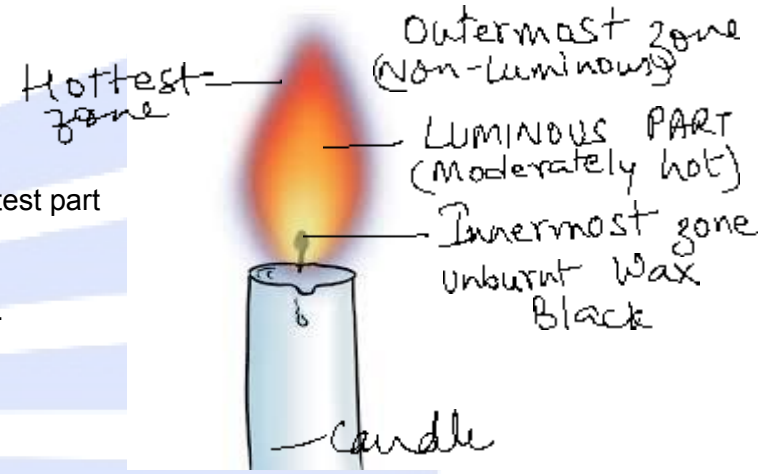
breaks. The chemical reaction between sodium bicarbonatev and sulphuric acid produces carbon dioxide. Carbon dioxide is heavier than air, it covers the burning substance like a blanket and cuts off the supply of air.

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

4. Flame

Flame is the region where combustion takes place. A flame is produced only by those substances that vaporise on heating, like wax. When a candle is burnt, the wax melts and vapourises. These vapours rise upwards and burn to produce a flame. The wick of the candle also burns.

Flame of a candle



Non luminous zone: the outermost part of the flame. It has wax vapours that burn completely in oxygen making the flame appear blueThis is the hottest part of the flame. It appears blue.

Luminous Zone: the middle zone that produces light. It is moderately hot. It is the zone of incomplete combustion. Less air is available here.

Dark zone: this is the innermost part of flame. The flame appears greyish black This is the coolest part. No combustion takes place here as there is no contact with air.

Zone of flame	use
Outer- non luminous, hottest	Welding, cutting of metals, goldsmith
Middle – yellow, luminous, moderately hot	Produces light, has unburnt carbon particles that form soot
Innermost-non luminous, coldest, unburnt particles	No use as such

Observe that the flame appears at the end of the glass tube when a match stick is brought near it. This is due to the wax vapours that are coming out of the glass tube

.

The black ring is formed on the glass slide due to deposition of unburnt carbon particles present in the luminous zone of the flame.

If we hold a thin long copper wire just inside the non-luminous zone of flame for about 30 seconds we

see that the portion of the copper wire just outside the flame gets red hot. Ist indicate that the non-luminous zone of the flame has a high temperature.

- Substances that do not vapourise on heating, do not produce a flame eg coal.
- Magnesium ribbon, when burnt in air , glows and produces light.

5. Harmful Effects of Burning Fuels

1. Air Pollution: Carbon fuels like wood, coal, petroleum release unburnt carbon particles. These fine particles are dangerous pollutants causing respiratory diseases, such as asthma.

2. Incomplete combustion of these fuels gives **carbon monoxide** gas. It is a very poisonous gas. It is dangerous to burn coal in a closed room. The carbon monoxide gas produced can kill persons sleeping in that room.

3. Combustion of most fuels releases carbon dioxide in the environment. Increased concentration of carbon dioxide in the air can cause Global warming. Global warming is the rise in temperature of the atmosphere of the earth. This results, among other things, in the melting of polar glaciers, which leads to a rise in the sea level, causing floods in the coastal areas. Low lying coastal areas may even be permanently submerged under water.

4. Burning of coal and diesel releases sulphur dioxide gas. It is an extremely suffocating and corrosive gas. Moreover, petrol engines give off gaseous oxides of nitrogen. Oxides of sulphur and nitrogen dissolve in rain water and form acids. Such rain is called acid rain. It is very harmful for crops, buildings and soil.

6. Search for better fuels

- Wood was used as domestic and industrial fuel. But now it has been replaced by coal and other fuels like LPG.People still use wood as a fuel because of its easy availability and low cost. However, burning of wood gives a lot of smoke which is very harmful for human beings. It causes respiratory problem. Trees provide us with useful substances which are lost when wood is used as fuel and cutting of trees leads to deforestation which is harmful for the environment.
- The use of diesel and petrol as fuels in automobiles is being replaced by CNG (Compressed Natural Gas), because CNG produces the harmful products in very small amounts. CNG is a cleaner fuel.