CHAPTER

09

FOSSIL FUELS, COMBUSTION AND FLAME

We use different kinds of fuels for various purposes at home, in industry and for running automobiles. These can be cowdung, wood, coal, charcoal, petrol, diesel, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), etc.

Some materials burn with flame (e.g. candle) whereas some burn without flame (e.g. coal).

Let us now study the chemical process of burning and the types of flame produced during this process.

In this chapter, we will discuss carbon, its various forms, its compounds, fuels and petroleum and their types.

Combustion

- A chemical process in which a substance reacts with oxygen to give off heat is called combustion.
- The substance that undergoes combustion is said to be combustible.
- It is also called a fuel which can be solid, liquid or gas.
- Sometimes, light is also given off during combustion either as a flame or as a glow, e.g. wood burns by producing a flame, but charcoal burns by producing light in the form of glow.

Combustible and Non-Combustible Substances

As all the substances around us do not burn, so there are two types of substances around us

- **Combustible substances** The substances which burn in air or oxygen are called combustible substances, e.g. petrol, LPG, kerosene, etc.

- **Non-combustible substances** The substances which do not burn in air or oxygen are called non-combustible substances, e.g. water, glass, sand, etc.

Necessary Conditions for Combustion

There are three necessary conditions for combustion. These are

(i) Presence of a combustible substance.

(ii) Presence of a supporter of combustion.

(iii) Heating the combustible substance to its ignition temperature or attainment of ignition temperature.

Supporter of Combustion

- A substance which helps in combustion is called a supporter of combustion, e.g. oxygen (or air).
- When the clothes of a person catch fire, the person is covered with a blanket to extinguish the fire. This is because the supply of air to the burning clothes is cut off by blanket, due to which the burning of clothes stop and the fire gets extinguished.

Ignition Temperature

- Before a substance catches fire and starts burning, it must be heated to a certain minimum temperature. The lowest temperature at which a substance catches fire and starts burning is called its ignition temperature.
- A combustible substance cannot catch fire if its temperature is lower than its ignition temperature.
- e.g. a piece of paper does not catch fire at the room temperature because its ignition temperature is much higher than room temperature. When we apply a burning matchstick to the paper, it starts burning. It is because the heat produced by burning matchstick heats the piece of paper to its ignition temperature and makes it burn.

Use of Kerosene Oil to Burn Wood or Coal

- Ignition temperature of paper or kerosene oil is low, so if some kerosene is sprinkled over the wood, the kerosene starts burning by a lighted matchstick.
- The heat produced by the burning of kerosene makes the wood to burn. The coal pieces are then placed over the burning wood.
- The large heat produced by the burning wood heats the coal to its ignition temperature. In this way, the coal starts burning.

Inflammable Substances

The substances which have very low ignition temperature and can catch fire easily with a flame are called inflammable substances, e.g. petrol, alcohol, LPG, etc.

How Fire can be Controlled

Fire can be extinguished in three ways

- By removing the fuel. But in most cases, fuel cannot be eliminated.
- By cutting off the air supply to the burning substances.

Fire Extinguishers

Substances which are used to extinguish fire are known as fire extinguishers, e.g. sand, water and carbon dioxide.

- The most common fire extinguisher is water but only, when things like wood and paper are on fire. It extinguishes fire by cooling the burning substances. But, if electrical equipment is on fire, water may conduct electricity, so it can give electric shock to the persons involved in fire-fighting. Thus, water cannot be used to extinguish fires caused by electricity.
- For fires involving electrical equipment and inflammable substances like petrol, carbon dioxide (CO_2) is the best extinguisher. CO_2 is denser than air and thus forms a layer around the burning substances, i.e. it covers the fire like a blanket due to which fresh air cannot reach the burning substances. Carbon dioxide can be stored as a liquid at high pressure on cylinders.

Types of Combustion

There are various types of combustion. Three important types of combustion are as follows

(i) Rapid Combustion

The combustion in which a large amount of heat and light are produced in a short time, is called rapid combustion, e.g. immediate burning of cooking gas (LPG) in a gas stove on bringing a burning matchstick or a gas lighter near it, burning of kerosene oil in kerosene stove, etc.

(ii) Spontaneous Combustion

- The combustion which occurs on its own without the help of any external heat, is called spontaneous combustion.
- In spontaneous combustion, the material suddenly bursts into flames without being heated, e.g. white phosphorus burns in air at room temperature on its own.
- The heat required to start the spontaneous combustion is produced internally by the slow oxidation inside the substance.
- Some spontaneous combustion reactions are very dangerous, e.g. the spontaneous combustion of coal dust has resulted in many disastrous fires in coal mines.
- Sometimes, due to the heat of the sun or due to the spark of lightning from the sky, spontaneous combustion of straw (dry grass) and forest wood takes place which leads to forest fire.

(iii) Explosions

- A sudden combustion in which a large amount of heat, light and sound are produced is called explosion.
- A large amount of gases is released quickly in an explosion, e.g. when a cracker is ignited, a sudden explosion takes place with the evolution of heat, light and sound. Explosion can also take place if pressure is applied on the cracker.

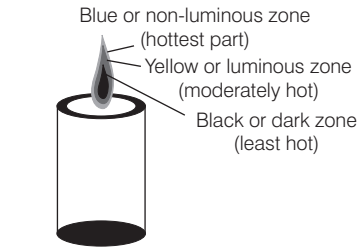
Flame

- The substances which vaporise during burning, give flames, e.g. kerosene oil and molten wax rise through the wick and are vaporised during burning and form flames. On the other hand, charcoal does not vaporise and so does not produce a flame. It just glows.
- When fuels burn, the flame produced depend on the oxygen which is available for burning the fuel.
  (i) When the supply of oxygen is not sufficient, the fuels burn incompletely producing mainly a yellow flame. e.g. the colour of candle flame is mainly yellow. Also the colour of kerosene lamp flame is yellow.
  (ii) When the supply of oxygen is sufficient, the fuels burn completely producing mainly a blue flame, e.g. in LPG stoves, the LPG burns with a blue flame.

Structure of a Flame

A flame consists of three zones

- **Innermost zone** It is a dark or black coloured zone. It consists of hot, unburnt vapours of combustible material. It is the least hot part of the flame.
- **Middle zone** It is the bright and luminous zone. It produces a moderate temperature. Here, partial combustion of the fuel takes place.
- **Outermost zone** It is non-luminous zone. Here, complete combustion of the fuel takes place because there is plenty of air around it. It has the highest temperature in the flame, i.e. it is the hottest part of the flame.



Different zones of flame

Fuels

- A fuel may be defined as any substance which supplies heat energy on burning without production of excessively undesirable side products, e.g. wood, coal, LPG, etc.
- A good fuel is one which has the following qualities

(i) Readily available (ii) Cheap

(iii) Burns easily in air at a moderate rate.

(iv) Produces a large amount of heat, i.e. high calorific value.

(v) Does not leave behind any undesirable substance.

(vi) Low ignition temperature.

Fuel Efficiency: Calorific Value

The total amount of heat in a calories liberated by the complete combustion of unit mass of a fuel in presence of air. It is expressed in cal per gram, kcal/g and kJ/kg.

Burning of Fuels Leads to Harmful Products

The increasing fuel consumption has harmful effects on the environment because burning fuels produce harmful products which pollute the air around us.

These are as follows

(i) Burning of carbon fuels like wood, coal, petroleum releases unburnt carbon particles in air which are dangerous pollutants causing respiratory diseases such as asthma.

For centuries, wood was used as domestic and industrial fuel. But, now it has been replaced by coal and other fuels like LPG. In many rural parts of our country, 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. Moreover, cutting of trees leads to deforestation which is quite harmful to the environment.

(ii) Incomplete combustion of carbon fuels gives carbon monoxide gas which is very poisonous gas. Excessive inhaling of this gas can kill a person.

(iii) Burning of most fuels releases carbon dioxide into air. Increased concentration of carbon dioxide in the air is believed to cause **global warming**. Global warming is the rise in temperature of the atmosphere of the earth. Due to this, the ice in polar regions will melt very fast, producing a lot of water.

(iv) Burning of coal and diesel releases sulphur dioxide gas. It is an extremely suffocating and corrosive gas. It may damage our lungs. Moreover, petrol engines give off gaseous oxides of nitrogen. Oxides of sulphur and nitrogen dissolve in rainwater and form acids. Such rain is called **acid rain.** It is very harmful for crops, buildings and soil.

The use of diesel and petrol as fuels in automobiles is being replaced by CNG (Compressed Natural Gas) because it produces harmful products in very small amounts.

PRACTICE EXERCISE

1. A substance which reacts with oxygen giving heat is called combustible substance. Which one of the following is combustible substance?
(a) Iron nail
(b) Stone piece
(c) Glass
(d) Wood

2. Which one of the following has the highest calorific value?
(a) Kerosene (b) LPG
(c) Biogas (d) Petrol

3. Magnesium ribbon on burning in air produces
(a) magnesium oxide, water and light
(b) magnesium oxide and heat
(c) magnesium oxide, heat and light
(d) magnesium oxide, water and heat

4. Which of the following is not a combustible substance?
(a) Camphor (b) Straw
(c) Glass (d) Alcohol

5. The substance that does not burn with flame is
(a) LPG (b) Dry glass
(c) camphor (d) Charcoal

6. On placing an inverted tumbler over a burning candle, the flame extinguishes after some time. This is because of non-availability of
(a) oxygen
(b) carbon dioxide
(c) water vapours
(d) wax

7. If a person's clothes catch fire, the best way to extinguish the fire is to
(a) throw water on the clothes
(b) use fire extinguisher
(c) cover the persons with a woolen blanket
(d) cover the person with a polythene sheet

8. The substance expected to have the highest ignition temperature out of the following is
(a) kerosene (b) coal
(c) petrol (d) alcohol

9. Choose the correct statement about inflammable substances from the following.
They have
(a) low ignition temperature and cannot catch fire easily
(b) high ignition temperature and can catch fire easily
(c) low ignition temperature and can catch fire easily
(d) high ignition temperature and cannot catch fire easily

10. Choose the incorrect statement from the following.
Forest fires are usually due to
(a) carelessness of humans
(b) cutting of trees
(c) heat of sun
(d) lightning strike

11. When the supply of oxygen is not sufficient, the fuels burn incompletely producing mainly
(a) blue flame (b) orange flame
(c) yellow flame (d) dark blue flame

12. Which zone of the flame has the highest temperature?
(a) Innermost zone
(b) Middle zone
(c) Outermost zone
(d) None of the above

13. The calorific value of a fuel is expressed in a unit called
(a) kilojoule litre
(b) kilojoule gram
(c) kilogram per mililitre
(d) kilojoule per kilogram

14. In villages, people use wood as fuel because
(a) it is considered to be an ideal fuel
(b) of its easy availability and low cost
(c) it is environment friendly
(d) it catches fire easily

15. Which among the following is considered as the cleanest fuel?
(a) Cow dung cake
(b) Kerosene
(c) Petrol
(d) Hydrogen gas

16. Choose the incorrect statement from the following.
A good fuel is one which
(a) is readily available
(b) produces a large amount of heat
(c) leaves behind many undesirable substances
(d) burns easily in air at a moderate rate

17. Shyam was cooking potato curry on a chulha. To his surprise he observed that the copper vessel was getting blackened from outside. It may be due to
(a) proper combustion of fuel
(b) improper cooking of potato curry
(c) improper combustion of the fuel
(d) burning of copper vessel

18. Which one of the following has the lowest calorific value?
(a) CH_4 (b) LPG (c) Coal gas (d) H_2

19. The fuel, among the following, that has low calorific value and causes high pollution is
(a) coal (b) cow-dung cake
(c) LPG (d) petrol

20. A gaseous fuel …… .
(a) gives a high ash content on burning
(b) have low calorific value
(c) cannot passed into pipelines
(d) can be burnt at any moment

Answers

1	*(d)*	2	*(b)*	3	*(c)*	4	*(c)*	5	*(d)*	6	*(a)*	7	*(c)*	8	*(b)*	9	*(c)*	10	*(b)*
11	*(c)*	12	*(c)*	13	*(d)*	14	*(b)*	15	*(d)*	16	*(c)*	17	*(c)*	18	*(c)*	19	*(b)*	20	*(d)*