COMBUSTION, FUELS AND FLAME

We use different kinds of materials as fuels for various purposes at home. You might have observed or heard about how people used to burn wood, coal, cakes of cow dung, kerosene etc., for cooking food at home. Blacksmiths in villages also use them for heating metals. Both in urban and rural areas, now a day's, LPG is used as fuel for cooking the food. We use the light from the burning candle or kerosene lamp, when there is no supply of electricity. You might have also observed burning of a candle or coal. What difference do you notice in the burning process?

- Why does candle give flame when it is burnt but why does coal burn without emitting a flame ?
- Do all fuels produce same amount of heat when they are burnt?
- What do we need to burn a material?
- Have you ever tried burning a piece of paper or wood or coal, a small rock or a pebble?
- Do all of them burn?

Let us do an activity to know which of these materials burn and which do not.

Activity-1

Do all materials burn ?

You will need a pair of tongs, some metal or clay dishes and a candle or a spirit lamp.

Using tongs, pick up a small piece of paper and bring it close to the lighted spirit lamp and keep it on flame as shown in figure-1.

Record your observation in table 1.

Fig-1

Carry out this experiment with a piece of charcoal, magnesium ribbon, straw, cotton cloth, nylon cloth, dry wood, pebble, wax, plastic piece etc, and record your observations.

You can also try to burn liquids.

Take 2ml of water in small plate. Bring lighted stick near to water in the plate (see figure 2).

Table 1

S.No.	Name of the material burnt	How does it burn		
		Burns immediately	Burns slowly	Does not burn
1.	Magnesium ribbon			
2.	Pebbles			
3.	Petrol			
4.				
5.				

- What do you observe in your attempt of burning water?
- Is there any difference in flame of lighted stick?
- What happened to the lighted stick when it is brought closer to water in the plate?

Fig- 2

Carry out this activity using coconut oil, mustard oil, kerosene, spirit, petrol etc. (sticks should be long enough to prevent any fire accident if the material catches fire)

Record your observation in table 1.

- What can we conclude from this activity?

We can conclude **that some materials burn and others don't.** In the above activity you observed that when materials burn in air, heat and light are produced.

A chemical process in which a material reacts with oxygen present in the air to generate heat is called **combustion**. The materials which burn when brought near a flame are **combustible** materials. Some of them can also be used as fuels. The materials which do not burn are called **non-combustible** materials.

- Which of the material in the above activity are combustible?

Think and discuss

- Why some material burn and why some do not? Give reasons.
- Why some materials which do not burn at normal temperature burn at higher temperatures?

What is needed for the process of combustion?

We know that we need a match stick or a lighter to burn a material.

- How will you prove that air is needed to burn a material?
- Can we burn a material in the absence of air?

Activity-2

Testing the necessity of air for burning

Take a small burning candle and put it on a table. Invert a glass tumbler over it. The candle continues to burn for some time. Then flickers and finally flame goes off. (See figure 3)

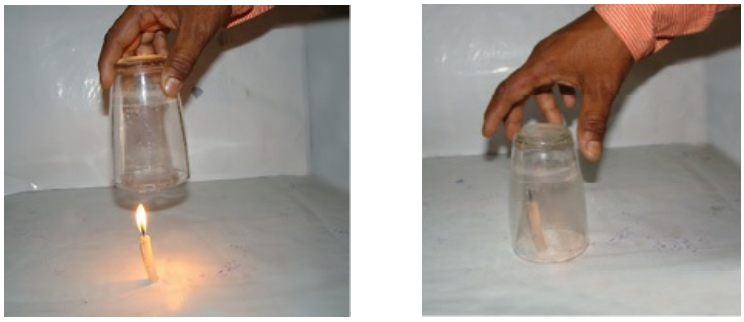


Fig-3

Remove the tumbler and again light the candle. Put the tumbler back over the candle. When the candle flame begins to flicker, remove the tumbler. What happens to the candle? Notice carefully.

We find that putting the glass tumbler over the candle cuts off the supply of air and the candle flame goes off.

This experiment proves that air is needed to burn a material. Some other experiments need to be conducted to prove that the oxygen present in air supports the combustion.

Think and discuss

If you lift the glass tumbler (Which is placed over a burning candle) to 1cm height what happens? Why?

We can carry out an experiment to demonstrate that oxygen helps in burning.

Lab Activity

Aim: To prove that oxygen helps in burning

Material required: Test tube, test tube holder, spirit lamp, match box, inscence stick (agarbatti), potassium permanganate crystals.

Procedure

Light a scented / incense stick (*agarbatti*), and let it burn for 10 s, then put out the flame and keep it aside.

Take potassium permanganate in a test tube. Hold the test tube with a test tube holder and heat it over the flame of spirit lamp. Oxygen is released on heating of potassium permanganate.

Insert the agarbatti with the burning stub, into the test tube as shown in figure 4.

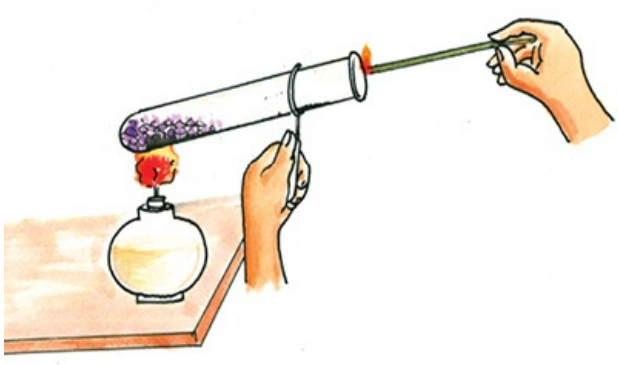


Fig-4

Observations

- How does scented stick started burning?

• Why does not it catch again fire when it is kept aside in air after putting its flame off?

You observe that stick burns with a flame. Here the oxygen supports combustion by helping Agarbathi to burn with bright flame.

Think and discuss

• How do you say that the gas released in the above experiment is oxygen?

• Can we replace potassium permanganate with any other substance to release oxygen?

• Is there any other procedure to prove that oxygen is needed for burning?

A few more examples of combustion are given below. Can you explain the reasons for the changes taking place ?

• A slow fire bursts into a flame when air is blown on it, but a candle burning with flame goes off when air is blown on it. Why?

• If a large quantity of dry grass is set on fire in forests then it is very difficult to put off the fire. Why?

• When an object catches fire, the fire is put off by covering with sand or a blanket. Why?

The examples and activities discussed above shows that combustion takes place only in the presence of air. We know that some materials catch fire as soon as they are brought near a flame, but some materials take a long time to start burning though they are kept near the flame.

• What could be the reason for this variation in burning patterns among combustible materials?

Let us explore this in the following activities.

Ignition Temperature

In activity 1, a candle is used to burn a piece of paper. Can we burn paper with out the help of flame ?

Activity-3

Burning a paper with sun rays

On a sunny day, go out and focus the sun rays on a piece of paper using a magnifying lens (Figure-5). Touch the spot after some time. How do you feel?

Fig-5

You must have heard about people in ancient times rubbing pieces of stones together to produce sparks. Have you tried it? Rub two stones hard together and touch them. What do you feel?

Now recall some of your experiences:

• Does a matchstick burn by itself?

• Why do you rub the match stick on the side of the match box to burn it?

• Can you burn a piece of wood by bringing it close to a lighted matchstick?

• Why do we use paper or kerosene oil to start fire in wood or coal?

On the basis of above observations and previous experiences, we can conclude that a combustible substance has to be initially heated to catch fire or burn. The lowest temperature at which a substance catches fire is called its **ignition temperature**. When a substance starts burning heat is produced and it helps to burn the substance continuously. The ignition temperature is different for different substances. The ignition temperature of a substance decides quickness of catching fire.

The substances which have very low ignition temperature and easily catch fire are called **Inflammable Substances**. Examples of inflammable substances are petrol, alcohol, liquified petroleum gas (LPG) etc.,

• Can you make a list of some more inflammable substances?

Activity - 4

Understanding ignition temperature

Take two small paper cups. Pour water in one of the cups. Put the two cups on different tripod stands and heat both of them using a candle as shown in the
figure-6.

Fig-6

- Which cup burns first?
- Does the water in the cup become hot? Why?

Explain why one cup burns quickly but the other does not, on the basis of ignition temperature. When heat is supplied to cups, the heat received by second cup is transferred to water in it. The water in this cup prevents the paper to reach its ignition temperature and hence it does not burn.

- When does the second cup start burning?

Make a guess and discuss with your teacher.

Types of Combustion

During summer time, dry grass catches fire in the forests. It may spread to the trees and very soon the whole forest will be on fire. It is very difficult to control such forest fires.

If the head of a match stick is rubbed on the side of a match box, it starts burning.

- What makes match sticks to catch fire?

A mixture of antimony trisulphide, potassium chlorate and white phosphorus with some glue and starch was applied on the head of a match stick made of suitable wood. When it struck against a rough surface white phosphorus got ignited due to the heat of friction. This starts the combustion of the match stick. However, white phosphorus proved to be dangerous both for the workers involved in the manufacturing of match boxes and for the users.

These days the head of the safety match stick 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 stick 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.

The type of combustion in which material suddenly burns into flames without the application of any external agent is called **spontaneous combustion**.

Turn on the knob of the gas stove in the kitchen and bring a burning match stick or a gas lighter near it. The gas burns rapidly and produces heat and light.

Such combustion is known as **rapid combustion**. Materials such as spirit, petrol and camphor burn even with a spark from a gas lighter.

Do you know?

1. You might have noticed words written as **highly inflammable** on petrol tankers. This is a warning to the public to keep flame away from the inflammable material.

2. We generally enjoy sound and light from fire works on festival days. When a cracker is ignited a sudden reaction takes place with the evolution of heat, light and sound. A large amount of gas is also liberated in this reaction. Such a reaction is called **explosion**. Explosions can also take place if pressure is applied on the crackers.

Think and discuss

- Why is phosphorus preserved in water? (Hint: think about the role of ignition temperature in combustion)
- Why Kerosene stoves and Bunsen burners have small holes in them? (Hint; Think about the role of air in combustion)
- It is hard to ignite match stick in rainy days. Why ?

Fuels

We know that combustion gives heat and light. The sources of heat for domestic, automobile and industrial purposes are mainly wood, charcoal, petrol, kerosene, LPG, CNG etc. These substances are fuels. In the previous chapter, we studied about the fossil fuels and their use in various ways. We not only use fossil fuels but also other kinds of fuels for different purposes at home, in automobiles and in industries. List different fuels that are used for !

Domestic purpose …….....

Automobiles/ Aircraft/ Trains/ Rockets

.....

Industry .....

Classify the above fuels into solid, liquid, gases and write them in table 2.

Table - 2

Solid	**Liquid**	**Gas**

Look at the fuels in the table 2.

- Can you decide the best fuel among them?
- What is the criteria to decide a best fuel?

Discuss with your friends.

Deciding the best fuel depends upon the purpose of its use. A best fuel for cooking may not be a best fuel for running an automobile.

In general, there are several factors that have to be kept in mind while choosing a fuel, like purpose of use, fuel efficiency and availability, reasonable price, easy to handle and safe to store, easy to ignite and put off etc. The fuel should also burn at a moderate rate and cause less pollution. In addition, it should have a high calorific value.

- What is calorific value ?

Suppose 1 kg of coal and 1 kg of cow dung are burnt. Which one produces more heat? Different substances produce different amounts of heat on burning. Heat is measured in kilo joules. **Calorific value** of a fuel is the amount of heat energy produced on complete combustion of 1 kg of that fuel. It is measured in **kilo joules per kg** (kj / kg).

Do you know?

Fuel	Calorific value (kj/kg)
Cow dung	6000-8000
Wood	17000-22000
Coal	25000-33000
Petrol	45000
Kerosene	45000
Diesel	45000
CNG	50000
LPG	55000
Biogas	35000-40000
Hydrogen	150000

Fire control

You must have seen or heard about fire breaking out in houses, shops, factories, etc.

- How can we put off the fire if it breaks out ?

We use many methods to extinguish a fire but they all follow one principle, which is the *principle of elimination of factors which support the combustion*.

Let us recall the factors which support the combustion:

(a) Presence of a combustible material or the fuel

(b) Supply of air or oxygen

(c) High temperature (More than the ignition temperature)

So, elimination of any one of the three factors will help in controlling the fire. Let us see some examples.

Example

If a fire breaks out in a house or in any business establishment the fire brigade will immmediately put off the electric mains and then start spraying water on the fire.

- Why the fire brigade start the work by putting of the electric mains?
- How water helps in eliminating the factors, which support the combustion?

Initially, the water spray cools the combustible material below its ignition temperature. This prevents the fire from spreading.

Then the heat turns the water into vapours which surround the burning material and prevent supply of oxygen to the burning materials. So, the fire is extinguished.

The most common fire extinguisher is water. But water works only when things like wood cloth and paper are on fire. If electrical equipment is on fire water may conduct electricity and harm those trying to douse the fire.

Water is also not suitable for fires involving oil and petrol, because water is heavier than the oil, it sinks below the oil and oil keeps burning on the top.

Since it is difficult to remove the combustible material from a fire, cutting of air supply and lowering the temperature are better methods.

In cases where water cannot be used, carbon dioxide gas is the best choice used which is heavier than oxygen. It can be stored as a liquid in cylinders under high pressure. When released from the cylinder, it expands and brings down the temperature.

It also covers the fire like a blanket. Since the contact between the fuel and oxygen is cut off, the fire is controlled.

That is why it is an excellent fire extinguisher. The added advantage of carbon dioxide is that in most cases it does not harm the electrical equipment. It is mandatory for offices, educational institutions and multistoried buildings to install fire extinguishers.

Flame

Activity - 5

Observing the behaviour of different solid fuels

Collect some fuels like candle, coal, domestic gas, charcoal, magnesium ribbon, wood, cakes of cow-dung, camphor, wick of the oil lamp, wick of kerosene stove, etc. Burn each of them one by one with the help of spirit lamp and note the time they take to catch fire. Also observe how do they burn?

- Do all of them burn in the same manner? If not, what difference do you notice?
- Do all of them form a flame while they are burning?

Record your observation in the following table

Table - 3

Material	Forms flame	Does not form flame	Time
Candle			
Magnesium			
Wick of Kerosene stove			
Charcoal			
Domestic gas			
Camphor			
Cow dung cake			

You may observe that a candle burns with flame where as charcoal does not. Some materials burn with flame, some do not. Kerosene oil and molten wax rise through the wick become gas and form flames. But charcoal cannot be vapourised. So it does not produce a flame. A fuel catches fire immediately if it is in the form of gas. Cooking gas catches fire immediately. Spirit and petrol turn into gas at room temperature. Hence, they catch fire quickly.

Think and discuss

A wax candle burns with a yellow flame. The domestic gas burns with a blue flame. Why?

Structure of a flame

Activity-6

Observing the structure of the flame

Light a wax candle and watch the flame. Carefully note the different coloured zones in the flame. How many colours are there in the flame?

Starting from the base of the flame, how many flame zones do you observe? What is the colour of the outer most zone of the flame?

Observe the innermost zone which is dark. What do you observe there? Is there combustion takes place? In this zone wax gets vapourised. This is a dark zone. See figure 7.

Observe near the base of the flame. Vapourised wax gets completely oxidized and burns with a blue flame. It is blue zone.

Do you know?

A candle is mainly a source of light but heat is also released. A candle is made of wax in which a thick thread is inserted. Wax in the candle melts when it is lighted by a match stick. A little of the wax forms vapour. This vapour combines with oxygen in the air to form flame. The heat of the flame melts more wax from the top of the candle. The liquid wax moves upward through the thread. It also changes to vapour when it reaches the top of the wick and burns with the flame.

Activity-7

Observing what happens in different zones of candle flame

- Light a candle. Hold a glass tube with a pair of tongs and introduce its one end in the dark zone of a non flickering candle flame. Keep lighted match stick near the other end of the glass tube as shown in figure-8. What do you observe? Do you see a flame? If so what is it that produces a flame? Notice that the wax near the heated wick melts quickly.

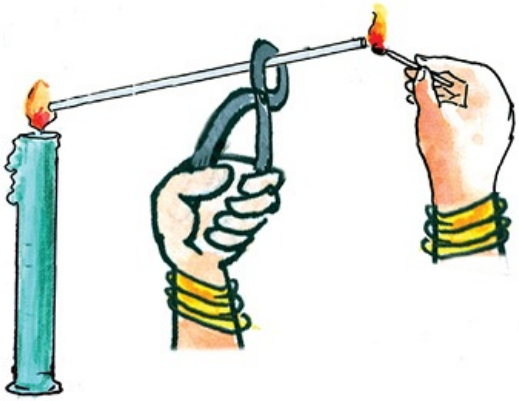


Fig-8

- When the candle's flame is steady, introduce a clean glass slide into the luminous zone (yellow zone) of the flame and hold for 10 seconds. See figure 9. What do you observe?

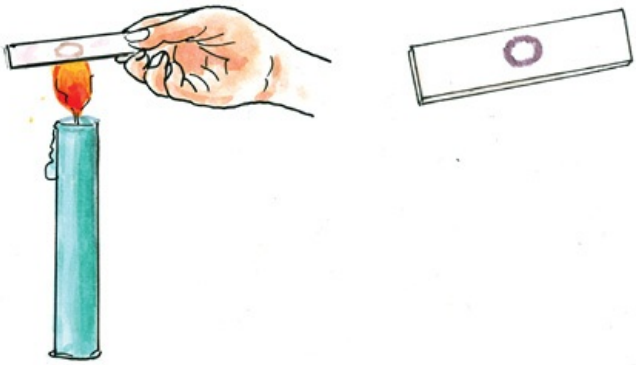
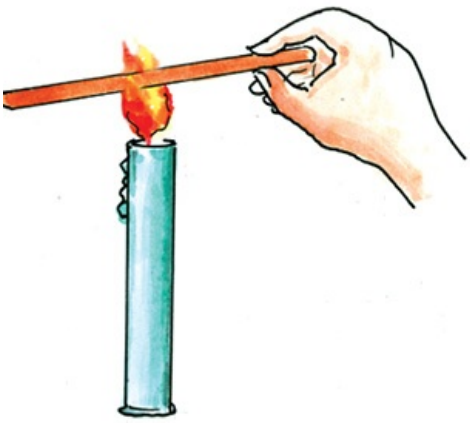


Fig-9

A blackish circular ring is formed on the glass slide. What is it? It indicates the deposition of un-burnt carbon particles present in the luminous zone of the flame. Incomplete combustion takes place in this zone.

Hold a thin long copper wire just inside the flame for about half a minute as shown in figure-10. What do you observe? The copper wire just outside the flame gets red hot. It indicates that the non-luminous zone of the flame has high temperature. It is the hottest part of the flame. It is blue in colour and complete combustion takes place due to good supply of oxygen.



Key words

Combustion, combustible and non - combustible materials, ignition temperature, inflammable material, spontaneous combustion, rapid combustion, explosion, fuels, calorific value.

What we have learnt?

- Burning a material in the presence of air (oxygen) is called combustion.
- Oxygen or air is needed for combustion to take place.
- The lowest temperature at which a substance catches fire is called its ignition temperature.
- The type of combustion in which material suddenly burns into flames without the application of any external agent is called spontaneous combustion.
- The type of combustion in which material burns rapidly and produces heat and light is called rapid combustion.
- The amount of heat energy produced on complete combustion of 1kg of fuel is called the calorific value of that fuel.
- Wax does not burn in the dark zone of the candle flame.
- In the blue zone of the candle flame, vaporized wax burns compleatly due to good supply of oxygen.

WHAT WE HAVE LEARNT?

1. Give four examples of combustible materials. (AS_1)
2. Give four examples of non combustible materials. (AS_1)
3. Why should not we store spirit or petrol near our living place? (AS_1)
4. Give an example of a good fuel. How do you choose that fuel? Explain. (AS_1)
5. The oil fires should not be sprayed with water. Why? (AS_1)
6. What precautions are to be taken while pouring water on fire? (AS_1)
7. Why a wick is not used in gas burners? (AS_1)
8. Water is not used to control fires involving electrical equipment. Why? (AS_1)
9. It is difficult to burn a heap of green leaves but not a heap of dry leaves. Explain why? (AS_1)
10. Give supporting arguments for both the statements (1) fire is useful (2) fire is harmful (AS_2)
11. In a few years the fuels on earth will be exhausted. Think, what would happen to human civilization ? (AS_2)
12. What would happen if oxygen stops to support combustion? – Make a guess. And if it is the situation for what other works fuels are useful. (AS_2)
13. Use of more fuels in our daily life causes air pollution and it is harmful to human being and the other life on earth. Suggest some remedies to avoid this. (AS_2)
14. Let us assume that you are on the moon. If you try to focus sun light on a paper using magnifying glass, does the paper catch fire ? or not? Why ? (AS_2)
15. Can you heat water in a paper vessel? How is it possible? (AS_3)
16. “Is combustion possible without the supply of oxygen?" Discuss with your teacher (AS_3)
17. Expalin giving reasons: In which of the following situations water will get heated in a shorter time? (AS_3)

a) Srikar kept water beaker near the wick in the yellow part of a candle flame.

b) Sonu kept water beaker in the outer most part of the flame.

18. Project work: Collect information about the experiments of Joseph Priestly. Write a two page report describing Priestly's experiments proving that oxygen is needed for burning. (AS_3)

19. List the ways adopted by fire fighters to combat fires. (AS_4)

20. Collect information available on different fuels. Find out the cost per kg. Compare the cost with calorific value. Prepare report on that. (AS_4)

21. Collect the information about annual fuel consumption in different parts of the world. How many years more the fossil fuels last? Make a poster with this information and issue an appeal to save fuel. (AS_4)

22. Draw the diagram of candle flame and label all the zones. (AS_5)

23. Where do you find spontaneous combustion and rapid combustion in your daily life? (AS_7)

24. How do you organize your daily works with fuels to conserve bio-diversity? (AS_7)

25. How do you feel about "Fuels have become a part of human life"? (AS_7)