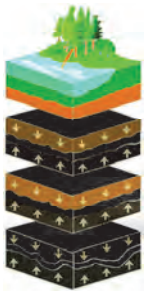
Chapter 16

Coal, Petroleum and Petrochemicals



We need energy to carry out our daily activities and for doing all kinds of work. This energy is obtained from many different sources. For example, we need electricity to run machines in factories and fuel (diesel, petrol and CNG) is needed to run vehicles. Different types of fuels such as wood, kerosene oil, LPG are used to cook food.

Have you ever wondered from where we get these fuels especially coal, petrol and diesel? Are these fuels produced in laboratories or factories? Where are they made and how? Actually, these fuels were formed from the remains of dead plants and animals that were buried under the earth's crust millions of years ago and therefore, they are called fossil fuels.

16.1 Origins of coal and petroleum

About 28 to 36 crore years ago, during the Carboniferous period, the dead bodies of animals and plants got buried under the soil. Slowly, more and more layers of soil were deposited over them. Deep inside the earth, in the absence of oxygen, they were subjected to high pressure and temperature and were transformed into coal. However, many people believe that coal was formed mainly from plants. There is some evidence to support this argument in the form of the large number of fossils found in coal beds. Most of these fossils are impressions of leaves and other fragile parts of plants (Fig. 1).

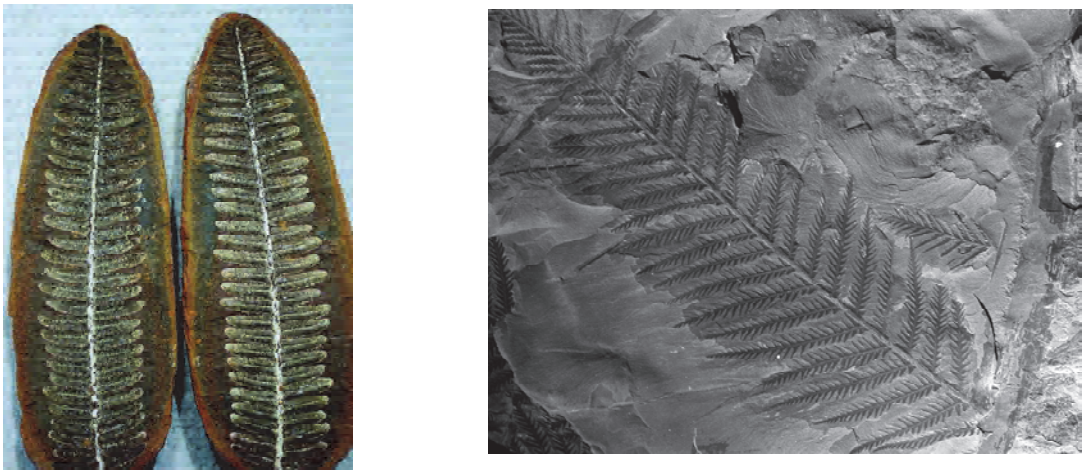


Fig. 1 : Imprints of leaves in layers of coal

It is believed that petroleum was formed from some organisms (plankton) living in the sea. As these plankton died, their bodies got deposited at the bottom of the ocean and were covered by more layers of sand and soil. Over millions of years, in the absence of oxygen and under high pressure and temperature, they were transformed into petroleum.

16.2 Types of Coal

You must have seen wood charcoal. This is a black coloured, brittle substance that is formed in very little time when wood is burnt in an insufficient supply of oxygen. However, the coal that we are talking about in this chapter is also black in colour, but hard as stone.

We have learnt that coal is formed by the decomposition of dead plants that get buried deep inside the earth. The decomposed plants are first converted into peat and because of continuous high pressures and temperatures are subsequently converted into lignite, bitumen and anthracite coal (fig.2).

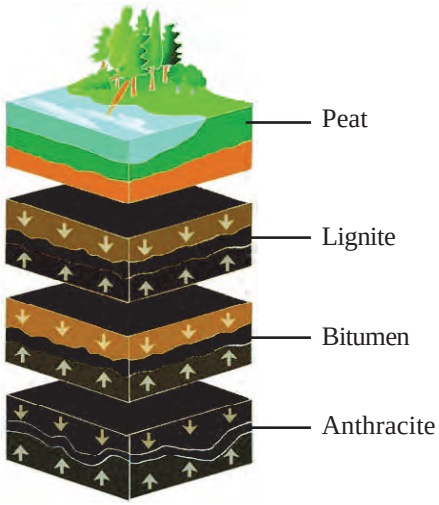


Fig. 2 : Different categories of coal

Coal is mostly made up of carbon and its compounds. Coal is divided into the following categories based on the percentage of carbon in its composition:

1. **Peat -** This is the first stage in the transformation of dead plants into coal. Peat has 25-35% carbon. It is mostly used as fuel.
2. **Lignite -** It is also known as brown coal. Lignite has 35-45% carbon. It is used in thermal power plants to produce electricity.
3. **Bitumen -** This is the most abundant type of coal found in nature. Bitumen is used more than any other type of coal. It has 45-85% carbon. It is mostly utilized in thermal and cement plants, in paper manufacturing units, and in automobile and garment industries. The coke used in steel manufacturing plants is bitumen. Bitumen has more sulfur than any other coal.
4. **Anthracite -** This is an excellent type of coal and also known as hard coal. The amount of carbon in anthracite is more than 85%. Because of the high carbon content it burns for a very long time. It is used as household fuel because it produces very little smoke and ash.

In the types of coal given above, we saw that classification was on the basis of increasing amount of carbon content. You may think that only carbon is present in coal but this is not true. Along with carbon, coal also has mositure, hydrogen, air (oxygen, nitrogen, sulphur) etc.

The amount of heat produced when equal quantities of coal are burnt is called heat or calorific content. Commercial grading of coal is done on the basis of heat content.

16.3 Grades of coal

Grade (G) is used to measure the heating power of coal. It is given in Gross Calorific Value whose unit is kcal/kg.

Table 1 : Grades of coal

Grade	(GCV) (kcal/kg)	Grade	(GCV) (kcal/kg)
G-1	Above 7000	G-10	4301 - 4600
G-2	6701 - 7000	G-11	4001 - 4300
G-3	6401 - 6700	G-12	3701 - 4000
G-4	6101 - 6400	G-13	3401 - 3700
G-5	5801 - 6100	G-14	3101 - 3400
G-6	5501 - 5800	G-15	2801 - 3100
G-7	5201 - 5500	G-16	2501 - 2800
G-8	4901 - 5200	G-17	2201 - 2500
G-9	4601 - 4900		

Different grades of coal are used in different activities. Our state of Chhattisgarh produces many different grades of coal. Let us find out the regions in our state where in coal is found.

16.4 Coal in Chhattisgarh

Chhattisgarh holds an important position in India in terms of coal mining and production. Underground and open coal mines are found in Korba, Raigarh, Sarguja and Korea in Chhattisgarh. In the district of Korba, G-4 and G-5 grade coal is found in the mines of Rajgamar, Bagdeva, Surakachhar and Bankimongra. Further, G - 11 grade coal is found in mines of Gevra, Dipka and Kushumunda. National Thermal Power Corporation (NTPC) and Chhattisgarh State Electricity Board (CSEB) have set up thermal power plants in Chhattisgarh. These thermal power plants use coal. Apart from this, the aluminium plant at Balco, the steel plant at Bhilai, thermal and steel plants in Raigarh and other industrial plants in Siltara (Raipur) also use coal. Because of its great utility and large number of uses, coal is sometimes called black diamond.

Questions

1. What are fossil fuels?
2. How is coal formed?
3. Which type of coal has maximum sulfur content?

So far we have learnt about the fossil fuel coal. Let us now study about another fossil fuel- petroleum.

16.5 Petroleum

The word petroleum has its origin in two words - petra (which means rock) and oleum (which means oil). So, petroleum means oil from rocks. We have already read about how petroleum is formed in a previous section. Petroleum is an oily, dark-coloured liquid with a very distinctive odour. It is usually found at great depths under the earth's surface.

Petroleum is a mixture of many hydrocarbons so it does not have a fixed chemical formula. The different hydrocarbons in the petroleum mixture cannot be separated using simple distillation methods therefore, a special technique called fractional distillation is used for separation.

16.5.1 Fractional distillation of petroleum

You must have seen vapours being formed when water is heated in a container. If we cover the container with a lid, we see some water droplets on the inner surface of the lid. This process is known as distillation. We will first try to understand the distillation of a mixture of two liquids. In distillation, if a mixture of two liquids is heated then both of them are converted into their vapour form . When we cool the vapours, they are converted back into the liquid form.

All liquids continuously evaporate even at room temperatures but on heating the amount of vapour being formed starts increasing. The amount of vapour being formed is inversely proportional to the boiling point of the liquid. This means that more vapour will be formed for the liquid which has a lower boiling point and less vapour will be formed for the liquid with the higher boiling point. When we cool down this vapour mixture, then we get more of the liquid which has a lower boiling point and less amount of liquid which has the higher boiling point. We can understand this further through the following example of liquids A and B:

Liquid A	+	Liquid B	**on heating** →	Vapour	**on cooling** →	liquid
(Lower boiling point)		(higher boiling point)		(more vapours of A, less vapours of B)		(more A, less amount of B)

If we want to completely separate these two liquids, we will have to repeat the distillation process again and again.

Petroleum is a mixture of many different hydrocarbons whose boiling points are very close to each other. It is very difficult to separate such mixtures using simple distillation methods therefore we have to use a technique for this separation which requires a special apparatus called a fractionating column. This method of separating a mixture of two or more miscible liquids whose boiling points are very close to each other is known as fractional distillation.

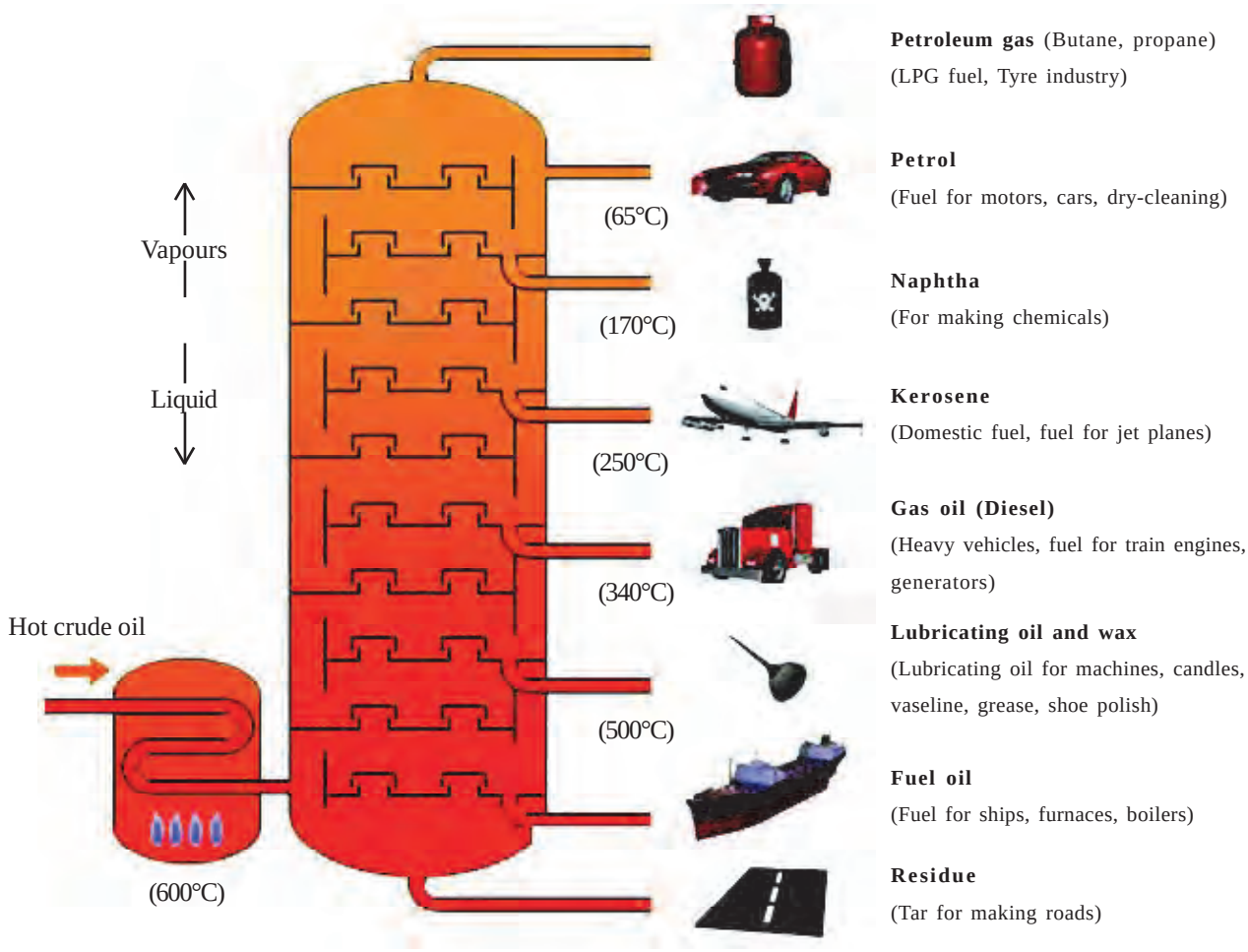


Fig. 3 : petroleum at different levels

In fractional distillation of petroleum, first of all the crude oil is heated in a furnace and the vapours are directed towards the lower part of the fractionating column. This mixture of vapours rises up in the column and then condenses into liquid and comes down. As more and more hot vapours are introduced into the column, the condensed factions again change into vapours. Thus, the distillation process is repeated continuously. In this way, the compounds with lower boiling points get condensed in the upper part of the column and then are collected separately. As we move down the column, liquids with higher boilings points are separated and collected. This is how fractions having different boiling points are separated from petroleum at different levels (Fig. 3).

We have seen that fractional distillation of petroleum yields many important substances at different temperatures in the column. These substances are known as petrochemicals and are used in various industries. Many of the industries in modern times are completely dependent on petrochemicals.

Questions

1. What is fractional distillation?
2. Why is fractional distillation of petroleum necessary? What type of gases are obtained in the upper part of the fractionating column?
3. Why does petroleum not have a chemical formula?

16.6 Petrochemicals

The chemicals obtained from petroleum are called petrochemicals. The story of the initial attempts to use petrochemicals is very fascinating. A long time ago, in the Gulf region, petroleum would seep out slowly, on its own, in small pits. Many of the components of this petroleum mixture could form vapours. So, after sometime most of the mixture would evaporate, leaving behind a sticky substance. This sticky substance was used for waterproofing boats. People also used it to join together bricks and stones while constructing houses. About 200 years ago, kerosene oil was separated from petroleum and from then on it started being used extensively as a fuel and for lighting.

In mid-nineteenth century, a jelly obtained from petroleum was used to treat burns and other wounds, especially by factory workers. This was the basis for using petroleum jelly in cosmetics. Today, petrochemicals are used in industrial production of detergents, fibres (polyester, nylon, acrylic etc.), polythene and other man-made plastics.

Our world has been revolutionized by the use of plastic products in various fields. The plastic industry plays an important role in our country's economy. The importance of plastics is increasing day by day with the wide-spread use of plastic objects.

16.7 Recycling plastic

Plastic objects are thrown away once they are used but they do not get decomposed in the soil. So it becomes necessary to either break-down plastics or make them suitable for reuse. The process of converting waste plastic objects into useful products is known as plastic recycling.

In 1988, different types of plastics were given identification codes by the Society of the Plastics Industry (SPI). Before recycling, plastic items are separated according to their identification codes. There are seven identification codes.

Identification codes are in the form of a number enclosed by clock-wise arrows arranged in a triangle (Table-2). The plastics which have the same identification code are recycled together.

Table 2 : plastic identification code

Identification Code							
Name of objects	Water bottle, Cold drink bottles, Jam jars	Water pipes, Toys, Juice bottles, Shampoo & cream containers	PVC pipes, Juice bottles				

Activity-1

- Note the identification code of various plastic objects around you.
- Group objects according to their identification codes.
- Did you find objects from each of the seven codes? Look at the codes of objects collected by your friends and discuss which ones are more common..
- Make table 2 in your copy. Write down the names of objects with identification codes 4-7 in the appropriate column of the table.
- Collect information about recycling plastic from different sources. Discuss in the classroom.

16.8 Combustion of fuels

We know that all objects need oxygen to burn. Burning in presence of oxygen is known as combustion. Heat is released during combustion, therefore it is an exothermic process.

The combustion of coal mainly produces carbon dioxide and heat.

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

If coal is burnt in insufficient oxygen then carbon monoxide is produced.

$$C + \tfrac{1}{2} O_2 \longrightarrow CO + \text{heat}$$

Ash is the solid left behind when coal is burnt. We find that burning of fuels produces carbon dioxide, carbon monoxide and ash and an excess of all these pollute the environment.

16.9 Effect of increasing use of fossil fuels on the environment

If we continue using fossil fuels at this rate, the environment will be adversely effected.

- A part of the carbon dioxide produced during burning of fossil fuels is used by plants in photosynthesis. But most of it is not used and this is one of the causes of the greenhouse effect which is leading to an increase in the earth's temperature.
- The carbon monoxide produced during combustion of fuels is a poisonous gas because it combines with hemoglobin in the blood at a faster rate than oxygen. If the amount of carbon monoxide in the blood exceeds a certain amount, it can cause death.
- The ash produced during combustion of coal is known as fly ash because it flies out of the chimney (?) and settles down in nearby areas. It can infect and harm lungs and cause silicosis.
- Nitrogen and sulfur are also found in fossil fuels. On combustion of these fuels, oxides of nitrogen and sulfur are also formed. These oxides dissolve in rain water and cause acid rain.

16.10 Conservation of fossil fuels

It takes millions of years for fossil fuels to form. But the current reserves of fossil fuels will last for only about a hundred years. So we must try to stop the misuse of fossil fuels. If we want fossil fuels to be available to future generations we must use it in a balanced manner.

- The community must be informed about ways to prevent misuse of fossil fuels.
- New scientific methods must be used in coal mining so that maximum quantity of coal can be obtained and there is no unnecessary loss.
- CNG (Compressed Natural gas) must be given preference as a fuel for vehicles because it does not contain nitrogen or sulfur.
- Plastics must be used in moderation.
- Efforts must be made for complete overall maintenance of vehicles to minimize use of petroleum products by vehicles. The petroleum conservation and research association (PCRA) of India gives various tips to save fuel while driving. For example : -
  - As far as possible, drive at a uniform and medium speed.
  - Switch off the engine at traffic lights or anytime you have to wait.
  - Check tyre pressure and ensure regular maintenance of vehicles.

Questions

1. What do we mean by the recycling of plastics?
2. What is combustion? Explain.

Keywords

Fossil fuel, coal, petroleum, fractional distillation, recycling, combustion, conservation, plankton, fly-ash, acid rain

What we have learnt

- Fossil fuels are formed by the transformation of the remains of dead animals and plants. Coal and petroleum are two fossil fuels.
- Coal is formed from the dead bodies of plants and animals and petroleum is formed from the dead bodies of sea creatures called planktons.
- The product obtained in the first stage of coal formation is peat. The best quality coal is anthracite.
- For commercial purposes, coals are divided into grades according to their heating potential.
- Petroleum does not have a fixed chemical formula because it is a mixture of various hydrocarbons.
- Fractional distillation is used to separate a mixture of liquids whose boiling points are very close to each other.
- Petroleum gas is obtained at the top-most part of the fractionating column and viscous fluid (tar) is obtained at the lowermost part.
- Various plastics used in daily activities are all petrochemical products.
- The process of converting useless plastic objects into useful products is known as plastic recycling.

Exercises

1. Choose the correct option:–

   (i) Coal is produced from the remains of

   (a) Plants (b) Animals

   (c) Both plants and animals (d) None of these

   (ii) The conditions necessary for formation of fossil fuels are:

   (a) High temperature (b) High pressure

   (c) Absence of oxygen (d) All of the above

(iii) Which type of coal has maximum carbon content

(a) Peat (b) Lignite

(c) Bitumen (d) Anthracite

(iv) What is the identification code found on objects made of PVC?

(a) 1 (b) 2

(c) 3 (d) 4

2. Fill in the blanks

(i) Coal and petroleum are …….fuels

(ii) During formation of coal, …….. is formed in the first stage and ……..is formed in the last stage.

(iii) The least carbon content is found in ..... type of coal.

(iv) Fractional distillation is carried out when there is a very small difference in the ..... of liquids in the mixture.

(v) Petroleum is a combination of two words - ..... and .....

3. How are fossil fuels formed?

4. Describe the different types of coal in detail.

5. Describe the environmental effects of the excessive use of fossil fuels.

6. The conservation of fossil fuels is a big necessity. Explain.

7. What products are obtained by the fractional distillation of petroleum? What are their uses?