JSR IAS ACADEMY

GENERAL SCIENCE

CHEMISTRY

Petroleum Products

Hydrocarbon

Hydrocarbon

- Hydrocarbons are the organic compounds consisting of hydrogen and carbon atoms.
- They are combustible and produce large amount of heat energy along with carbon dioxide and water vapour, on burning.

Figure 6.1 Formation of Hydrocarbons

Sources of Hydrocarbons

- Hydrocarbons occur naturally and they are found in fossil fuels like crude oil, natural gas and coal.
- About 300 million years ago plants and animals died and they were buried on the ocean floor.Overtime they were covered by silt and soil layers.
- Then they were buried deep inside the earth and **compressed through temperature and pressure** and converted to fossil fuels like oil and natural gas.

Properties of Hydrocarbons

- Most of the hydrocarbons are insoluble in water.
- Hydrocarbons are less dense than water. So they float on top of water.
- Most hydrocarbons react with oxygen to produce carbon dioxide and water.
- Hydrocarbons can be gases (e.g. methane and propane), liquids (e.g. hexane and benzene) or waxes (paraffin).
- Hydrocarbons are capable of making bonds with one another. Th is property is known as **catenation.** Due to this property they form more number of complex molecules.

Types of Hydrocarbons

The four general classes of hydrocarbons are:

1. alkanes,
2. alkenes,
3. alkynes
4. arenes.

Some of the common hydrocarbons are **methane, ethane, propane, butane and pentane.**

Methane

- Methane is the simplest hydrocarbon in which **four hydrogen atoms are linked with one carbon atom**.
- It is a **colourless, odourless and infl ammable gas**.
- It is an eco-friendly fuel because it does not produce any harmful products.
- It is used as a fuel in **electricity generation.**
- Methane is also known as **marsh gas** as it is present in marshes.
- Dead and decaying plants and animals release methane gas. It is a renewable source of energy.
- Sewage sludge can also be decomposed by microorganisms to produce **methane gas along with impurities like carbon dioxide and hydrogen sulphide**. Aft er removing these impurities, methane gas can be used as an efficient fuel.

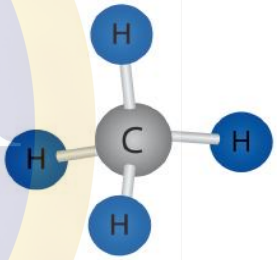
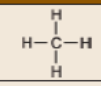
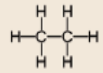
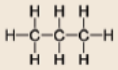
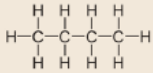
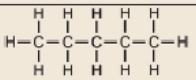


Figure 6.2 Structure of methane

Name	Formula	Structure
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	

Propane

- Propane is an odourless and highly inflammable gas.
- It is heavier than air. It is liquefied through pressurisation and commonly used as LPG (Liquefied Petroleum Gas) along with butane.
- Propane is used as fuel in heating, cooking, and vehicles.
- Propane can also be used as refrigerants.

Propane is used in LPG cylinders. Since it is an odouress gas, any leakage cannot be detected. Hence, a chemical by name Mercaptan is mixed with LPG to help in detection of any leakage of LPG.

Butane

- Butane is a gas at room temperature and atmospheric pressure.
- They are highly flammable, colorless gases that quickly vaporize at room temperature.
- Butane is used as a fuel gas and propellant in aerosol sprays such as **deodorants.**
- Pure forms of butane can be used as refrigerants.
- Butane is also used as lighter fuel for a common lighter or butane torch.

Pentanes

- Pentanes are liquids with low boiling point.
- They are used as fuels and solvents in the laboratory.
- They are also used to produce polystyrene.

Natural Gas

- Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane along with other higher alkanes and a small percentage of **carbon dioxide, nitrogen and hydrogen sulphide (H2S).**
- If the natural gas contains lower hydrocarbons like methane and ethane, it is called **dry gas.**
- If higher hydrocarbons like propane and butane are also present in the gas, it is called **wet gas.**
- Natural gas is always found above the oil in the oil wells.
- This gas is trapped inside the small spaces in underground rocks called **reservoirs.**
- Conventional natural gas can be extracted through drilling wells.
- Natural gas can also be found in reservoirs with oil and is extracted along with oil. This is called **associated gas.**
- Natural gas is a fossil fuel used as a source of energy for heating, cooking and electricity generation.
- Natural gas occurs in Tripura, Rajasthan, Maharashtra, Andhra Pradesh (Krishna, Godavari Basins) and Tamil Nadu (Cauveri Delta).
- It is also formed by the decomposition of organic matter in marshy areas and waste sewages.
- The natural gas formed by this way contains mainly methane.

Uses of Natural Gas

- Natural gas is used as an industrial and domestic fuel.
- It is used in thermal power stations.
- It is used as fuel in vehicles as an alternative for petrol and diesel.
- When heated it decomposes and forms hydrogen and carbon. Hydrogen thus formed is used in the manufacture of fertilizers.
- It is used to manufacture chemicals, fabrics, glass, steel, plastics and paints.
- It is also used in electricity generation.

Moderate temperature and humidity is needed to keep paintings and other ancient artifacts from being destroyed by environmental factors. Thus natural gas is used in museums to protect the monuments.

Advantages of Natural Gas

- It produces lot of heat as it is easily burnt.
- It does not leave any residue.
- It burns without smoke and so causes no pollution.
- This can be easily supplied through pipes.
- It can be directly used as fuel in homes and industries.

Compressed Natural Gas

- When the natural gas is compressed at high pressure, it is called **Compressed Natural Gas (CNG).**
- Nowadays it is used as fuel in automobiles.
- The primary hydrocarbon present in CNG is methane **(88.5%).**
- Natural gas is liquefied for shipping in large tankers. This is called **Liquefied Nitrogen Gas (LNG).**
- CNG is stored at high pressure whereas LNG is stored in ultra cold liquid form.

CNG has the following properties.

- It is the cheapest and cleanest fuel.
- Vehicles using this gas produce less carbon dioxide and hydrocarbon emission.
- It is less expensive than petrol and diesel.

More to Know

The average composition of CNG.

Constituents	Percentage
Methane	88.5
Ethane	5.5
Propane	3.7
Butane	1.8
Pentane	0.5

Fuel Gases

Apart from natural gas, there are some other gases used as fuel.

- Producer gas,
- coal gas,
- bio gas
- water gas

Producer Gas

- Producer gas is a gaseous mixture of carbon monoxide and nitrogen.
- It is produced by passing air mixed with steam, over red hot coke at a temperature of 1100 ˚C.
- It is used as an industrial fuel for iron and steel manufacturing.

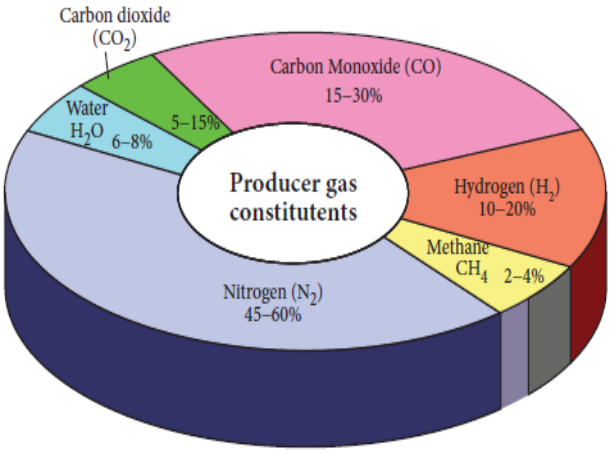


Figure 6.6 Composition of Producer Gas

DO YOU KNOW?

Producer gas is known by different names in different countries. It is referred as Wood gas in USA and as Suction gas in UK.

Coal Gas

- It is a mixture of gases like **hydrogen, methane and carbon monoxide** obtained by the destructive distillation of coal.
- Heating coal in the absence of air is called **destructive distillation.**
- It is used in heating open hearth furnace in the manufacture of steel.
- It is also used as a reducing agent in certain metallurgical operations.

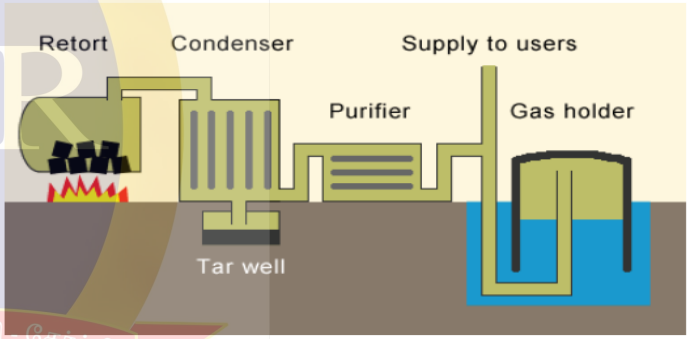


Figure 6.7 Production of coal gas

Water Gas

- It is a gaseous mixture of carbon monoxide and hydrogen.
- It is made by passing steam over incandescent coke at a temperature of 1000°C.
- It is also called as syngas or synthesis gas as it is used to synthesize methanol and simple hydrocarbons.
- It is used as an industrial fuel also.

$$C_{(g)} + H_2O_{(g)} \xrightarrow{1000°C} CO_{(g)} + H_{2\,(g)}$$

Bio Gas

- Bio-gas is a mixture of methane and carbon dioxide.
- It is produced by the decomposition of plant and animal waste which form the organic matter.
- The breaking down of organic matter in anaerobic condition (ie., in the absence of oxygen) leads to the formation of biogas.
- It is an example for renewable source of energy.

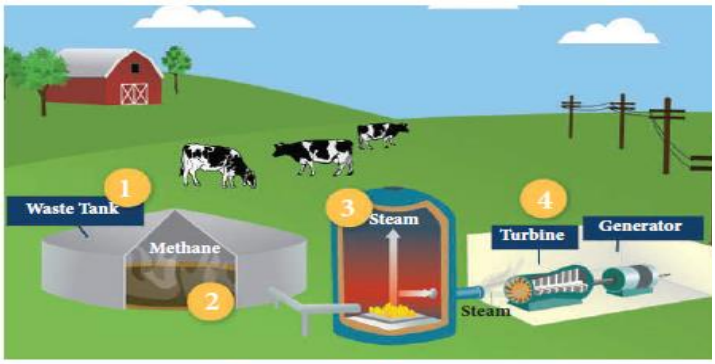


Figure 6.8 Bio-gas

Coal

- Coal is one of the fossil fuels. It is a mixture of free carbon and compounds of carbon containing hydrogen, oxygen, nitrogen and sulphur.
- As coal contains mainly carbon, the slow process of conversion of dead vegetation into coal is called **carbonization.**
- The US is the international leader in coal reserves, with nearly 30% of the world's supply.
- Coal mining was started in India in 1774.
- India now ranks third among the coal producing countries in the world.
- USA and China have two third of the world's coal reserve.

Types of Coal

Coal is classified into four main categories based on the amounts of carbon it contains and the heat energy it can produce.

- lignite,
- sub bituminous,
- bituminous
- anthracite.

Among these four types anthracite is the most desirable one due to its high heat content.

Lignite

- Lignite is a **brown colored coal** of lowest grade. It has least content of carbon.
- The carbon content of lignite is **25 – 35%.**

Sub bituminous

- When **lignite becomes darker and harder** over time sub-bituminous coal is formed.
- **Sub bituminous coal is a black and dull coal**. It has higher heating value than lignite and contains **35-44% carbon.**

Bituminous

- **Bituminous coal is dark and hard.**
- It contains **45-86% carbon**.

Anthracite

- It is the highest grade coal. It is **hard and dark black in colour.**
- Anthracite coal is very hard, **deep black and shiny.**
- It contains **86-97% carbon** and has a heating value slightly higher than bituminous coal.

Coke:

- Coke contains **98% carbon**. It is **porous, black and the purest form of coal.**

Coal tar:

- Coal tar is a mixture of different carbon compounds. It is a thick, black liquid with unpleasant smell.

Coal Gas:

- Coal gas also known as town gas is mainly a mixture of gases like hydrogen, methane and carbon monoxide.

DO YOU KNOW?

It is also known as **Black Diamond** owing to its precious nature. On destructive distillation, 1000 kg of coal gives 700 kg of coke, 100 litres of ammonia, 50 litres of coal tar and 400 m^3 of coal gas.