

Coal and Petroleum

Renewable and Non-Renewable Sources of Energy

Natural resources are the materials that occur in nature and are useful to humans. These resources may be either living or non living.

Living resources includes living organisms like forests and wildlife or the products derived from these living organisms like leather, wood etc. It also includes the fossil fuels like coal, petroleum, natural gas etc.

that are derived from remains of dead and decayed living organisms over a long period of time.

Non living resources include the land, water, soil, air and mineral ores.

Based on whether a source of energy can be replenished, it can be classified as a

- Renewable source of energy
- Non-renewable source of energy

Renewable sources of energy are those that are replenished at a rate faster than that at which they are consumed. About 13 percent of the primary energy comes from renewable resources. Renewable resources of energy are known as **inexhaustible** sources of energy as they can be easily regenerated at a constant rate.

Examples of renewable sources of energy include sunlight, wind, tides, and geothermal energy.

Non-renewable sources of energy are those that are consumed at a rate faster than that at which they are replenished. Non-renewable resources of energy are known as **exhaustible** sources of energy as they can be easily exhausted.

Examples of non-renewable resources of energy are fossil fuels, which include coal, petroleum, and natural gas. These resources are widely used. In addition to being an exhaustible source of energy, fossil fuels also release polluting emissions on burning.

Coal: It is a non-renewable source of energy made up of complex compounds of carbon, hydrogen and oxygen along with some free carbon and compounds of nitrogen and sulphur. It is found in mines under the Earth's surface. In India, coal is found in abundance in Jharkhand, West Bengal, Orissa and Chattishgarh. It is a most common source of energy for us.

Petroleum: It is a dark coloured viscous liquid also known as crude oil or black gold. It is a complex mixture of many hydrocarbons with water, salt, earth particles and other compounds of carbon, oxygen, nitrogen and sulphur. We obtain petroleum by drilling oil wells into earth's crust at its reservoirs. Assam and Mumbai are the two petroleum reservoirs of India. The petroleum extracted from wells has to be purified to obtain different useful components.

The process of separating useful components from the crude oil is called refining and this process is done by fractional distillation in big refineries. The petroleum gas obtained as a by-product from the fractional distillation of petroleum majorly contains butane and a small quantity of propane and ethane. These gases generate a lot of heat on burning and can be liquefied easily under pressure. This petroleum gas liquefied under pressure is known as LPG (liquefied petroleum gas) which we use it in domestic gas stoves as fuel. Gas cylinders are used to store LPG and a strong smelling substance called ethyl mercaptan C_2H_5SH is added in this gas to detect any leakage.

Natural Gas: Same as petroleum, natural gas is also found deep under the Earth's crust either alone or above the petroleum reservoirs. The main constituents of natural gas are methane (upto to 95%), ethane and propane. It easily burns to produce heat. In India, there are number of reservoirs of natural gas such as in Tripura, Jaisalmer, offshore area of Mumbai and Krishna-Godavari delta.

Disadvantages of Fossil Fuels

What are the consequences of using fossil fuels?

Fuels that were formed millions of years ago by the dead remains of plants and animals under conditions of high temperature and pressure are called fossil fuels. Coal, petroleum, and natural gas are examples fossil fuels.



We use petrol and diesel to run cars, trucks, and other automobiles. Use of coal is considered irreplaceable in several industries. Fossil fuels are the most commonly used fuel today. Thus, fossil fuels are very useful. However, using these fuels has several disadvantages.

Fossil fuels take million of years to form. They are limited or exhaustible resources and therefore need to be conserved.



Combustion of fossil fuels produces air pollutants such as major greenhouse gases, nitrogen oxides, sulphur dioxide, volatile organic compounds, and heavy metals. Burning of such fuels increases the concentrations of sulphuric, carbonic, and nitric acids in the atmosphere. This results in **acid rain**.

Let us understand the major environmental effects of using fossil fuels.



The greenhouse effect and global warming

Before humans started using fossil fuels, there was a uniform recycling of carbon dioxide and oxygen in the atmosphere.

Plants absorb carbon dioxide and emit oxygen during the process of photosynthesis. Animals inhale oxygen and exhale carbon dioxide, thus maintaining a balance.

However, as humans began burning fossil fuels, more carbon dioxide was emitted into the atmosphere and the delicate balance between oxygen and carbon dioxide in the atmosphere was destroyed.

Greenhouse effect is caused by the accumulation of carbon dioxide in the Earth's atmosphere.

Let us understand what greenhouse effect is and how it affects the environment.

A potential danger of global warming is the melting of the polar ice caps, which is causing the ocean levels to rise. This may lead to flooding of many coastal cities.

Apart from the effects on the environment, fossil fuels have other disadvantages. Some of the important disadvantages are listed below.

- They are **exhaustible** sources of energy
- They are **non-renewable** sources of energy
- They **take millions of years to form**. Hence, their **availability is limited**
- They **release pollutants** such as carbon dioxide, which contributes to global warming
- They **release ash and unburnt particles** of carbon; they also release oxides of nitrogen and sulphur, which cause **acid rain**

In spite of all these disadvantages, fossil fuels are the most commonly used form of energy. As a result of their continuous use, there is an increase in such phenomena as global warming, air pollution, acid rain, and other problems related to the environment.

Coal - Its Formation and Characteristics

Most of us have seen coal being used in some way or the other. It is also used in traditional fireplaces. In earlier times, coal was used to run rail engines. It is hard, stone-like blackish substance that releases heat and smoke on burning.

Hence, coal was formed by decomposition of dead remains of plants when they got buried in the land owing to the high temperature and pressure conditions present there.

Coal is mainly carbon. Therefore, this process of change of dead vegetation to coal is called **carbonisation**. Coal is also called a fossil fuel because it is formed from the dead remains of plants and vegetation.

Characteristic features of coal

- It is black in colour.
- It is as hard as stone.
- On burning, it releases heat and polluting smoke.
- It is formed from dead vegetation.
- It takes millions of years to form. Thus, we cannot make coal under laboratory conditions.

Types of coal are:

Peat: It has a carbon content of 28%. The transformation of coal from wood i.e, the primary state is called peat. It is also called as the rough coal. Compounds such as acetic acid, cyclic organic compounds, methanol and acetone are obtained from destructive distillation of peat.

Lignite: It has 28-30% content of carbon. It also contains moisture and volatile matter. The heat energy of lignite is 27kJ/g. Railway engines, thermal power stations and big and small industries uses lignite as the fuel. It is also used to obtain coal gas, in which coal tar is obtained as the residue. This residue is comprised of phenol, cresol, cyclic hydrocarbons and other cyclic compounds are present.

Bituminous coal: It comprises of 78-86% carbon. The heat energy of bituminous coal is 30 kJ/g. It also consists of volatile material and moisture. In the production of electricity and steel, it is used as a fuel.

Anthracite: This is the matured form of coal. It has 94-98 % of carbon. Its heat energy is 33kJ nearly, it also has small proportion of moisture and volatile material. The amount of

residue produced on burning purely anthracite also, smoke and smell are not produced. These are the reasons why anthracite is considered as the best type of coal.

Products of Coal and Their Characteristics

Coal is a hard and black substance that is used for burning to generate heat

The uses of coal are

- As a fuel for cooking
- For heating of bricks
- As an industrial fuel
- In railway engines to produce steam
- In thermal power plants to generate electricity

The products that are obtained after processing coal are:

- Coke
- Coal tar
- Coal gas
- The following table summarises the characteristics and uses of the products that are obtained from coal

Product	Characteristics	Uses of the product
Coke	A tough, porous, black substance. It is almost pure form of carbon.	It is used in the manufacture of steel and in the extraction of many metals.

Coal tar	A black, thick liquid with an unpleasant odour. It is a mixture of about 200 substances.	It is used in the manufacture of synthetic dyes, drugs, naphthalene balls, explosives, plastics, perfumes, paints, photographic and roofing materials etc. Now, bitumen is used instead of coal-tar for making of roads.
Coal gas	It is a gas that is formed during the process of obtaining coke from coal.	Coal gas was first used to illuminate street lights! Now it is used in industries as a fuel for generating heat.

Petroleum : Its Formation and Characteristics



Petrol and diesel are fuels that power automobile engines. They are the most commonly used fuels for transportation. **Do you know where these fuels come from?**

Petrol and diesel are refined products that are produced from petroleum. Petroleum is found in the Earth's interiors and is extracted by drilling deep inside the Earth. **Do you know what petroleum is and how it was formed?**

Petroleum was formed millions of years ago from the dead organisms of the seas.

Let us learn how these dead organisms of the seas got converted into petroleum.

Sea organisms died and got accumulated at the bottom of the sea. In course of time, sand and clay got deposited over these dead organisms. The movement of water led to the deposition of more sand and clay over these organisms. Over a period of millions of years, a thick layer was thus formed.

This thick covering of sand and clay compressed the organic material. Under conditions of high pressure and temperature, this organic material, over millions of years, got converted into petroleum.

The three necessary conditions that helped to convert the dead organic material into petroleum are

- High pressure
- High temperature
- Decomposition of sea organisms in the absence of air

Extraction and refining of petroleum:

Petroleum deposits inside the Earth are dug up and deep-drilling machines are used to pump out petroleum. After digging when the pipes reach the petroleum reservoirs, they are filled with oil due to pressure inside the hole. To pump out the oil, pressure is reduced and compressed air is passed through the pipes.

In this process dilute sulphuric acid is used to remove basic impurities and sodium hydroxide is used to remove acidic impurities from petroleum.

The washed petroleum is sent to fractionating tower through preheated pipes. As a result petroleum vapour rises.

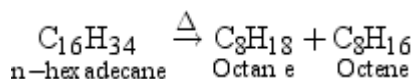
When the vapours of petroleum rise up in the fractionating tower they begin to cool down to form liquid products at various fractionating columns present inside the tower. The components with low boiling points are obtained at higher points in the column while the components with higher boiling points are obtained at lower points in the column. The residual gas is obtained at the top of the tower.

Various products obtained from fractional distillation of petroleum are petrol, kerosene, diesel oil, lubricating oil, vaseline, paraffin wax etc.

Cracking

The process of heating higher alkanes to sufficiently high temperatures in absence of oxygen, in order to obtain lower hydrocarbons is known as cracking or pyrolysis.

For example, n - hexadecane on heating cracks into n-octane and octene (an alkene).



Characteristics of petroleum

- It is a dark and oily liquid
- It has an unpleasant odour
- It is a commonly used source of energy
- It releases pollutants on burning
- It cannot be manufactured under laboratory conditions as its formation takes millions of years

- It is a mixture of many constituents. The process of separating its various components is known as refining. Refining of petroleum is carried out in oil refineries

Environmental effects of excessive use of fossil fuels

Combustion of fossil fuels leads to depletion of oxygen in atmosphere and production of air pollutants such as carbon dioxide, nitrogen oxides, sulphur dioxide, carbon monoxide, etc. The average temperature of the earth increases as a result of increasing amount of carbon dioxide in atmosphere.

Fossil fuels are a non-renewable source of energy

Fossil fuels are exhaustible natural resources as the amount of these fuels in nature is limited and can be exhausted by human activities. These resources cannot be renewed over a short period of time (say, hundred years).

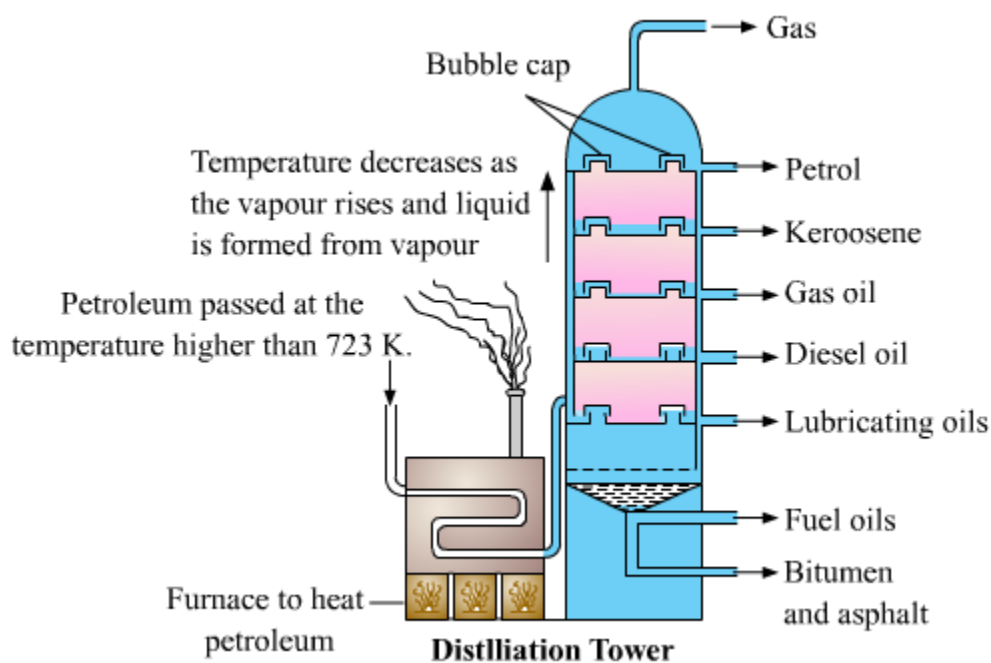
Petroleum, Its Products and Their Uses

Petrol and diesel, used as fuels in cars, scooters, and bikes are produced from petroleum. Refining of petroleum produces many products including petrol and diesel.

Let us understand what is refining.

The separation of various constituents of petroleum is known as refining. Refining of petroleum is done at oil refineries.

After the refining of petroleum, the by-products that are obtained are used for various purposes. The following table lists the various products of petroleum and their uses.



Petroleum product	Uses of the product
L.P.G or liquefied petroleum gas	As a cooking fuel at homes and as a fuel for generating heat in industries
Diesel	As a fuel for heavy motor vehicles, electric generators
Kerosene	As a fuel in stoves, lamps, and also for jet aircrafts
Petrol	As a dry-cleaning agent, solvent, motor fuel, aviation fuel
Lubricating oil	For lubrication purposes
Paraffin wax	As a base for ointments, making of candles, vaseline etc
Bitumen	For road surfacing purposes, paints etc.

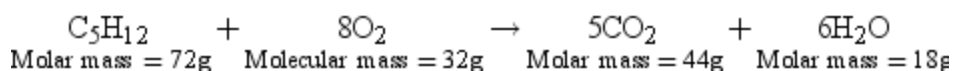
Several useful products are obtained from petroleum. These are called petrochemicals and are used for manufacturing detergents, polythenes, plastics, and synthetic fibres like polyester, nylon etc.

Combustion of hydrocarbons

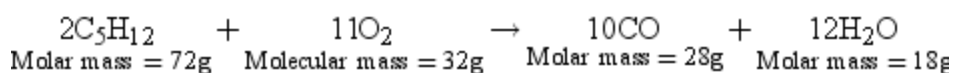
Combustion of hydrocarbons breaks them into gaseous products. These gases are responsible for pollution of environment. The gases released during combustion are known as exhaust gases and the quantity of these gases help us in determining the rate of combustion of a particular hydrocarbon.

When complete combustion of a hydrocarbon occurs it gets converted into carbon dioxide and water. However, incomplete combustion of hydrocarbon leads to formation of carbon or carbon monoxide.

Consider the combustion of pentane which produces carbon dioxide on complete combustion and carbon monoxide on incomplete combustion.



According to this equation, 72g of pentane requires 256g (8x32) of oxygen for complete combustion, producing 220g (5x44) carbon dioxide and 108g (6x18) of water. However, if the amount of oxygen available is less than that required it will result in incomplete combustion as evident from the following reaction:



This equation shows that incomplete combustion of pentane occurs when 144g (2x72) of pentane is burnt with 352g (11x32) of oxygen forming 280g (10x28) of carbon monoxide and 216g (12x18) of water.

Emission test

The Government of India has prescribed a limit for emission of carbon monoxide (one of the most poisonous pollutants) by each kind of vehicle.

An instrument known as a Gas Analyser is used to estimate the amount of carbon monoxide emitted from vehicles which uses a specific test to analyse the gases present in the exhaust gas of the vehicle. This test is known as emission test.

Do You Know:

In the year 2005, 84 million barrels or $1.34 \times 10^7 \text{ m}^3$ of petroleum was utilised in the world!

The Conservation Of Petroleum

Petroleum is a natural resource. High temperature and pressure conditions compressed the dead organisms under the sea. Over a period of millions of years, this organic material gradually got converted into petroleum. Petroleum reserves are therefore, limited i.e. they are found only in a few places on the Earth. However, petroleum is a widely used fuel in the

world. The ever increasing population has further increased the demand for petroleum and its products.

Since petroleum was formed from dead organisms under the sea over millions of years ago, it cannot be prepared in the laboratory.

It is thus important to conserve petroleum.

The preservation and careful management of petroleum in order to reduce its unwanted loss and minimize its unnecessary use are the guiding principles of conservation of petroleum.

In India, the Petroleum Conservation Research Association (PCRA) advises people on the various methods that can be adopted to conserve petroleum. Some of these methods are:

- Driving at a constant and moderate speed
- Maintaining correct air pressure levels in the tyres of automobiles
- Proper and regular check-ups of vehicles
- Switching off the engines at traffic junctions
- Greater use of public transport facilities such as buses and metros whenever possible

Compressed Natural Gas

Petroleum gas

Petroleum gas is a gaseous mixture consisting mainly of propane (C_3H_8) and butane (C_4H_{10}). It is the gaseous fraction obtained during the fractional distillation of petroleum.

We hear that CNG or compressed natural gas is a very good fuel. Do you know why?



CNG or compressed natural gas is found deep inside the Earth in regions where petroleum is also found. Natural gas is a good fuel because it burns completely, without any residue, and releases fewer polluting emissions. This is the reason why CNG is considered to be a clean fuel.

Natural gas is formed from dead organisms which decompose in the absence of air under conditions of high pressure and temperature.

LPG and CNG

LPG stands for liquified petroleum gas, comprises of gases mainly butane and in small

proportions butene and propene. The mixture of these gases is liquified at high pressure and then filled in cylinders. Bad smelling methyl mercaptan is mixed such that it gets noticed when leakage of gas takes place. It is usually used as a household fuel.

CNG stands for compressed natural gas, consists of majorly methane and in less proportion ethane and propane. It can be used as a fuel instead of petrol in automobile engines like buses, trucks, etc. by reducing the volume at high pressures. As CNG is completely combusted, no other poisonous gas is released and hence no pollution occurs but when incomplete combustion takes place it heats up the mechanical machinery of the vehicle which is one of the disadvantage of CNG.

Important characteristics of natural gas

- It is a fossil fuel
- It releases fewer pollutants on burning
- It can be easily transported through pipelines
- It is compressed and stored under high pressure
- It is basically found in regions where petroleum is also found. It is found above petroleum deposits because it is a gas and is lighter than petroleum
- It takes millions of years to form and is found deep inside the Earth

Uses of natural gas

- As a fuel at home and in industries
- As a fuel for motor vehicles in the form of CNG
- In the production of chemicals and fertilisers (because it produces hydrogen gas, which is used in manufacturing urea, a fertiliser)

Natural gas is advantageous as compared to other fuels because

- It can be transported easily through pipes
- It burns without leaving any residue
- It is a clean fuel as it releases fewer pollutants
- It can be directly brought to homes through supply pipes and used as a fuel