COAL AND PETROLEUM

Concepts Covered

- Natural Resources
- Fossil Fuels
- Formation of Fossil Fuels
- Coal, Types of Coal, and its uses
- Petroleum, its constituents and uses
- Effect of Fossil Fuels on the Environment
- An Alternative Source of Energy

Introduction

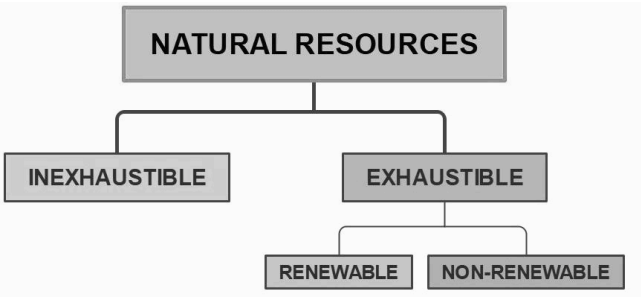
Our nature is bountiful. It has a variety of plants, animals, minerals, and fuels along with water, soil, air, etc. on which man is dependent for his daily needs and comforts.

All such materials which are used by humans for their survival and welfare are called Resources. Natural resources indicate the potential wealth of a country. Natural resources are those which are obtained from nature, examples of natural resources are air, water, soil, minerals, etc. Man-made resources are those which are made by human beings.

Coal

Petroleum

Types of Natural Resources:
Depending upon the abundance and availability, the natural resources are categorized into two types:



Inexhaustible

(i) Resources that are in unlimited quantity.
(ii) Resources that are not likely to be exhausted by human activity or their use.
Examples: Air, Water, and Solar radiation.

Exhaustible

(i) Resources that are in limited quantity.
(ii) Resources that are likely to be exhausted due to human activities.

Renewable

(i) Can replenish themselves by quick recycling and replacement within a reasonable time.
(ii) Not likely to be exhausted.
(iii) **Examples:** Soil, Forests and Wildlife

Non-Renewable

(i) Cannot replenish themselves by recycling and replacement.
(ii) These may be exhausted.
(iii) **Examples:** Minerals, Fossil fuels.

Fuels

Fuel is a substance, which burns in the air to produce energy without releasing harmful gases in large quantities.

Extended Learning

Calorific value of a fuel: The calorific value of a fuel is the amount of heat liberated by the complete burning of a unit mass or volume of fuel. For liquid or gaseous fuels, the volume of fuel is considered whereas for solid fuels mass of fuel is considered to find out the calorific value.

Fuels can be classified as natural (primary) fuels and derived (secondary) fuels. If a fuel is present in its natural state, it is called natural fuel. If fuel is processed to improve its quality, it is called derived fuel.

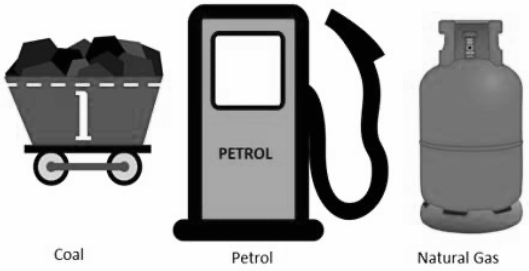
Characteristics of an ideal fuel

(1) It should have a high calorific value.
(2) It should not cause any pollution or should not produce harmful gases in combustion.
(3) It should be of low cost and easily available.
(4) It should be easy to handle, store and transport.
(5) It should have a moderate ignition temperature.
(6) It should have a moderate rate of combustion.

Fossils

The remains of dead plants and animals which are buried under the rocks millions of years ago are called fossils. The fuels which were formed by the decomposition of the remains of prehistoric plants and animals buried under the earth millions of years ago are called fossil fuels.

They are formed by what is known as the fossilization of living organisms. Fossils are the remains of plants and animals trapped between layers of rocks.



Examples: Coal, petroleum, and Natural gas.

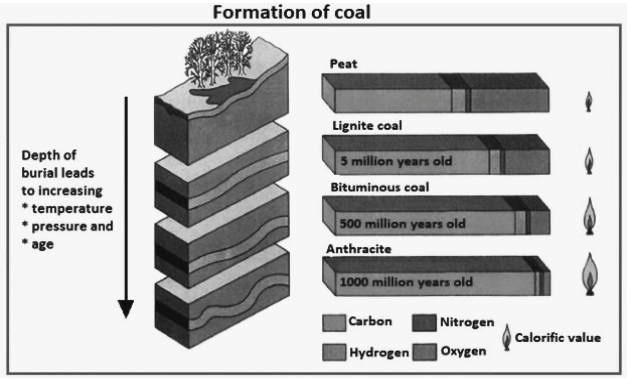
Coal

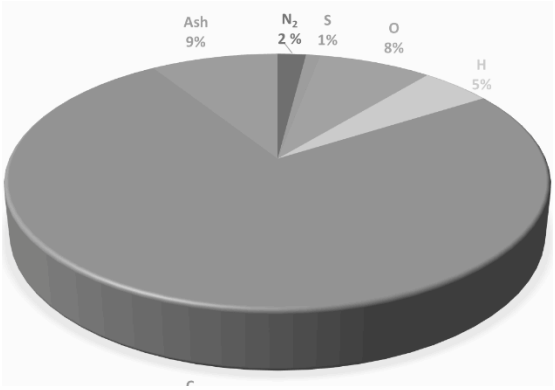
Coal is a mineral of dark brown or black colour. Coal is a complex mixture of carbon, hydrogen, and oxygen compounds. Some nitrogen, sulphur and phosphorus compounds are also present in it. It is found in coal mines deep under the surface of the earth. It is one of the earliest used fossil fuels.

Formation Of Coal

Coal was formed by the decomposition of plants and trees buried under the surface of the earth long ago. It is believed that millions of years ago, due to earthquakes, floods, and volcanic activities, the forests were buried under the surface of the earth and were covered with sand, clay, and water.

Due to high temperature and pressure inside the earth, wood, in the absence of air, was converted into coal. The slow chemical process of conversion into coal is called carbonization. Carbonization is a very slow process and may have taken thousands of years to take place. For this reason, coal is considered as a fossil fuel.





Types of Coal

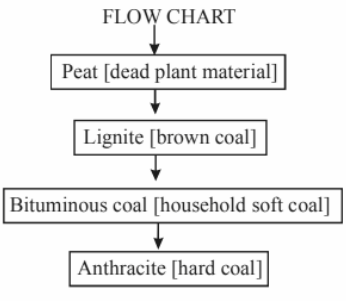
Coal formation is a continuing process. Depending on the carbon content, moisture, and volatile compounds, coal is classified into Four categories: **Peat, Lignite, Bituminous, and Anthracite.** The different varieties of coal formed depend on how long, at what temperature and pressure the coal is buried under the surface of the earth. Bituminous and anthracite are generally used as fuel in industry and our households.

Anthracite	Bituminous
(i) Superior quality of coal. (ii) Black and hard. (iii) Burns with a blue flame. (iv) Provides more heat.	(i) Hard, black, and shiny. (ii) Gives yellow flame and less smoke. (iii) Contains more gaseous contents. (iv) It is used as household soft coal.

Peat	Lignite
(i) Inferior quality of coal. (ii) Gives more smoke and less heat. (iii) Brown in colour. (iv) It is obtained from dead plant material.	(i) Dark brown in colour. (ii) Provides flame with more smoke.

Uses

- Coal is used as a fuel to convert water into steam to run thermal power plants for the generation of electricity. It is also used as fuel in homes and factories, and to run steam engines.
- Coal is used in the preparation of fuel gases, such as coal gas.
- Coal is used in the preparation of synthetic oil and synthetic natural gas.
- Coal is also used to obtain natural gas. For this, finely ground coal is heated with hydrogen under pressure in the presence of a suitable catalyst.
- The destructive distillation of coal gives coke, coal tar, coal gas, etc.
- Coal is the source from which several organic compounds such as benzene, toluene, phenol, aniline, naphthalene, and anthracene are obtained.

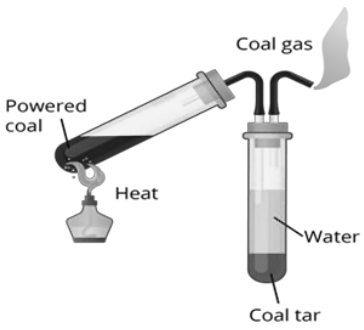


Destructive distillation of coal

On strong heating of coal in a closed tube, it breaks down into different components such as coal gas, coal tar, ammonical liquor and coke. This process is called destructive distillation.

Take some coal powder in a hard glass test tube and insert a holed rubber stopper and an inverted glass tube into it. Take another test tube containing water, and fit it with a cork having two holes, through which a jet tube is attached. Assemble the apparatus as shown in the figure. Heat the test tube and record your observations.

1. The colourless gas which burns when ignited is coal gas.
2. The light grey porous residue left in the hard glass test tube is coke.
3. The brownish-black oily layer at the bottom of the test tube is coal tar.
4. The clear colourless layer above the oily layer is Ammoniacal liquor.



Destructive Distillation of Coal

Coke

Coke contains 98% carbon. It is a tough, black, and porous substance. Coke has a higher calorific value than coal itself. So, it is a very good fuel. It is an almost pure form of carbon. It is used to prepare industrially important gases such as water gas (CO + H_2) and producer gas. It is a good starting material for the preparation of acetylene, acetic acid, and plastics like polyvinyl chloride. It is a good reducing agent also.

1. Water Gas

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$$

$$\text{Carbon} + \text{Water} \longrightarrow \underbrace{\text{Carbon monoxide} + \text{Hydrogen}}_{\text{Water Gas}}$$

2. Producer Gas

$$2C_{(s)} + O_{2(g)} + 4N_{2(g)} \longrightarrow 2CO_{(g)} + 4N_{2(g)}$$

$$\text{Carbon} + \underbrace{\text{Oxygen}}_{\text{Gas}} + \underbrace{\text{Nitrogen}}_{\text{Gas}} \longrightarrow \underbrace{\text{Carbon monoxide} + \text{Nitrogen Gas}}_{\text{Producer Gas}}$$

Coal Tar

- Coal tar is made of a variety of carbon compounds.
- It is a **thick, black liquid** with an **unpleasant odour.**
- Fractional distillation of coal tar yields benzene, toluene, phenol, and aniline, among other chemicals.
- Dyes, explosives, paints, synthetic fibres, medicines, and pesticides are all made of coal tar.
- **Naphthalene balls** used to repel moths and other insects are made from coal tar.

Coal Tar

Coal Gas

- It is also known as town gas and is composed primarily of hydrogen, methane, and carbon monoxide.
- Since the gases in coal gas are flammable, it makes a great fuel. It has a lot of calories.

Ammonia

- Ammonia is another by-product of coal mining.
- It is used to make fertilisers like ammonium sulphate and ammonium superphosphate, among other things.

Ammonia

Check Your Concept - 1

(1) Name some inexhaustible substances.

(2) What is meant by destructive distillation?

(3) Describe characteristics and uses of coke.

Products obtained from coal tar are used as starting materials for manufacturing various substances used in everyday life and in industry, like synthetic dyes, drugs, explosive, perfumes, plastics, paints, photographic materials, roofing materials etc.

Petroleum

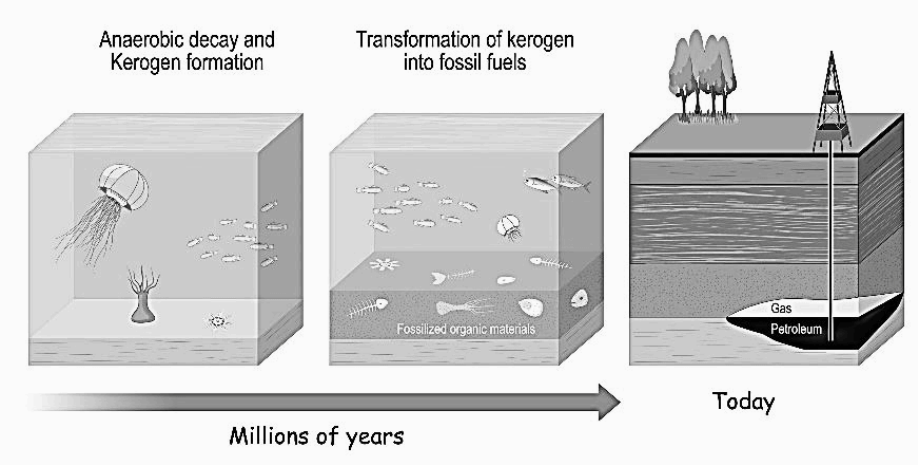
The word Petra means rock, and oleum means oil. Petroleum is also called crude oil, mineral oil, and rock oil. Due to the widespread commercial use of petroleum, it is also called **black gold**. Black gold is also termed as petrochemicals as many useful products are obtained from petroleum.

Properties

- It is yellowish black in colour.
- It is a dark viscous, oily liquid with an unpleasant odour.
- It is a mixture of various constituents such as paraffin wax, petroleum gas, diesel, lubricating oil, petrol, etc.

How was Petroleum Formed?

It is believed that millions of years ago, the microscopic plants and animals which lived in seas, died. Their bodies sank to the bottom of the sea and were soon covered with layers of sand and clay. For millions of years, these remains, in the absence of air, got converted into petroleum under the combined effect of high temperature, high pressure, and bacteria. The petroleum so formed passed through porous rocks until it got trapped between some impervious rocks. Natural gas always occurs above the petroleum under the earth, as shown in fig.



Occurrence of petroleum

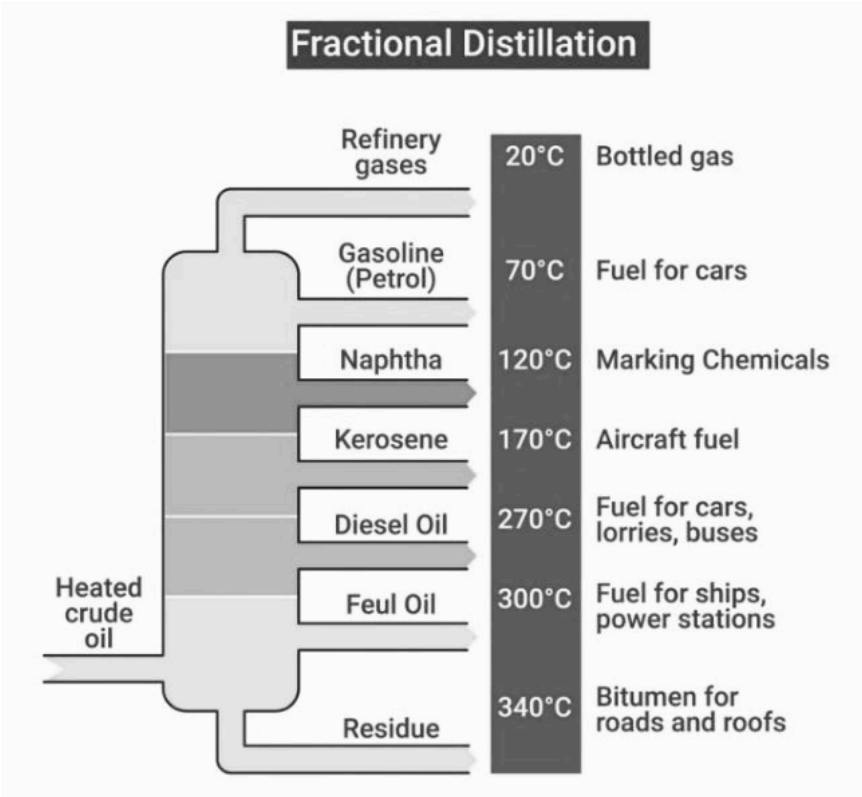
Petroleum occurs at a moderate depth (500 m to 200 m) between the 2 layers of impervious rocks. Petroleum is lighter than water & hence, floats over it. Natural gas is found above petroleum, trapped between the rock cap and petroleum layer.

Refining of petroleum

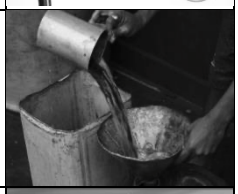
Petroleum is a mixture of several hydrocarbons. It also contains water, salt, and rocky materials. It cannot be used as a fuel or a basic material to produce other useful components in this form. Before being put to use, it has to be purified or refined. The process of separating the various components of petroleum from one another is known as the refining of petroleum. This is done by a process called fractional distillation which is based on the fact that the different components of petroleum have distinctly different boiling points. In fractional distillation, crude petroleum is heated to a temperature of 40°C or slightly above in a furnace.

Petrochemicals

The useful substances which are obtained from petroleum and natural gas are called petrochemicals. Petrochemicals provide the raw material for the preparation of a large variety of substances. These are used for making synthetic fibres, synthetic rubber, plastic, perfumes, fertilizers, explosives varnishes, dyes, and drugs.



Constituents of petroleum and its uses

Constituents	Uses	Images
LPG (Liquefied petroleum gas)	▪ It is a commonly used fuel in homes and industries. ▪ The main constituent is **butane.** ▪ The advantages of LPG are that no **residue** is left behind, **no smoke** is produced, **no harmful gas** is released on burning, has **high calorific** value, easy to handle and convenient for storage.	
Petrol	▪ It is **brownish red** and pale yellow when undyed. ▪ It is **less** viscous. ▪ Used as a **motor** fuel. ▪ Used as aviation fuel. ▪ Used as a **solvent** for dry cleaning.	
Kerosene	▪ It is **blue** in colour. ▪ Fuels for **jet aircraft,** stoves, and lamps.	
Diesel	▪ It is **yellowish-green** in colour. ▪ It is more **viscous** compared to petrol. ▪ Fuels for **heavy** vehicles and electric generators.	
Lubricating oil	▪ Used as a **lubricant** to reduce friction. ▪ Reduces **corrosion** of metals when applied. ▪ Helps in reducing the heat produced due to **friction.**	
Bitumen	▪ It is dark **brown** or brown in colour. ▪ Used in **damp** proofing. ▪ It is used in the manufacturing of **paints** and **metalling** roads.	

Fuel Oil: The boiling range of fuel oil is between 623 K to 673 K. It is used in industries to heat boilers and furnaces. It is a better fuel than coal because it burns completely leaving behind no ash, whereas coal burns to produce a large amount of ash which has to be removed regularly.

Paraffin Wax: It boils at above 673 K. It is obtained by the fractionation of residual oil. It is used for making candles, Vaseline, grease, polishes, etc.

DID you KNOW

Kerosene is used as a fuel for jet aircrafts.

Uses of petroleum

(1) Petroleum products are used as fuels.
(2) Lubricating oils and Vaseline are used as lubricants.
(3) Paraffin wax, a product of petroleum, is used for manufacturing candles, polishes, waxed paper, waterproofing, etc.
(4) Some of the by-products of petroleum after purification are used in the preparation of medicines, ointments, face creams and cosmetics.

Check Your Concept - 2

(1) What do you mean by refining and petroleum refinery?

(2) What are the different uses of petroleum?

DID you KNOW

Many useful substances are obtained from petroleum which can be used for the manufacturing of detergents, fibers (polyester, nylon, acrylic etc.) polyethene and many other plastics. Due to its great commercial importance, petroleum is also called Black Gold.

Natural Gas

Natural gas was formed millions of years ago along with petroleum when microscopic sea plants and animals died and got buried under the soil. These plants and animals under anaerobic conditions changed to gas.

Composition

It consists mainly of methane (about 85%), ethane (about 10%), propane (about 3%), and butane. When natural gas is compressed at high pressure, then it is called CNG (compressed natural gas). CNG is used for power generation. It is now being used as a fuel for transport vehicles because it is less polluting. The great advantage of CNG is that it can be used directly for burning in homes and factories where it can be supplied through pipes. Such a network of pipelines exists in Vadodara (Gujarat) and some parts of Delhi.

Occurrence

It is generally found trapped between impervious rocks, sometimes along with petroleum & sometimes without petroleum. In our country, natural gas has been found in Tripura, Rajasthan, Maharashtra, and the Krishna Godavari Delta.

Uses of Natural Gas

Natural gas is currently used in two forms:
CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas).

Advantages of Natural Gas

- As a fuel - It has a very high calorific value of 55 kJ/g
- It does not produce any poisonous gas on burning.
- It burns with a smokeless flame, so it does not cause much pollution.

Consequences of uses of coal and Petroleum

Coal and Petroleum are exhaustible sources of energy. **So, the excessive mining and use of fossil fuels would lead to the following:**

1. The natural deposits of coal and petroleum on over-extraction will get exhausted. At the rate at which we are using these resources, the stock of coal and petroleum can last for only about 20-30 years.
2. Import of coal and petroleum will increase.
3. There will be severe rain on the foreign exchange reserve to meet the cost of importing petroleum
4. Petroleum products will become costly and may even go beyond the reach of an ordinary person.

Conservation of Fossil Fuels

The wise and judicious use of fossil fuels is called the conservation of fossil fuels. We can do it by adopting the following measures.

1. Do not waste or misuse fossil fuels.
2. Use these fuels only when absolutely necessary.
3. Manage these fossil fuels properly so that they can be used for a longer period of time.
4. Adopt and use alternative or renewable sources of energy such as solar, wind, and biomass energy. It is better to use biogas as a domestic fuel than fossil fuels.

It is believed that it took millions of years for the dead organisms to change into coal, petroleum, or natural gas. Furthermore, their known reserves are limited.

Another problem with fossil fuels is that they are steadily increasing air pollution, and their use is linked to global warming. So, we must use fuels only when it is absolutely necessary. By adopting these strategies, we can save these fuels for the manufacture of many substances which are dependent on petrochemicals.

In India, the **Petroleum Conservation Research Association (PCRA)** gives some tips to save on petrol and diesel while driving. These are:

(1) Drive at a constant & moderate speed as far as possible. Driving at a high speed or slow speed wastes a lot of fuel.
(2) Switch off the engine if you have to wait at traffic lights or for any other reason.
(3) Check the tyre pressure regularly, low pressure or too high-pressure waste fuel.
(4) Make sure that you send your vehicle to a garage for regular maintenance.

Check Your Concept - 3

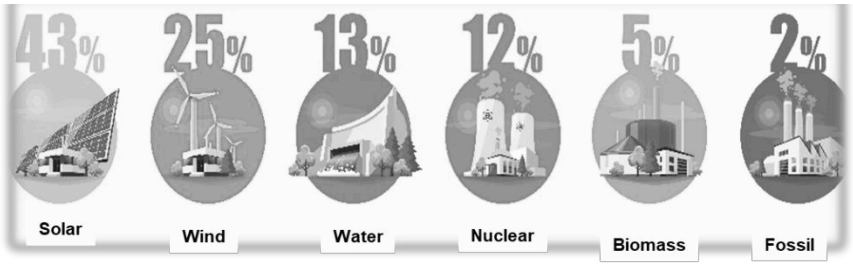
(1) What is meant by 'Natural gas'?

(2) What are different measures taken for conservation of fossil fuels?

(3) Write the advantages of natural gas?

Alternative Energy Sources

A large fraction of the worldwide consumption of fossil fuels is used for the production of electricity. To conserve fossil fuels, scientists, governments, industries, and others are getting together to utilize other (renewable) energy sources for generating power.



The methane gas from cow manure can be used to create energy.

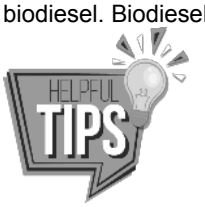
Example:

(1) Why CNG is a better fuel than petrol?
Answer: CNG (Compressed Natural Gas) is considered to be a better fuel than petrol as it is less harmful to the environment and less costly than petrol. It burns without emitting smoke and also doesn't produce deadly and harmful gases as petrol produces**.**

(2) Is LPG more environmentally friendly?
Answer: LPG gas has been identified as more environmentally friendly than all other fuel types when tested in cars and vans, so it makes perfect sense to be used in industrial machinery such as forklifts.

Alternative Fuels

The term synthetic petrol is used to mean petrol made from sources other than crude oil, or petroleum. Petrol can be made from coal or natural gas through a complex chemical process.
This is done in countries which are rich in coal or natural gas but do not have enough petroleum to meet the demand for petrol. Significant research has been done in recent years to produce vehicular fuel from vegetable matter and animal fat. For example, ethanol (alcohol) made from the decomposition of plants is being mixed with petrol in several parts of our country. And special plantations of plants like Mahua and Jatropha are being developed to produce biodiesel. Biodiesel is made from animal fat and vegetable oil.



- Hydrocarbons are organic compounds composed of carbon and hydrogen only.
- Largest sources of all sorts of hydrocarbons are petroleum, natural gas, and coal gas.
- Methane (Alkane) is the simplest hydrocarbon.
- Methane is the chief constituent of natural gas.
- Methane is also known as the 'Fire-damp' of coal mines, and 'marsh gas'.
- Propane and Butane can be liquefied under pressure, hence are supplied in cylinders (LPG-Liquefied Petroleum Gas) for domestic use.
- Petroleum and coal are fossil fuels.
- Lignite is solid fossil coal which is formed from peat and contains 60 to **70**% carbon, the newest form of fossil coal.
- Anthracite is the oldest form of fossil coal, having 95% carbon.
- The main solid fuels are wood, charcoal, and coal.
- The main liquid fuels are kerosene, petrol, and diesel.
- The main gaseous fuels are natural gas, biogas, and bottled gas (IPG).
- The burning of fuel is an exothermic reaction.
- Hydrocarbons containing up to 5 carbon atoms in their molecules are gaseous at ordinary temperature.
- Combustion is a process of oxidation.
- Very rapid combustion occurs in an explosion.
- Charcoal is obtained by heating wood in the absence of air.
- Coke is obtained by the destructive distillation of coal.
- Bituminous coal is a solid fossil fuel of plant origin.
- Paraffin wax is a hydrocarbon.
- Unrefined form of petroleum is known as crude oil.
- Photosynthesis is a process in green plants with which food is manufactured from carbon dioxide and water in the presence of sunlight.
- Distillation is the process of converting liquid into vapor and then changing again to liquid.

Solved Examples

(1) **What is meant by carbonization?**
Answer: The slow process of conversion of dead vegetation into coal is called carbonization.

(2) **What is the purest form of carbon?**
Answer: Coke.

(3) **Name the petroleum product used for the surfacing of roads.**
Answer: A petroleum product 'Bitumen' is used for surfacing roads.

(4) **What are petrochemicals?**
Answer: The useful substances which are obtained from petroleum and natural gas are called petrochemicals.

(5) **Explain why fossil fuels are exhaustible natural resources.**
Answer: Fossil fuels take millions of years to be formed. They are limited in nature and cannot be replenished easily, once consumed. Hence, they are considered exhaustible natural resources.

(6) **Why is petroleum also known as 'black gold?**
Answer: Due to its great commercial importance, petroleum is known as 'black gold.

(7) **What are the effects of global warming?**
Answer: Global warming is the increase in the average temperature of Earth's atmosphere and oceans, it results in the melting of the glacier in the polar region which leads to rising sea levels, causing floods in coastal areas. Even low-lying coastal regions may get permanently submerged under water because of global warming.

(8) **What is meant by 'Natural gas'?**
Answer: Natural gas is a fossil fuel, which is stored under high pressure as compressed natural gas (CNG). It is also used as a starting material for the manufacture of several chemicals and fertilizers.

(9) **What is coal tar and what are its uses?**
Answer: Coal tar is a black thick liquid with an unpleasant smell product obtained coal tar is used as starting material for the manufacture of many dyes, drugs, explosives, perfumes, plastics, paint, photographic materials, roofing materials etc.
Naphthalene balls used to repel moths and other insects are also obtained from coal tar.

(10) **What is water gas?**
Answer: A mixture of CO + H_2 is called water gas. water gas is used with producer gas for the production of fuel gas. it is used to remove carbon monoxide from fuel cell applications. It is used to get pure hydrogen for the synthesis of ammonia.

Exercise

FILL IN THE BLANKS

(1) A natural gas stored under high pressure is called _____.
(2) _____is liquefied form of dead organic matter.
(3) _____is used for running light vehicles.
(4) _____ is used for extraction of metals from their ores.
(5) Petroleum or crude oil pumped out from. _____. is not pure.
(6) These days _____is being used in vehicles in place of petrol and diesel.
(7) _____ gas is present in natural gas.
(8) _____is the fuel used as Aviation fuel.
(9) _____ is the residue left after destructive distillation of coal.
(10) Coke is formed when coal is heated in _____ of air

TRUE OR FALSE

(1) CNG is more polluting fuel than petrol.
(2) Kerosene is not a fossil fuel
(3) Coal tar is a black thick liquid with an unpleasant smell.
(4) Petroleum is called black gold.
(5) Coal tar is a mixture of various substances
(6) Coke is an almost pure form of carbon.
(7) Excessive use of coal for energy improves the quality of air.
(8) Coke and coal are two names for the same substance.
(9) Coal is mainly used to produce electricity.
(10) The petroleum pumped out from oil wells can be used as it is.

OBJECTIVE TYPE QUESTIONS

(1) The white semi-solid fraction of petroleum used for making Vaseline is
(A) Asphalt (B) Lubricating Oil
(C) Paraffin Wax (D) Fuel Oil

(2) Fossil fuel found below the sea is
(A) Petrol (B) Petroleum
(C) Kerosene (D) Diesel

(3) The purest form of carbon is
(A) Coal (B) Charcoal
(C) Coke (D) All of these

(4) Coal tar contains about
(A) 300 substance (B) 400 substance
(C) 200 substance (D) 100 substance

(5) Compounds of carbon and hydrogen are known as
(A) Hydrogen Carbides (B) Hydrocarbons
(C) Carbohydrates (D) Hydrogen Carbines

(6) Mark the incorrect statement.
(A) burning of coal in a sufficient amount of oxygen produces carbon dioxide.
(B) when coal burns an insufficient amount of oxygen, carbon monoxide is formed.
(C) charcoal is a better fuel than kerosene to be used as fuel for cooking at home.
(D) LPG is considered to be good fuel for domestic use.

(7) Gasoline is the name of
(A) Crude Oil (B) Gaseous Fraction of Petroleum
(C) Mixture of Residue Left (D) Mixture of Uncondensed Oils

(8) LPG is a mixture of
(A) Methane and Ethane (B) Methane and Propane
(C) Propane and Butane (D) Methane and Butane

Answer Key

FILL IN THE BLANKS

(1) CNG
(2) Petroleum
(3) Fossil fuel
(4) Refining
(5) Oil wells
(6) Methane
(7) Kerosene
(8) Coke
(9) CNG
(10) Absence

TRUE OR FALSE

(1) False
(2) False
(3) False
(4) True
(5) True
(6) True
(7) False
(8) False
(9) True
(10) False

OBJECTIVE TYPE QUESTIONS

(1) (C)
(2) (B)
(3) (C)
(4) (C)
(5) (B)
(6) (C)
(7) (B)
(8) (C)