GCSE Science (Modular) - Module 6 Revision Guide (Chemistry)

Foundation Tier Part Two

Fossil Fuels

Coal, oil and natural gas are fossil fuels. They come from dead animals and plants which have been covered by layers of sedimentary rock, and heated under pressure in the absence of air over millions of years.

Crude oil is obtained from the earth's crust. Oil and gas are less dense than water and so rise to the top of porous rock layers. They may then become trapped below a layer of non-porous rock. Trapped gas or oil can be obtained by drilling through the non-porous layer.

Crude oil is a mixture of a very large number of compounds. Most of the compounds in crude oil consist of molecules called **hydrocarbons**, because they are made up of hydrogen and carbon atoms only.

Fractional Distillation

A mixture consists of two or more elements or compounds, not chemically combined. The chemical properties of each substance in a mixture are unchanged, and so the substances can be separated by physical methods, e.g. distillation. The hydrocarbons in crude oil can be separated by **fractional distillation**. This means evaporating the oil and allowing it to condense at different temperatures. This produces various **fractions**, each containing molecules with similar numbers of carbon atoms and boiling points.

Properties of Hydrocarbons, Cracking

Hydrocarbon molecules in crude oil vary in size. The larger a molecule is (the more carbon atoms it has):

- the higher its boiling point;
- the less volatile it is;
- the less easily it flows (the more viscous it is); and
- the less easily it ignites (the less flammable it is).

This limits the use of large hydrocarbon molecules (such as bitumen) as fuels. So, large hydrocarbon molecules are broken down using a process called cracking. This produces smaller, more useful molecules. Some of these smaller molecules are useful as fuels; others can be used to make plastics (polymers) such as poly(ethene) and poly(vinyl chloride) (PVC).

The atmosphere and air pollution

For 200 million years the proportions of different gases in the atmosphere has been much the same as today:

- about 4/5 nitrogen and about 1/5 oxygen; and
- small amounts of various other gases, including carbon dioxide, water vapour and noble gases.

Burning (also called combustion) is a very common chemical reaction in which substances react with oxygen in the air. Burning is an oxidation reaction which produces compounds called oxides. Many fuels contain hydrogen, which produces water vapour when burnt. They also contain carbon, which produces carbon dioxide gas when burnt. Carbon dioxide is a “greenhouse gas” – burning fossil fuels and so increasing the levels of carbon dioxide in the atmosphere may cause global warming.

Fuels may also contain some sulphur, which produces sulphur dioxide when the fuel is burnt. The high temperatures produced by burning fuels (especially in furnaces and engines) can also cause the nitrogen and oxygen in the air to react to produce nitrogen oxides. These gases, sulphur dioxide and nitrogen oxides, dissolve in rain to make it acidic. If rivers and lakes become too acidic, plants and animals cannot survive. Acidic fumes and acid rain can also damage metalwork and stonework on buildings.

GCSE Science (Modular) - Module 6 Revision Guide (Chemistry)

Higher Tier Part Two

Where does oil come from and how can so many useful products be made from it?

Fossil Fuels

Coal, oil and natural gas are fossil fuels. They come from dead animals and plants which have been covered by layers of sedimentary rock, and heated under pressure in the absence of air over millions of years.

Crude oil

Crude oil is obtained from the earth's crust. Oil and gas are less dense than water and so rise to the top of porous rock layers. They may then become trapped below a layer of non-porous rock. Trapped gas or oil can be obtained by drilling through the non-porous layer.

Crude oil is a mixture of a very large number of compounds. Most of the compounds in crude oil consist of molecules called **hydrocarbons**, because they are made up of hydrogen and carbon atoms only.

Fractional Distillation

A mixture consists of two or more elements or compounds, not chemically combined. The chemical properties of each substance in a mixture are unchanged, and so the substances can be separated by physical methods, e.g. distillation. The hydrocarbons in crude oil can be separated by **fractional distillation**. This means evaporating the oil and allowing it to condense at different temperatures. This produces various **fractions**, each containing molecules with similar numbers of carbon atoms and boiling points.

Properties of Hydrocarbons, Cracking

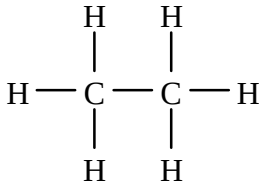
Hydrocarbon molecules in crude oil vary in size. The larger a molecule is (the more carbon atoms it has):

- the higher its boiling point;
- the less volatile it is;
- the less easily it flows (the more viscous it is); and
- the less easily it ignites (the less flammable it is).

This limits the use of large hydrocarbon molecules (such as bitumen) as fuels. So, large hydrocarbon molecules are broken down using a process called cracking. This produces smaller, more useful molecules. Some of these smaller molecules are useful as fuels; others can be used to make plastics (polymers) such as poly(ethene) and poly(vinyl chloride) (PVC).

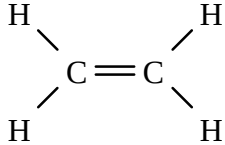
Alkanes

Carbon atoms form the spine of the hydrocarbon molecules. When they are joined by a single covalent C–C bond they are known as alkanes. You should be able to represent and interpret the structure formed, e.g. ethane, C_2H_6 (on the right).



Alkenes

When the hydrocarbons are joined by C=C double covalent bonds they are called alkenes. You should be able to represent and interpret the structure formed, e.g. ethene, C_2H_4 (on the right).



Polymerisation

Unsaturated hydrocarbons are reactive and so are useful for making many other substances including polymers. Polymers have large molecules and are formed when many small molecules of substances called monomers join together. This process is called polymerisation.

When unsaturated monomers join together to form a polymer with no other substance being produced, the process is called addition polymerisation. Plastics made by this process include poly(ethene) from ethene.

What effect does burning oil and other fossil fuels have on the Earth's atmosphere?

Burning fossil fuels

Burning (also called combustion) is a very common chemical reaction in which substances react with oxygen in the air. Burning is an oxidation reaction which produces compounds called oxides. Many fuels contain hydrogen, which produces water vapour when burnt. They also contain carbon, which produces carbon dioxide gas when burnt. Carbon dioxide is a "greenhouse gas" – burning fossil fuels and so increasing the levels of carbon dioxide in the atmosphere may cause global warming.

Pollution

Fuels may also contain some sulphur, which produces sulphur dioxide when the fuel is burnt. The high temperatures produced by burning fuels (especially in furnaces and engines) can also cause the nitrogen and oxygen in the air to react to produce nitrogen oxides. These gases, sulphur dioxide and nitrogen oxides, dissolve in rain to make it acidic. If rivers and lakes become too acidic, plants and animals cannot survive. Acidic fumes and acid rain can also damage metalwork and stonework on buildings.

Origin and maintenance of the Earth's atmosphere

During the first billion years of the Earth's existence there was intense volcanic activity. This activity released the gases which then formed the original atmosphere, and the water vapour which condensed to form the oceans. During this period, the Earth's atmosphere was probably mainly carbon dioxide, and there would have been little or no oxygen. There would also have been water vapour, and small amounts of methane and ammonia (though very much more than there is today). When plants evolved and successfully colonised most of the Earth's surface, the following things happened:

- the atmosphere gradually became "polluted" with oxygen – this meant that there were very few places where micro-organisms which could not tolerate oxygen could live;
- most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels;
- the methane and ammonia in the atmosphere reacted with the oxygen;
- nitrogen gas was released into the air, partly from the reaction between oxygen and ammonia, but mainly from living organisms (including denitrifying bacteria); and
- the formation of oxygen in the atmosphere resulted in the development of an ozone layer – this filters out harmful ultraviolet radiation from the Sun allowing the evolution of new living organisms.

For 200 million years the proportions of different gases in the atmosphere has been much the same as today:

- about four-fifths nitrogen;
- about one-fifth oxygen; and
- small amounts of various other gases, including carbon dioxide, water vapour and noble gases.

Carbon dioxide will react in sea-water to produce insoluble carbonates (mainly calcium carbonate) which are deposited as sediment, and soluble hydrogen carbonates (mainly calcium hydrogen carbonate and magnesium hydrogen carbonate). These reactions can absorb only some of the carbon dioxide released into the atmosphere by burning fossil fuels. In addition, carbonate rocks are sometimes moved deep into the Earth by geological activity, where they may then release carbon dioxide again via volcanoes.