The content on this sheet is assessed on paper 2 only.

Topic 8a—Fuels

* Indicates that these are some examples only: you could be asked about any substance / reaction.

8.1—Hydrocarbons

Hydrocarbons are compounds (consisting of molecules) that contain carbon and hydrogen atoms only.

8.2—Crude oil

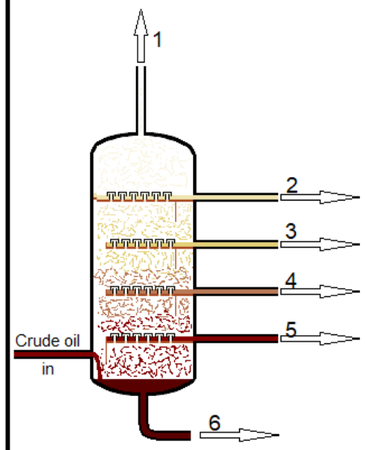
a) Crude oil is a mixture of lots of different hydrocarbon molecules.

b) The molecules can have either a chain structure, or a ring structure.

c) Crude oil can be used in the petrochemical industry as both fuel and feedstock.

d) Crude oil is described as being non-renewable, as it is a finite source which will eventually run out.

8.3 & 4—Fractional distillation



Fraction 1 is called gases, and is used for domestic heating and cooking.

Fraction 2 is called petrol and is used as fuel for cars.

Fraction 3 is known as kerosene, and is used as fuel for aircraft.

Fraction 4 is diesel oil, and is used as fuel for some cars and trains.

Fraction 5 is called fuel oil, and is used to fuel large ships and power stations.

Fraction 6 is called bitumen and is used to surface roads & roofs.

Crude oil must be separated into simpler, more useful fractions. The crude oil is heated and pumped into the fractionating column/tower. The column is hotter at the bottom and cooler at the top. Most of the hydrocarbons in the mixture vaporise and rise up the column, which gets gradually cooler. As the hydrocarbons cool to their boiling points, they start to condense into liquids, and are collected on the trays. The hydrocarbons in each fraction have similar physical and chemical properties to one another.

8.5—Properties of the fractions

a) the different hydrocarbons (which are mostly alkanes) have different chain lengths. This means their number of carbon and hydrogen atoms changes. As the chain length **increases**, the following properties are affected:

b) the boiling point increases.

c) the ease of ignition decreases.

d) the viscosity (resistance to flow) increases.

8.6—Homologous series

The alkanes are an example of a homologous series of compounds.

a) all of the members of a homologous series have the same general formula. For the alkanes, this is C_nH_{2n+2}.

b) Each member of a homologous series differs by CH_2 from the last.

c) Their physical properties gradually change as you go through each member. With the alkanes, for example, their boiling point increases as you add each CH_2.

d) they have similar chemical properties, as all members of a homologous series react in similar ways.

8.7—Complete combustion

Combustion is a chemical reaction in which a fuel reacts with oxygen. During complete combustion, energy is released, and the only two products are carbon dioxide and water.

8.8—Incomplete combustion

During incomplete combustion, there is a lack of oxygen. In this case, there may be carbon monoxide produced. If there is a severe lack of oxygen, then pure carbon can also be formed.

8.9—Behaviour of carbon monoxide

Carbon monoxide is a toxic gas produced during incomplete combustion. It is toxic as it binds to the haemoglobin in blood, meaning that oxygen cannot be carried around the body, therefore causing someone to die if they inhale too much.

8.10—Problems of incomplete combustion

Carbon monoxide produced in appliances is toxic.

The soot (pure carbon) produced by combustion can also cause problems by blocking pipes in boilers, causing buildings to look blacker and causing breathing problems/issues.

8.11—Production of sulfur dioxide

Some fuels contain impurities of sulfur. When these fuels burn, the sulfur is oxidised to form sulfur dioxide gas. This can dissolve in rain water to form acid rain.

8.12—Problems with acid rain

Acid rain can react with limestone or metals in some buildings and statues, causing them to be weakened.

If it is concentrated enough, it can also cause environmental damage to plants and trees, causing them to lose leaves and die.

If too much acid rain falls into rivers, it can cause the water to become too acidic for some aquatic life to survive.

8.13—Production of nitrogen oxides

Nitrogen is normally a very inert/unreactive gas. However, inside combustion engines, where the temperasture is very high, nitrogen and oxygen from the air can react together to form nitrogen oxides. Like sulfur dioxide, these gases are pollutants which contribute to acid rain.

8.14—Use of hydrogen as a fuel

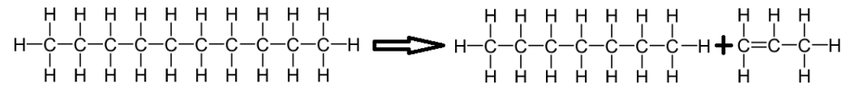
The table below summarises *some* of the advantages & disadvantages of using hydrogen gas as fuel in cars, as opposed to crude oil products like petrol.

Advantages	Disadvantages
• The only product of combustion is water, which has no environmental impact. • More energy is released per gram of fuel than petrol. • Hydrogen can be made by the electrolysis of water (amongst other methods), so is renewable.	• There are not many filling stations that sell hydrogen. • Hydrogen is a highly flammable gas. For this reason, it can be difficult to store. • Not many car engines can burn hydrogen: most of them would have to be adapted/modified.

8.15—Non-renewable fuels

There is only a finite supply of crude-oil derived fuels, such as petrol, kerosene and diesel. For this reason, they are described as non-renewable, as once they are burnt, they cannot be (quickly) replenished.

8.16—Cracking*



In cracking, long-chain alkane (hydrocarbon) molecules are broken down into smaller alkanes and alkenes. These smaller molecules are useful as fuels and for manufacturing plastics.

8.17—Why is cracking necessary?

Longer chain hydrocarbons are not in high demand, but there is a large supply of these available. These molecules are cracked to produce more short-chain hydrocarbons, which are in much higher demand (for use as fuels), but have a smaller supply.