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Topic 10

Crude oil, fractionation and petrochemicals

MATHS SKILLS

The only mathematic skill required for this section is the balancing of chemical equations.

Crude oil is a **mixture** of many hydrocarbons and this means that it can be **separated** into its components using a physical method.

These hydrocarbons are **miscible** and have similar boiling points and therefore they can be separated by **fractional distillation**.

Most of the hydrocarbons are alkanes.

The separation of crude oil into its constituents is called **fractionation** and the different parts are called **fractions**.

Before the crude oil enters the fractionating tower it is heated and **evaporates** to form a vapour.

As it enters the tower the fractions with the higher boiling points **condense** lower down the tower to form liquids.

The fractions with lower boiling points continue to rise up the tower until the temperature falls below their boiling point and they also condense.

The fractions that are gases at room temperature leave the tower as gases.

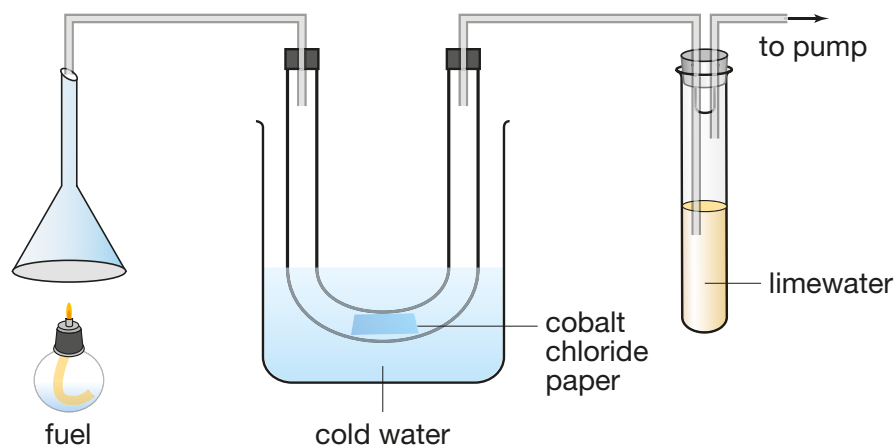
See Snap It! box on page 113 for details about the fractionation.

All alkanes have simple molecular structures. The boiling points of the fractions depend on the size of the molecules in that fraction. The larger the molecules the greater the **intermolecular forces** and the higher the boiling points.

Hydrocarbons are good **fuels**. They undergo complete **combustion** in air (oxygen) to give carbon dioxide and water as products and this combustion gives out lots of **heat energy** in an **exothermic** reaction.

If there is not enough oxygen then incomplete combustion takes place and poisonous carbon monoxide is produced. (This is covered in more detail in the sub topic Atmospheric pollutants).

The apparatus, shown below, is used to test for the products of complete combustion:



DO IT!

Describe how the apparatus shown can be used to identify the products of combustion. Note that cobalt chloride paper changes from blue to pink in the presence of water.

Your description should explain the use of a pump, the upturned filter funnel, the cold water and why the limewater is placed after the cobalt chloride paper.

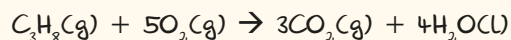
WORKIT!

Write out a balanced equation for the combustion of propane (C_3H_8) in oxygen.

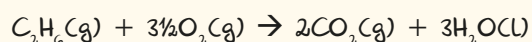
The reactants are C_3H_8 and O_2 . The products are H_2O and CO_2 .

The best way of balancing these equations is to balance the carbons, then the hydrogens and then count up the number of oxygen atoms needed. For the oxygen you can have $\frac{1}{2}O_2$ if odd numbers are needed.

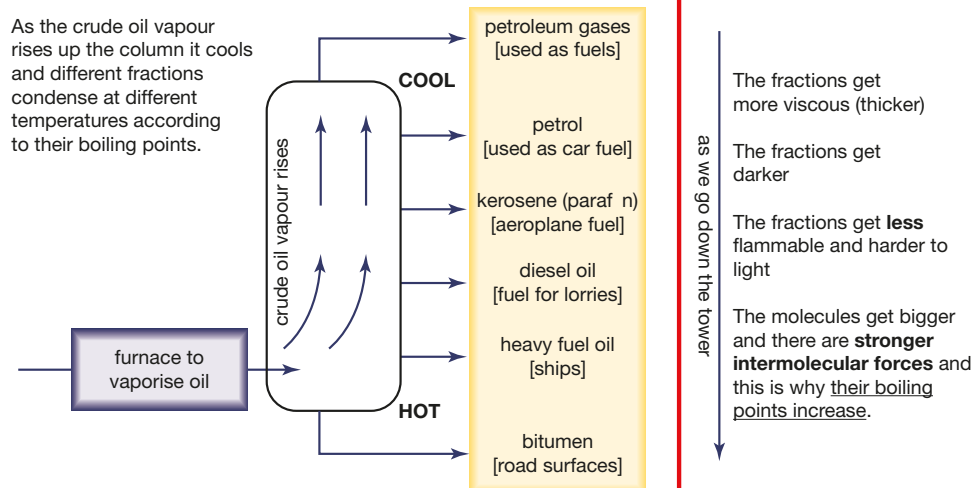
For propane you have 3 carbons and therefore 3 carbon dioxide molecules; you have 8 hydrogens and therefore 4 water molecules. This means that the total number of oxygen atoms is 10 and this means that we need 5 oxygen molecules on the reactant side.



The combustion of ethane (C_2H_6) illustrates the use of $\frac{1}{2}O_2$ because after going through the procedure we find that 7 oxygen atoms are needed on the reactant side.

**SNAPIT!**

As the crude oil vapour rises up the column it cools and different fractions condense at different temperatures according to their boiling points.

**CHECKIT!**

- List the uses of the main fractions coming from the fractionating tower.
- Why is fractional distillation used to separate crude oil into its fractions?
- What happens to the boiling point of the fractions as we go down the column? Explain why.
- One fraction X comes off the tower above another fraction Y. Compare the thickness, appearance, ease of lighting and boiling point of X and Y.
- In the investigation of the products of combustion what are the changes observed in the cobalt chloride paper and the limewater?
- Complete and balance the following equations for the complete combustion of methane (CH_4) and butane (C_4H_{10}).

