IGCSE Co-ordinated Sciences 0654
Unit 10: C3 Petrochemicals & C4 Chemicals from Plants

Recommended Prior Knowledge
Familiarity with molecular structures and models.

Context
Knowledge from this Unit may be useful in the study of topic C11 Dyes and drugs.

Outline
Composition, fractionation and uses of crude oil (petroleum) are a basis for study of the homologous series of alkanes and alkenes. Polymerisation of alkanes is extended to cover thermoplastics and naturally occurring polymers.

AO	Learning outcomes	Suggested Teaching activities	Learning resources
AB	Know that crude oil (petroleum) is a mixture of hydrocarbons. Know that in molecules containing carbon, the carbon atoms may be joined in chains, branched chains or rings.	Students need to be able to draw structural formulae accurately.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.
		First establish rules of number of bonds formed for carbon and hydrogen (links to valency, Group number and electronic configuration are possible). Then allow student to draw structures for the first few members of the alkanes. They may use computer drawing packages (details of which are given in the websites). Allow students to use ball and spoke models to build the molecules, concentrating on the smaller alkanes. If not available, use simple plasticine and pipe cleaners or similar.	Drawing packages: http://scistore.chemstore.com/ http://www.acdlabs.com/ http://www.softshell.com
ABC	Understand the meaning of the terms *molecular formula* and *graphical formula.*	Students should be shown and/or work out the molecular formula and graphical formula for the smaller alkanes. They can check their answers	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.

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	Understand how the melting and boiling points, viscosity and flammability of hydrocarbons depend on molecular size.	using the website. There are opportunities for students to produce line graphs to show trends of boiling point viscosity and flammability against number of carbon atoms down the series of straight chain alkanes. Students can get data from the first website. The second website has data and tasks for students to carry out. Discuss effect of increased molecular mass down the series on boiling point. Link to fractional distillation. An animated diagram of a fractionation tower on this website can be used to illustrate the ideas involved.	Structural formulae table: http://www.rjclarkson.demon.co.uk/ *Teaching and Assessing Practical Skills in Science* by Dave Hayward http://www.ausetute.com http://www.creative-chemistry.org.uk/ http://science.howstuffworks.com
A	Understand the difference between *saturated* and *unsaturated* hydrocarbons.	Extend the use of molecular models to compare the structures of alkanes and alkenes, and relate to the terms saturated and unsaturated. Emphasise the inclusion of a double covalent bond in alkenes.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.
ABC	Know that aqueous bromine can be used to distinguish between a saturated and an unsaturated hydrocarbon.	Demonstrate or allow students to carry out an experiment to show the decolourisation of bromine water by an alkene. Contrast with the lack of reaction with an alkane.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12. Teaching and Assessing Practical Skills in Science by Dave Hayward
A	Know that alkanes are unreactive but that alkenes have distinct chemical reactions.	Make general reference to the unreactivity of alkanes with many reagents and the much higher reactivity of alkenes. Emphasise this difference when covering the reactions and uses of alkanes and alkenes below.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.
AB	Know that alkanes and alkenes are members of homologous series of compounds, each member of such a series having similar properties.	Use structural formulae / ball and spoke models to emphasise difference of CH_2 between members. Emphasise that the functional group determines chemical reactions, but mass of molecule affects physical properties e.g. state. These web sites	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12. http://www.rjclarkson.demon.co.uk

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		can be used to show the physical and chemical properties of the alkanes.	
AB	Be aware of the wide range of uses of petroleum fractions for fuels, lubricants, waxes and in the synthesis of other chemicals. Know the meaning of the terms *fractional distillation, cracking, polymerisation, polymer, monomer* and *catalyst.* Appreciate the importance of catalysts in the petrochemical industry.	Fractional distillation may be demonstrated. A synthetic crude oil substitute may be used for this. The web sites can be used to link the demonstrated experiment to the industrial process.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12. http://www.elmhurst.edu http://science.howstuffworks.com
		Opportunity for display work. Students find magazine pictures and advertisements to illustrate the uses of the fractions. The pictures can be mounted on a large outline of the fractionating column, showing where fractions emerge, with boiling points and chemical detail, such as number of carbon atom range in each fraction.	The petroleum industry: http://www.ukpia.com/home.aspx Refining petroleum: http://www.refiningonline.com/ http://science.howstuffworks.com Uses of petroleum: http://www.wpbschoolhouse.btinternet.co.uk
		Students can use display work to show awareness that the use of the fractions as fuels is rapidly depleting crude oil, the essential raw material for plastics and other petrochemicals.	
		Students can simulate polymerisation reactions by joining together paper clips or beads.	
		Use of catalysts may be demonstrated by the cracking of paraffin described below.	
AB	Know that alkenes may be manufactured by the cracking of petroleum. Know that ethanol may be formed by the catalytic addition of steam to ethene.	Petroleum jelly on mineral wool can be cracked using hot broken pot as a catalyst. The resultant gas can be collected over water (this experiment demonstrates that large molecules, such as those in the near-solid jelly, form small gaseous molecules, a clear demonstration of	IGCSE Chemistry by B Earl and LCR Wilford, Chapter 12.

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		the effects of cracking on molecular size). The ethene produced can be tested using bromine water (see below). Students should be made aware of the importance of cracking to the petrochemical industry to meet demand for smaller molecules e.g. petrol components, from larger molecules in crude oil for which there is little demand. These websites can be used to illustrate the ideas. The schoolscience website includes a tour through a virtual refinery to show the cracking process. Contrast the production of ethanol by fermentation and by addition of steam to ethene.	http://www.kcpc.usyd.edu http://www.schoolscience.co.uk
A	Understand the difference between *addition* and *condensation polymerisation*, using simplified models.	Use simple models to demonstrate the addition and condensation polymerisation. Students could role play these reactions. The web sites can be used to reinforce the ideas presented in class. The making of nylon can be demonstrated.	Details of polymerisation reactions: *IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 13. http://www.bbc.co.uk/schools/gcsebitesize/ http://www.kcpc.usyd.edu http://www.kcpc.usyd.edu http://www.rjclarkson.demon.co.uk An animation of condensation polymerisation: http://www.careyotto.com
ABC	Know the meaning of the term *plastic* and know how thermoplastics and thermosets behave on heating.	Students can test a range of plastics by heating in a fume cupboard.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12. Teaching and Assessing Practical Skills in Science by Dave Hayward http://www.plastics.org

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ABC	Understand the difference between *thermoplastics* and *thermosets* in terms of weak 'between molecule' forces and cross linking.	Samples of plastics can be heated in a fume cupboard to classify them as thermoplastic or thermoset, and carry out more detailed identification with the help of keys. Students can carry out a survey of plastics to relate plastic type to uses. Students can use data from the website to relate properties of plastics to their uses. Simplified molecular models may be used to demonstrate strong bond in the cross linking in thermosets, and contrast this with weaker inter-molecular forces in thermoplastics. Students may role model the heating or these two types of plastic.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12. Teaching and Assessing Practical Skills in Science by Dave Hayward http://www.bbc.co.uk/schools/gcsebitesize
A	Know that sugars, starch and cellulose are carbohydrates.	Show students examples of these compounds.	http://www.sucrose.com/
A	Know that carbohydrates are compounds of carbon, hydrogen and oxygen.	Emphasise C(H_2O) empirical formula. Look at formulae of simple sugars.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.
AB	Appreciate that bonding in carbohydrate molecules is essentially the same as in simpler carbon compounds.	Make molecular models of simple sugars.	*IGCSE Chemistry* by B Earl and LCR Wilford, Chapter 12.
ABC	Know that starch and cellulose are polymers of glucose. Know that protein molecules consist of long chains of amino acids. Know that amino acids are compounds of nitrogen, carbon, hydrogen and oxygen and that some also contain sulphur.	Students can compare drawings of structure of glucose, cellulose and starch, and drawings of structures of amino acids and polypeptides. Students can then navigate through a series of illustrated web pages to see the structures of carbohydrates and other interesting details. Students can make molecular models of amino acids. This may be done simply using paper clips or beads, or using molecular model kits.	http://www.bbc.co.uk/education

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		Students may carry out tests for starch and simple sugars, and use these to follow the hydrolysis of starch into simple sugars. Diffusion of sugars and amino acids through membranes can be related to digestion.	*Teaching and Assessing Practical Skills in Science* by Dave Hayward
AB	Know that cellulose and rubber are important natural polymers and be able to name some common uses of these substances.	Different types of paper may be examined under a microscope and the structures related to uses.	http://library.osu.edu
	Appreciate the use of wood and other plant materials in making paper and in building and to understand the need to conserve such resources.	Students could survey newspapers or the internet to find references to conservation of building materials. Try making paper using the second web link.	http://www.recyclenow.com http://www.reyclezone.org.uk
A	Understand how large molecules can be separated from smaller ones by a partially permeable membrane.	The passage of small molecules such as water and ions, but not larger molecules such as simple sugars through a partially permeable membrane may be demonstrated. This can be related to dialysis.	http://www.bbc.co.uk/schools/gcsebitesize