UNIT 3 Organic Chemistry 1 (includes Covalent Bonding and Energy from Chemicals)

Recommended Prior Knowledge Unit 1

Context This unit is suitable for studying towards the middle of the course. It is a necessary preparatory unit for Organic Chemistry 2. Ideas about Energy from Chemicals are used in Speed of Reaction (Unit 7).

Outline This is a lengthy unit. The ideas all relate to the petrochemical industry. Students study fractional distillation and cracking of crude oil, leading to a study of the properties and reactions of two homologous series: the alkanes and alkenes. It is suggested that the alkanes are used as examples of typical covalent compounds – thus an introduction to covalent bonding is taught alongside learning about the structures of alkanes. Following an introduction using simpler molecules (see syllabus), more able pupils should be able to draw 'dot and cross' diagrams for more complex molecules, e.g. alkanes, and molecules which contain double or triple bonds. The unit ends with a study about energy changes in chemical reactions. All students should be able to draw energy profile diagrams. Work on the petrochemical industry lends itself to 'topic' based work and the opportunity for students to carry out their own research.

There are several possible routes through the unit. Syllabus learning outcomes 2.5 (Covalent bonding) and 5 (Energy from chemicals) can be taught alongside 11.1 (Alkanes), using alkanes as examples to teach the key ideas. Another approach is to teach covalent bonding and energy discretely as preparation for teaching alkanes and alkenes together towards the end of the unit. More able students should understand that the relative bond energies of products and reactants determine the nature of the energy change in reactions.

	Summary of learning Outcomes (see syllabus for full detail)	**Suggested Teaching Activities**	**Further teacher guidance**	**Online resources**
11 5 g	**Organic Chemistry** State that crude oil is the main source of organic chemicals and discuss issues relating to its use as a fuel or chemical feedstock. Link crude oil to other fossil fuels, particularly natural gas.	Discuss the range of products made from oils e.g. fuels, detergents, plastics, paints, dyes, fibres etc. Students could make an 'oil diary' for a day to show how they use oil products.	This issue is best addressed in an integrated approach by discussion across the unit. Students should realise that we depend on oil for chemicals to make many 'everyday' goods, and that oil reserves are being rapidly depleted by their use as fuels.	www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Oil and useful products'
5 h i	**Energy from Chemicals (part 1)** describe how crude oil is separated into useful fractions by fractional distillation. name the main fractions and uses (see syllabus for list) – NB. The importance of the naptha fraction as the main	Students need to be familiar with how the process of fractional distillation works by considering the different boiling points of the oil fractions. Most text books have suitable diagrams to use. See the list of web sites for virtual visits to oil platforms and refineries.	This cross-links to Syllabus Learning Outcome 1.2(a), purification by distillation.	www.schoolscience.co.uk Click on: 'Virtual visit to an oil platform' 'Virtual visit to Fawley refinery' Also click on 'Chemistry 14-16' then 'Exploring for oils'

	organic feedstock.	Crude oil is a complex mixture of hydrocarbons – natural gas is largely methane. Use the properties of these to introduce the general physical properties of covalent compounds (in contrast to ionic compounds).		and 'Fossils into fuels' http://www.btinternet.com/~chemistry.diagrams/fractcolumn.htm http://www.btinternet.com/~chemistry.diagrams/sep_crude_oil.htm
2.5 a, b c	**Covalent bonding** Describe how covalent bonds are formed and use dot and cross diagrams to show how bonds are formed (see syllabus for full list of compounds) Deduce the arrangement of electrons in other covalent molecules	Students need to be able to draw dot and cross for all the molecules given in Syllabus section 2.5 (b). They should start by drawing compounds that contain only single bonds and then progress to double (CO_2) and triple (N_2) Introduce bonding in alkanes (and alkenes) here. Examination questions commonly ask students to draw outer electrons only and expect to see both dots and crosses in the diagrams.	Ideas about covalent bonding relate to learning outcomes across the unit. It is suggested that this is taught alongside 11.1 Alkanes (below)	www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Structure and Bonding' www.s-cool.co.uk/contents.asp click on 'GCSE revision' then 'Chemistry' then choose topic: 'Chemical Bonding' . Use the 'Quick learn' section.
d	Relate the physical properties of covalent compounds to their structure and bonding.	Students can research data about the physical properties of some of the compounds for which have drawn dot and cross diagrams (above). They need to explain the properties in terms of their bonding and simple structure.	It is important to contrast the properties of covalent compounds to those of ionic (from Unit 2). Students should be able to identify the type of bonding in a compound from tabulated data such as melting and boiling points, electrical conductivity etc.	
11.1 a	**Alkanes** Describe alkanes as a homologous series with reference to their… general formula	Students can produce a table of names, formulae (both condensed and structural), melting and boiling point, relative molecular mass for the alkanes. They can use	This syllabus area provides the opportunity for introducing relative atomic and molecular mass:	www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm

b	trends in physical properties trends in size and mass	databooks or online databases to find the information independently. Discuss the trends in the properties and produce a summary of the main points. NB. Use of the term ‘saturated’ and the general formula C_nH_{2n+2} If resources are available, students should build 3-D models of the alkanes. Molecular modelling kits can be used, but if these are not available they can use cocktail sticks or drinking straws for bonds and modelling clay or soft sweets for atoms.	Syllabus Learning Outcomes 3e and f. There is also opportunity to teach or practise using empirical and molecular formulae, Syllabus Learning Outcome 3h	Click on ‘Extra Organic Chemistry’ www.s-cool.co.uk/contents.asp click on ‘GCSE revision’ then ‘Chemistry’ then choose topic: ‘products from crude oil’ . Use the ‘Quick learn’ section.
c	Name and draw the structures of alkanes C1 to C4	Students need to learn to name and give the formulae for the first four alkanes. One approach is to make flashcards for the students to put in order, match names with formulae. The cards can then be used for students to test each other.	This can be taught alongside Covalent Bonding 2.5 (above).	www.nyu.edu/pages/mathmol/library click on ‘hydrocarbons’
d	Define isomerism and identify isomers	Students need to learn the definition for isomers. Again, if possible they can build 3-D models of the isomers of butane and use them to draw structural formulae.		http://antoine.frostburg.edu/cgi-bin/senese/tutorials/isomer/index.cgi
e	Describe the properties of alkanes (combustion and substitution)	This is a further opportunity to practise balancing equations. Students should be able to write equations for combustion and substitution reactions of the first four alkanes. The gases from a burning candle or Bunsen burner can be collected and tested for water and carbon dioxide.	This provides an opportunity to teach Redox in terms of oxygen gain, Syllabus Learning Outcome 6.2(a) This is also an opportunity to teach the tests for carbon dioxide and water, Syllabus learning outcome 1.3(c))	
5 a	**Energy from Chemicals (part 2)** describe enthalpy changes in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions	Use the burning of methane as the initial example for constructing an energy profile. Test-tube reactions suitable for	Use past papers to see the layout of energy profile diagrams that are used in examinations.	www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiments 16, 22, 84

b c, d e	represent energy changes using energy profile diagrams explain energy changes in terms of bond making and bond breaking describe combustion of fuels as exothermic	experimenting with temperature and energy changes include: • magnesium and aqueous copper sulphate • hydrochloric acid and sodium hydroxide • any metal carbonate and hydrochloric acid • dissolving ammonium salts. Students should draw energy profile diagrams for the reactions they carry out and label them with reactants, products, activation energy and enthalpy change.	Ideas about Activation Energy should be introduced here, although a fuller treatment follows in Unit 7. Students should appreciate that even very exothermic reactions (e.g. combustion of methane) require an initial energy input (a lighted match) Experiments using the various types of 'hand-warmer' available for outdoor expeditions can be useful here.	www.spartechsoftware.com/reeko/Experiments/ExpSteelWoolGeneratingHeat.htm www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Rates of Reaction' http://www.coruseducation.com/CoffeeCan/index1.html http://science.howstuffworks.com/fire.htm
f j	discuss the use, advantages and disadvantages of hydrogen as a fuel describe photosynthesis and explain that it provides renewable energy	Students should compare using ethanol and hydrogen with using fossil fuels such as natural gas and oil fractions, and discuss issues such as… • hazards. • storage/ liquid and gas states • method of manufacture • pollutant gases produced • long-term future/ renewable v non-renewable.		Use a search engine to search for 'Hydrogen car' to see the latest examples of hydrogen fuelled vehicles. http://www.bmweducation.co.uk/cleanEnergy/default.asp www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 54
11.2 a	**Alkenes** Describe alkenes as a homologous series	NB. Use of the term 'unsaturated' and the general formula C_nH_{2n}		
b	Name and draw the structures of alkenes C2 to C4	Flash cards can be used in the same way as recommended for alkanes.		
c	Discuss how alkenes are manufactured by cracking	This can be demonstrated by heating vaseline soaked on mineral wool in a horizontal test tube, passing the vapour over a broken pot catalyst (in the middle of the test tube) and collecting the product		www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 96

		(ethene) over water.		See online links suggested under 'fractional distillation' above for oil refining. http://www.btinternet.com/~chemistry.diagrams/cracking.htm
e	Describe the properties of alkenes (combustion, polymerisation, addition reactions)	This is a further opportunity for equation writing practice. Students should be able to draw the structures of alkenes showing the double bond reacting to form saturated products. Suggested experiment: distinguishing between hexene and hexane using aqueous bromine.		
d f, g	Describe how to identify unsaturated hydrocarbons using aqueous bromine Describe the manufacture of margarine by hydrogenation of polyunsaturated vegetable oils	Students can test different vegetable oils and melted animal fats for 'degree of unsaturation' by counting the number of drops of aqueous bromine that each will decolourise.	This topic can be used to reinforce the use of transition metals as catalysts (Syllabus learning outcome 8.3, Unit 2) by stressing the role of nickel in hydrogenation. This is also an opportunity to teach Redox in terms of hydrogen gain (Syllabus Learning Outcome 6.2 (a))	www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiment 9
11.5 a b c d	**Macromolecules** Define macromolecules and describe addition polymerisation of ethene. Deduce the structure of a polymer from a given monomer and vice versa. Know some uses of poly(ethene)	Students can practise drawing monomers and polymers of compounds related to ethene. They should be able to identify the repeating unit in a given polymer. Examples to try: polystyrene, PVC, Teflon, polypropylene. Students can work out polymer lengths from relative mass data.	An interesting extension is to look at the international symbols for recycling plastics (see web site) and identifying which compounds are used for different packaging. This is an opportunity to teach ideas about empirical and molecular formulae, Syllabus Learning Outcome 3h	www.chemsoc.org/networks/learnnet/classic_exp.htm Look at experiments 77, 95. Recycling symbols: http://www.cswd.net/recycling/symbols.shtml www.psrc.usm.edu/macrog/index.htm

2.3 b d	**Structure and properties of materials** compare the structure of molecular and giant molecular substances to deduce their properties (see syllabus for list of substances) be able to deduce physical properties of substances from their structure and vice versa.	Students need to be able to explain physical properties in terms of bonding and structure. They can research the properties of the substances in section 2.3 by using data books or online data-bases. A suggested experiment is to ask students to distinguish between silver sand (giant covalent), salt (ionic) and powdered wax (simple covalent) by experiment.	This links to previous work on covalent and ionic bonding. Again, students should practise identifying the type of bonding from tabulated data such as melting and boiling points, electrical conductivity etc.	www.wpbschoolhouse.btinternet.co.uk/page10/page10.htm Click on 'Structure and Bonding' www.s-cool.co.uk/contents.asp click on 'GCSE revision' then 'Chemistry' then choose topic: 'Chemical Bonding' . Use the 'Quick learn' section.
c	compare the bonding, structure and properties of diamond and graphite	Students need to be familiar with the 3-D diagrams of the two forms of carbon. One activity is to give student cards of different properties and their explanations and ask them to work out which property fits which explanation e.g. 'Property: diamond is denser than graphite' 'Reason: atoms in diamond are closer together than in graphite'		http://www.btinternet.com/~chemistry.diagrams/molecular_diagrams.htm