Collins

Cambridge IGCSE™

Combined Science

TEACHER'S GUIDE

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C11 Organic chemistry

Contents

Overview of the section

This section covers the organic chemistry content of the course. It is unlikely that students will have studied organic chemistry before starting this course. You will need to spend time developing their understanding of organic formulas, the general terminology they are likely to meet during the section, the naming of organic compounds and improving their familiarity with terms such as ‘saturated’, and ‘unsaturated’.

Supplement In addition a homologous series and its general characteristics can be introduced and then these ideas can be reinforced during the study of individual topics.

After the general introduction hydrocarbon fuels are the focus before concentrating on the two homologous series: alkanes and alkenes. The study of alkenes links to later work on addition polymerisation in the polymers topic.

All the topics in the section require a good understanding of covalent bonding and the properties of simple covalent compounds. Discussion of the combustion of hydrocarbons links to pollution in Topic C10a *Chemistry of the environment*. In the suggested teaching sequence, all the topics are included in the second year of the course. As with other sections, it is important to use orientation to establish the extent of your students’ prior knowledge.

Starting points

The Student Book section opener puts the ideas in the section into context and sets the scene. It also allows students to acknowledge and value their prior learning, and provides a benchmark against which future learning can be compared.

The questions provide a structure for introducing the section and can be used in a number of different ways:

- You could ask students to consider the questions as an introductory homework task.
- You could put students into groups to share their own ideas and understanding and then to report back to the whole class.
- Students could be given access to the Internet, preferably with a tight timescale, to find out the information required.

You could then use a spider chart or other form of wall chart to summarise everybody’s ideas.

Recording these initial ideas allows you to retain them for reference as the individual topics are developed. In this way, your students’ progress in learning can be readily acknowledged.

C11a General introduction to organic chemistry

Introduction

This topic, as its name implies, is a general introduction. Its contents are replicated in the subsequent topics in this section. For students following the supplementary course the concept of a homologous series is introduced and knowledge that in a homologous series all the compounds will have similar chemical properties.

Links to other topics

Section	Essential background knowledge	Useful links
C2 Atoms, elements and compounds	C2c Simple molecules and covalent bonds	
C11 Organic chemistry		C11b Fuels C11c Alkanes C11d Alkenes C11e Polymers

Topic overview

C11a.1	**Orientation** This learning episode introduces and defines the terminology that will be used throughout the section. There are no further activities and you can move straight to Topic C11b Fuels.

Career links

These are some scientific careers that focus on this area of chemistry but careers in many other fields use the knowledge and skills gained studying science.

Forensic analysts, **environmental chemists** and **food scientists** are just three examples of careers which make use of a wide range of knowledge on organic chemistry.

Pharmaceutical chemists develop active ingredients to improve or create new medicines.

Learning episode C11a.1 Orientation

Learning objectives

- State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds.
- State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds.
- **Supplement** State that homologous series are families of similar compounds with similar chemical properties.
- **Supplement** Describe the general characteristics of a homologous series as:
  a) having the same general formula (recall of specific general formulas is **not** required)
  b) displaying a trend in physical properties
  c) sharing similar chemical properties.

Resources

Student Book What are alkanes?; What are alkenes?

Approach

Students should be familiar with some organic compounds from their study of Topic C2c *Simple molecules and covalent bonds*. By revising some of the molecules they have encountered already it should be possible to provide a quick introduction to some homologous series, as well as saturated and unsaturated compounds. The time spent on this will depend on your overall strategy for studying organic chemistry. You may decide to introduce these ideas in the context of the other topics in this Section.

C11b Fuels

Introduction

This topic introduces organic chemistry as well as providing a very direct link to Topic C11c *Alkanes* and Topic C11d *Alkenes*. Fractional distillation features in Topic C12a *Experimental design and chromatography*. In Topic C2c *Simple molecules and covalent bonds* students explored the nature of bonding in hydrocarbon molecules and learned the physical properties associated with simple molecular compounds. The problems of the combustion and incomplete combustion of hydrocarbon fuels are covered in Topic C10a *Chemistry of the environment*.

The topic starts with a general introduction to the fossil fuels coal, natural gas and petroleum (crude oil) before looking in some detail at separating petroleum into its components by fractional distillation.

Cracking is covered in Topic C11d *Alkenes* to emphasise that cracking is needed to convert the larger molecules in petroleum fractions into more useful fractions. Finally, the continuing use of fossil fuels is considered.

There is some opportunity for developing practical skills in this topic.

Links to other topics

Sections	Essential background knowledge	Useful links
C2 Atoms, elements and compounds	C2c Simple molecules and covalent bonds	
C10 Chemistry of the environment		C10a Chemistry of the environment
C11 Organic chemistry	C11a General introduction to organic chemistry	C11c Alkanes C11d Alkenes
C12 Experimental techniques and chemical analysis		C12a Experimental design and chromatography

Topic overview

C11b.1	**Orientation** This learning episode provides an opportunity to revise or reinforce ideas on the main fossil fuels and their non-renewable nature. An opportunity is taken to revise the nature of covalent bonding and to draw some dot-and-cross diagrams of hydrocarbons. Reference is also made to fractional distillation as a process of separating liquids with different boiling points.
C11b.2	**The fractional distillation of petroleum** This learning episode focuses on the industrial use of the fractional distillation of petroleum (crude oil). The process is demonstrated and emphasis is placed on the nature and uses of the major fractions obtained from the fractional distillation. **Supplement** This focuses on the different properties of the fractions.

C11b.3	**Consolidation and summary** This learning episode considers the advantages and disadvantages of using fossil fuels before recapping the key ideas encountered in the topic. Time can be allocated to studying the End of topic checklist and then answering the End of topic questions in the Student Book.

Career links

These are some scientific careers that focus on this area of chemistry but careers in many other fields use the knowledge and skills gained studying science. **Policy advisors** for the government use their knowledge and understanding of chemistry to brief politicians on scientific research to inform changes that may be needed to their policies. **Petroleum geologists** find sources of crude oil by analysing structures underground using geological and geophysical methods.

Learning episode C11b.1 Orientation

Learning objectives

- Name the fossil fuels: coal, natural gas and petroleum.
- Name methane as the main constituent of natural gas.
- State that hydrocarbons are compounds that contain hydrogen and carbon only.
- State that petroleum is a mixture of hydrocarbons.
- State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds.
- State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds.

Resources

Student Book What are fossil fuels?

Approach

Students should be very familiar with the names of the common fossil fuels – coal, natural gas and petroleum (crude oil). They should also be familiar with the term ‘non-renewable’.

Check the level of this existing knowledge with a few questions. Ask students what they understand by the term ‘hydrocarbon’, which they should have met in the earlier Topic C10a *Chemistry of the environment*.

Ask students to draw a dot-and-cross diagram for the simplest hydrocarbon: methane, CH_4. Revise ideas on covalent bonding from Topic C2c *Simple molecules and covalent bonds* if and as required.

Supplement Ask students to draw a dot-and-cross diagram for ethene, C_2H_4.

Explain the terms saturated and unsaturated in the context of methane and ethene. Explain also that methane belongs to a family of organic compounds called alkanes, whereas ethene belongs to a family of organic compounds called alkenes (both of which will be studied later in the course). Ask what the characteristic properties of simple covalent substances are.

Explain that petroleum is a mixture of a large number of organic compounds, many of which are used as fuels. Ask what process can be used to separate a mixture of liquids – if necessary, remind students about fractional distillation. Explain that the next learning episode will look in more detail at the fractional distillation of petroleum.

Learning episode C11b.2 The fractional distillation of petroleum

Learning objectives

- Describe the separation of petroleum into useful fractions by fractional distillation.
- Name the uses of the fractions as:
  (a) refinery gas fraction for gas used in heating and cooking;
  (b) gasoline / petrol fraction for fuel used in cars;
  (c) naphtha fraction as a chemical feedstock;
  (d) diesel oil / gas fraction for fuel used in diesel engines;
  (e) bitumen fraction for making roads.
- **Supplement** Describe how the properties of fractions obtained from petroleum change from the bottom to the top of the fractionating column, limited to: decreasing chain length; lower boiling points.

Resources

Student Book Fractional distillation

Worksheet C11b.2 The fractional distillation of petroleum (crude oil)

Resources for a demonstration (see Technician's notes, following)

Approach

Ask students what process can be used to separate a mixture of liquids with different boiling points (fractional distillation). Explain that petroleum (crude oil) can be separated into components using fractional distillation, but rather than separating liquid by liquid (or compound by compound), it is separated into fractions with a range of boiling points. These fractions are therefore likely to contain more than one compound.

Demonstrate the fractional distillation of a petroleum or crude oil substitute (see Technician's notes). Explain that petroleum or crude oil is too dangerous to be allowed in schools and that the technician has made up a safer substitute, though it is still harmful.

Use Worksheet C11b.2 so that students can record the observations and measurements and analyse their findings.

Supplement Link the trend in boiling point to the decreasing chain length, as shown in Fig. C11.5 in the Student Book.

It is important that students know some of the key components of the fractions (refinery gases, gasoline/petrol, naphtha, diesel oil/gas oil and bitumen), where they are produced in the fractionating column and, for students following the supplementary course, the approximate number of carbon atoms they have in their molecules and the trend in boiling points.

SAFETY INFORMATION

Wear eye protection (splash-proof goggles).

Petroleum/crude oil substitute is highly flammable and harmful.

Ventilate room well to remove smoke, and only use small amounts.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

You will need the following resources for the demonstration of fractional distillation:

100 cm^3 petroleum/crude oil substitute made from: • 55 cm^3 liquid paraffin; 20 cm^3 paraffin oil (kerosene) • 11 cm^3 white spirit; 4 cm^3 petroleum ether (100–120 °C) • 4 cm^3 petroleum ether (80–100 °C); 6 cm^3 of petroleum ether (60–80 °C) • black artists' oil paint (to provide colour) about 6 cm^3 is needed for the demonstration
Bunsen burner and heatproof mat
mineral wool
Tongs
side-arm borosilicate glass boiling tube, delivery tube and rubber connection tubing
thermometer (0–360 °C), teat pipette, beaker, watch glass
small test-tubes to collect fractions and test-tube holder
eye protection (splash-proof goggles)
SAFETY INFORMATION *Crude oil must not be used in schools.*

Learning episode C11b.3 Consolidation and summary

Learning aims

- Review the learning points of the topic summarised in the End of topic checklist.
- Test understanding of the topic content by answering the End of topic questions.

Common misconceptions

Some students think that all fossil fuels will run out in the next few years. (Supplies of coal are relatively large.)

Resources

Student Book The fossil fuel dilemma; End of topic checklist and End of topic questions

Approach

Ask students to work with a partner to make a list of key words from this topic. They could then work together to produce a spider diagram showing how the different concepts are linked. They could compare their list with the list of key terms given in the Student Book. Discuss the checklist and ask questions to see how much of the content students are comfortable with.

Students could make flashcards of the key content and then use the flashcards to quiz each other on the information.

Use the Science in Context box, *The Fossil Fuel Dilemma*, in the Student Book to consider the advantages and disadvantages of using fossil fuels to generate energy. Are alternative forms of energy the answer? Should coal be used more extensively? The content of these Science in Context boxes is beyond the syllabus but provides the opportunity to explore the content more deeply.

Ask students to work individually through the End of topic questions in the Student Book without looking at the text. As they work, walk around the classroom observing their answers and questioning them as necessary to find out which questions are causing difficulties.

After a set period, ask students to stop working. Discuss any areas of difficulty you observed as you walked round the class.

Reinforce the point that students will do further work on alkanes and alkenes, and on the concept of saturated and unsaturated hydrocarbons, in topics that follow this one.

Students should complete any unanswered questions for homework, but you should stress that they should answer the questions without looking at the text, so that they can see how much they have remembered.

C11c Alkanes

Introduction

Students should already be familiar with covalent bonding from Topic C2c *Simple molecules and covalent bonds*. There are also links to methane as a greenhouse gas and the incomplete combustion of fuels in Topic C10a *Chemistry of the environment.* This topic builds on the introduction to organic chemistry provided in Topic C11a *General introduction to organic chemistry* and Topic C11b *Fuels*. It is also the basis for the subsequent study of Topic C11d *Alkenes*.

The topic reaffirms terms such as 'hydrocarbon' and 'saturated', followed by the use of the names of alkanes in naming all organic compounds. At supplementary level the nature of a homologous series can be revised. Students will have another opportunity, if needed, to revise dot-and-cross diagrams.

Links to other topics

Sections	Essential background knowledge	Useful links
C2 Atoms, elements and compounds	C2c Simple molecules and covalent bonds	
C10 Chemistry of the environment		C10a Chemistry of the environment
C11 Organic chemistry	C11a General introduction to organic chemistry C11b Fuels	C11d Alkenes

Topic overview

C11c.1	**Orientation** This learning episode starts with a revision of covalent bonding and, for students following the supplementary syllabus, introduces or revises the concept of a homologous series within the organic chemistry branch of chemistry. The names of the first four alkanes are introduced, together with information about their states of matter at room temperature and their uses as fuels. The terms 'hydrocarbon' and 'saturated' are revised. At supplementary level the general characteristics of a homologous series are introduced or revised.
C11c.2	**The chemical properties of alkanes** This learning episode starts with the combustion of alkanes, re-emphasising their general use as fuels. The concept of complete and incomplete combustion is revised (first encountered in Topic C10a *Chemistry of the environment*) and the potential dangers associated with incomplete combustion.
C11c.3	**Consolidation and summary** This learning episode provides an opportunity for a quick recap of the ideas encountered in the topic and time for the students to answer the End of topic questions in the Student Book.

Career links

These are some scientific careers that focus on this area of chemistry but careers in many other fields use the knowledge and skills gained studying science. **Gas engineers** service boilers and fires to make sure that combustion of the fuel is complete and does not produce the toxic gas carbon monoxide, or particulates which can be harmful to human health. **Car designers** work with scientists to design car engines which use the fuel in the most efficient ways.

Learning episode C11c.1 Orientation

Learning objectives

- State that the bonding in alkanes is single covalent and that alkanes are saturated hydrocarbons.
- **Supplement** State that a homologous series is a family of similar compounds with similar chemical properties.
- **Supplement** Describe the general characteristics of a homologous series as:
- having the same general formula (recall of the alkane general formula is **not** required); displaying a trend in physical properties; sharing similar chemical properties.

Resources

Student Book What are alkanes?

Worksheet C11c.1 Covalent bonding in alkanes

Resources for demonstration (see Technician's notes, below)

Approach

Explain that alkanes are a 'family' (or for supplementary syllabus, a homologous series) of organic chemicals.

Show samples of alkanes: methane (natural gas/Bunsen burner), propane (camping gas canister) and butane (lighter fuel). Mention that they are all fuels. Emphasise the meaning of the term 'hydrocarbon'. The samples are just shown to illustrate their everyday use – photos could be used instead.

Ask students what they can recall about the nature of covalent bonding. Use molecular models to illustrate the structure of alkanes and Worksheet C11c.1 to recap on dot-and-cross bonding diagrams.

SAFETY INFORMATION
Wear eye protection (splash-proof goggles).

Supplement Revisit (from Topic C11a) the idea that members of a homologous series have similar chemical properties – point out that all the alkanes are used as fuels as they can be combusted. Discuss how the samples show a trend in physical properties – this is another characteristic of a homologous series (refer to the data on boiling points in Table C11.1 in the Student Book). Show how to draw the displayed formulas of each alkane and write their structural formulas. You may also wish to show how the formulas of alkanes match the general formula C_nH_{2n+2}.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

The following resources are needed for the demonstration of alkanes:

a bottle or canister of camping gas (propane)
lighter fuel (butane)

Learning episode C11c.2 The chemical properties of alkanes

Learning objectives

- Describe the properties of alkanes as being generally unreactive, except in terms of combustion.

Resources

Student Book The properties of alkanes; Combustion of alkanes

Approach

Students will be familiar with the combustion of alkane fuels. Explain that hydrocarbons burn in a plentiful supply of air or oxygen to form carbon dioxide and water (as shown by the blue flame on a Bunsen burner).

Ask what happens if the air supply is restricted. (This is demonstrated by the yellow flame on the Bunsen burner.) Emphasise that incomplete combustion can produce carbon and carbon monoxide, and that carbon monoxide is toxic.

Supplement Let students practice constructing equations for the complete and incomplete combustion of simple hydrocarbons. Refer to the equations given in the Student Book.

Learning episode C11c.3 Consolidation and summary

Learning aims

- Review the learning points of the topic summarised in the End of topic checklist.
- Test understanding of the topic content by answering the End of topic questions.

Resources

Student Book Some interesting facts about methane; End of topic checklist and End of topic questions

Approach

Ask students to work with a partner to make a list of key words from this topic. They could then work together to produce a spider diagram showing how the different concepts are linked. They could compare their list with the list of key terms given in the Student Book. Discuss the checklist and ask questions to see how much of the content students are comfortable with.

Students could make flashcards of the key content and then use the flashcards to quiz each other on the information.

Refer to the Science in Context box on methane in the Student Book (if not used in Topic

C10a *Chemistry of the environment*), to highlight that methane is a greenhouse gas (supplementary level) and that it contributes to global warming. The content of these Science in Context boxes is beyond the syllabus but provides the opportunity to explore the content more deeply.

Ask students to work individually through the End of topic questions in the Student Book without looking at the text. As they work, walk around the classroom observing their answers and questioning them as necessary to find out which questions are causing difficulties.

After a set period, ask students to stop working. Discuss any areas of difficulty you observed as you walked round the class.

Students should complete any unanswered questions for homework, but you should stress that they should answer the questions without looking at the text, so that they can see how much they have remembered.

C11d Alkenes

Introduction

This is a short topic that extends understanding of covalent bonding from Topic C2c *Simple molecules and covalent bonds*, Topic C11a *General introduction to organic chemistry* and the introductory work on alkanes in Topic C11c *Alkanes*. It also provides the basis for a more detailed consideration of addition polymerisation in Topic C11f *Polymers*.

The topic focuses on the structures of the alkenes, the nature of alkenes as unsaturated hydrocarbons and the test that can be used to distinguish between saturated and unsaturated hydrocarbons.

Supplement The supplementary syllabus includes the use of catalytic cracking to produce alkenes from larger alkane molecules in petroleum fractions and addition reactions with bromine, hydrogen and steam.

Links to other topics

Section	Essential background knowledge	Useful links
C2 Atoms, elements and compounds	C2c Simple molecules and covalent bonds	
C11 Organic chemistry	C11a General introduction to organic chemistry C11b Fuels C11c Alkanes	C11e Polymers

Topic overview

C11d.1	**Orientation** This learning episode picks up on many of the ideas covered in Topic C11a *General introduction to organic chemistry* and Topic C11b *Fuels*, including the distinction between a saturated and unsaturated hydrocarbon and the covalent bonding associated with a C=C double bond. **Supplement** The characteristics of a homologous series are revised and the structural and displayed formulas of alkenes are introduced.
C11d.2	**Cracking crude oil fractions** **Supplement** The reason for the importance of the catalytic cracking of the larger molecules in crude oil fractions is emphasised (converting the less useful longer-chain alkanes into more useful shorter-chain alkenes and hydrogen).
C11d.3	**The chemical properties of alkenes** This learning episode focuses on alkenes as examples of hydrocarbons and the reaction with bromine water. The decolourisation of bromine water is introduced as a way of identifying an alkene as an unsaturated hydrocarbon. **Supplement** Addition reactions with bromine, hydrogen and steam are introduced.

C11d.4	**Consolidation and summary** This learning episode recaps on the ideas encountered in the topic, as well as considering a Science in Context box, *Saturated and Unsaturated Fats* in the Student Book. Time can be allocated to answering the End of topic questions in the Student Book.

Career links

These are some scientific careers that focus on this area of chemistry but careers in many other fields use the knowledge and skills gained studying science. **Petrochemical engineers** develop ways that crude oil can be broken down into smaller fractions which are used to make plastics and fuels.

Learning episode C11d.1 Orientation

Learning objectives

- State that the bonding in alkenes includes a double carbon–carbon covalent bond and that alkenes are unsaturated hydrocarbons.
- **Supplement** State that a homologous series is a family of similar compounds with similar chemical properties.
- **Supplement** Describe the general characteristics of a homologous series as:
  (a) having the same general formula (recall of the alkene general formula is **not** required)
  (b) displaying a trend in physical properties

Resources

Student Book What are alkenes?

Approach

Ask students to name the first two members of the alkane family (for supplementary syllabus, a homologous series) and to draw the displayed formulas for these.

Illustrate that in contrast to the alkanes, the alkenes contain a C=C double bond, that is, the alkenes are unsaturated hydrocarbons. Ask students to draw the displayed formula for ethene (and then for supplementary, propene and butene).

Supplement Ask students if they can remember the characteristics of a homologous series (general formula, gradual trend in physical properties and common chemical properties). You may also wish to show how the formulas of alkenes match the general formula C_nH_{2n}.

Supplement Use Table C11. in the Student Book to look at the trend in boiling points, and the subsequent states of matter at room temperature and pressure, of the alkene series.

Learning episode C11d.2 Cracking crude oil fractions

Learning objectives

- Supplement Describe the manufacture of alkenes and hydrogen by the cracking of larger alkane molecules using a high temperature and a catalyst.
- Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine.

Resources

Student Book What are alkenes?; Cracking

Worksheet C11d.2 Cracking liquid paraffin

Resources for a class practical (see Technician's notes, below)

Approach

Supplement Refer to Table C11.4 in the Student Book, which shows the typical percentages of the different fractions produced by the fractional distillation of crude oil. Explain that the fractions most easily used are the fractions, such as gasoline (13%) containing short-chain hydrocarbon molecules, and so the fractions containing longer chain hydrocarbons must be converted into smaller hydrocarbon molecules, which are more useful. Emphasise that one of the products of cracking is always an alkene. Explain that bromine water is used to identify unsaturated hydrocarbons such as alkenes.

Tell students that alkenes are much more reactive than alkanes, so they can be converted (by addition reactions) into a much wider range of useful chemicals, as will be described in Topic C11e *Polymers*.

Worksheet C11d.2 provides details of a class practical involving the cracking of liquid paraffin. **Warn students to be careful that a 'suck back' does not take place**. This process also features in the Developing Practical Skills box in the Student Book.

You will need to decide whether to refer to both and, if so, in what order you will introduce them.

The test with a lighted spill should confirm the presence of hydrogen in the gas present. Explain that hydrogen may be formed during some cracking reactions, depending on the starting molecule and the conditions.

SAFETY INFORMATION
Wear eye protection (splash-proof goggles).
Aqueous bromine (bromine water) is harmful.
Ensure that the laboratory is well ventilated.

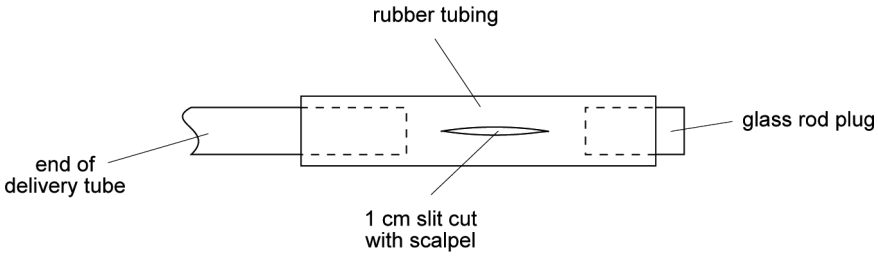
Technician's notes

Be sure to check the latest safety notes on these resources before proceeding. The following resources are needed for the class practical C11.4b, per group:

medicinal paraffin (sometimes called liquid paraffin)
aqueous bromine (bromine water (0.02 M)) – diluted until the colour is barely visible – 5 cm^3
pot fragments
Bunsen burner and heatproof mat
stand and clamp, boiling tube, bung and delivery tube with Bunsen valve (see below for details on how to make a Bunsen valve)
mineral wool and tongs
water basin, test-tubes, 2 dropping pipettes
eye protection (splash-proof goggles)

It is recommended that a Bunsen valve is fitted to the end of the delivery tube to reduce the risk of suck- back. Bunsen valves can be made easily as follows.

You will need a piece of clean, unused soft rubber tubing, about 3 cm long and a piece of glass rod, 1–2 cm long. Attach the rubber tubing to the end of the delivery tube and then attach the glass rod to the other end of the tubing, as shown in the diagram. Make a slit along one side of the rubber tubing, about 1 cm in length.



Learning episode C11d.3 The chemical properties of alkenes

Learning objectives

- Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine.
- **Supplement** Describe the properties of alkenes in terms of addition reactions with:
- bromine or aqueous bromine; hydrogen in the presence of a nickel catalyst; steam in the presence of an acid catalyst.

Resources

Student Book Addition reactions of alkenes

Resources for demonstration (see Technician's notes following)

Approach

Demonstrate the reaction of an alkene (hexene or cyclohexene) with aqueous bromine (CARE). Students are not allowed to use cyclohexene in the classroom, so this must be a teacher demonstration (see Technician's notes). The bromine water is decolourised.

Explain that this reaction is used to identify alkenes (or more accurately any unsaturated hydrocarbon, including alkynes, which contain a C≡C triple bond).

Supplement Use Fig. C11.14 in the Student Book to illustrate the displayed formula of the product of the reaction and the reason for describing the reaction as 'addition'.

Supplement Describe the addition reactions of ethene with bromine, hydrogen and steam. In each case, ask students to write the displayed formula of the product formed.

SAFETY INFORMATION
Wear eye protection (splash-proof goggles).
Aqueous bromine is harmful.
Hexene and cyclohexene are highly flammable.
Ensure that the laboratory is well ventilated.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

The following resources are needed for the demonstration of an alkene reacting with bromine:

an alkene (such as hexene or cyclohexene)
0.005 mol / dm^3 concentration of aqueous bromine
test-tube, droppers, test-tube holder
eye protection (splash-proof goggles)

Learning episode C11d.4 Consolidation and summary

Learning aims

- Review the learning points of the topic summarised in the End of topic checklist.
- Test understanding of the topic content by answering the End of topic questions.

Resources

Student Book Saturated and unsaturated fats; End of topic checklist; End of topic questions

Approach

Ask students to work with a partner to make a list of key words from this topic. They could then work together to produce a spider diagram showing how the different concepts are linked. They could compare their list with the list of key terms given in the Student Book. Discuss the checklist and ask questions to see how much of the content students are comfortable with.

Students could make flashcards of the key content and then use the flashcards to quiz each other on the information.

Use the Science in Context box on saturated and unsaturated fats in the Student Book to emphasise the importance of recognising this distinction in a healthy diet. The content of these Science in Context boxes is beyond the syllabus but provides the opportunity to explore the content more deeply.

Ask students to work individually through the End of topic questions in the Student Book without looking at the text. As they work, walk around the classroom observing their answers and questioning them as necessary to find out which questions are causing difficulties.

After a set period, ask students to stop working. Discuss any areas of difficulty you observed as you walked round the class.

Students should complete any unanswered questions for homework, but you should stress that they should answer the questions without looking at the text, so that they can see how much they have remembered.

C11e Polymers

Introduction

As with all the organic chemistry topics, this topic builds on knowledge of covalent bonding covered in Topic C2c *Simple molecules and covalent bonds*. In addition, there are links to Topic C11d *Alkenes* in relation to addition polymerisation.

The topic starts with a recap on the family (for supplementary, homologous series) of alkenes. After this revision, the topic focuses on addition polymerisation. There are opportunities to consider some of the environmental aspects of the use of synthetic polymers, particularly recycling and disposal.

There are few opportunities for students to develop their investigative skills.

Links to other topics

Section	Essential background knowledge	Useful links
C2 Atoms, elements and compounds	C2c Simple molecules and covalent bonds	
C11 Organic chemistry	C11a General introduction to organic chemistry C11c Alkenes	

Topic overview

C11e.1	**Orientation** This learning episode provides an opportunity to revise the organic chemistry of alkenes, focusing on the chemical name ending in –ene and their displayed formulas. The terms 'monomer', 'polymer' and 'polymerisation' are introduced.
C11e.2	**Synthetic polymers** This learning episode is in two parts. **Part 1 Addition polymerisation** This part focuses on how many monomers can combine to form addition polymer molecules, using the example of the formation of poly(ethene) from ethene monomers. Examples are given of common addition polymers and their uses.
	Part 2 The problems of plastics This is beyond the scope of the syllabus but using the Science in Context box in the Student Book provides a focus for discussion of the problems posed by the non-biodegradability of many synthetic polymers.
C11e.3	**Consolidation and summary** This learning episode is an opportunity to recap on the key ideas of the topic. Time can be allocated to studying the End of topic checklist and then answering the End of topic questions in the Student Book.

Career links

These are some scientific careers that focus on this area of chemistry but careers in many other fields use the knowledge and skills gained studying science. **Plastics engineers** research ways in which plastics can be made to be more biodegradable as well as the best ways to recycle them.

Learning episode C11e.1 Orientation

Learning objective

- Define polymers as large molecules built up from many smaller molecules called monomers.

Resources

Student Book Addition polymers

Approach

Ask students to draw the displayed formula for ethene. Check that they can remember the name of this compound.

Introduce the terms ‘monomer’, ‘polymer’ and ‘polymerisation’. Explain that the topic will consider some synthetic polymers, together with polymers that are often referred to as plastics. Ask students, in groups, to make a list of as many things as they know about polymers – allow only a few minutes to do this. Review the lists. Disposal of plastics and recycling will be common emerging themes.

Explain that the topic focuses on one way of making synthetic polymers. This method involves alkenes and makes use of their reactivity and ability to undergo addition reactions.

Learning episode C11e.2 Synthetic polymers

Learning objectives

- State that the formation of poly(ethene) is an example of addition polymerisation using ethene (an alkene) monomers.

Resources

Student Book Addition polymers

Approach

Part 1 Addition polymerisation

Introduce the definition of an addition polymer. Use displayed formulas to illustrate how ethene molecules can undergo addition reactions to form a polymer chain called poly(ethene). Students do not need to recall details of this diagram.

Describe some of the addition polymers in common use and their uses, such as poly(propene) – carpets; poly(chloroethene) or PVC – plastic sheets; and poly(phenylethene) or polystyrene – yoghurt cartons, packaging.

Part 2 The problems of plastics

Rehearse some of the familiar problems of using plastics, both in terms of their disposal and recycling. Emphasise and explain the non-biodegradability of many addition polymers.

Refer to the ‘three Rs’ (Reduce, Reuse, Recycle) and ask the students how these three Rs are being used, or could be used more effectively, to prevent waste.

Use the Science in Context box *The Challenges of Recycling Plastics* in the Student Book to explain that recycling is complicated, not just because different plastic materials need to be separated. The content of these Science in Context boxes is beyond the syllabus but provides the opportunity to explore the content more deeply.

Learning episode C11e.3 Consolidation and summary

Learning aims

- Review the learning points of the topic summarised in the End of topic checklist.
- Test understanding of the topic content by answering the End of topic questions.

Resources

Student Book End of topic checklist and End of topic questions

Approach

Ask students to work with a partner to make a list of key words from this topic. They could then work together to produce a spider diagram showing how the different concepts are linked. They could compare their list with the list of key terms given in the Student Book. Discuss the checklist and ask questions to see how much of the content students are comfortable with.

Students could make flashcards of the key content and then use the flashcards to quiz each other on the information.

Take the opportunity to revise aspects of the chemistry of alkenes, particularly if students had limited recall of these at the start of this topic.

Ask students to work individually through the End of topic questions in the Student Book without looking at the text. As they work, walk around the classroom observing their answers and questioning them as necessary to find out which questions are causing difficulties.

After a set period, ask students to stop working. Discuss any areas of difficulty you observed as you walked round the class.

Students should complete any unanswered questions for homework, but you should stress that they should answer the questions without looking at the text, so that they can see how much they have remembered.

