Unit 28: Industrial Applications of Organic Chemistry

Unit code: H/502/5573

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to familiarise learners with the structure, naming and properties of a range of organic compounds and to investigate the industrial uses of these compounds.

Unit introduction

The majority of the substances we use every day are, or contain, organic compounds. Pharmaceuticals such as aspirin and paracetamol, synthetic fibres for our clothes such as nylon and polyesters, fuels for our transport vehicles, soaps and detergents, dyes, flavourings, perfumes and liquid crystal display materials are just a few of the many organic substances that are manufactured on an industrial scale for us all to use.

In this unit, learners will develop knowledge of the key classes of organic compounds that are industrially important and their chemistry which makes them useful to us.

The number of known organic compounds is enormous and growing. This is because carbon, the basis of organic compounds, can form molecules consisting of chains and rings of atoms that enable it to bond with itself and other elements. The classes of organic compounds, their naming and their ability to form different arrangements of the same atoms (isomerism) are recurring themes. Learners should find answers to the following questions:

- What types of organic compounds are there?
- What functional groups are there?
- How are they named?
- What are their properties?
- What are the mechanisms for their reactions?
- How can one class of organic compound be prepared from another?
- What are the industrial uses of organic compounds?
- Why is isomerism important?

Is it easy and safe to carry out reactions of organic compounds in the laboratory?

The simplest of all organic compounds are the hydrocarbons. Learners will study these and their industrially useful reactions. Learners will then look at a range of functional group compounds and collect information about them. This study will include their properties, reactions and how they can be converted into one another. This latter aspect allows the synthesis of organic compounds with particular structures, fitting them for specific commercial uses.

This unit enables learners to consider what it is like to work in the science industry. It is suitable for all learners who are interested in a career in science.

Learning outcomes

On completion of this unit a learner should:

1 Know the properties of hydrocarbons

2 Know the properties of simple functional group compounds

3 Understand the importance of isomerism

4 Be able to carry out reactions involving organic compounds.

Unit content

1 Know the properties of hydrocarbons

Hydrocarbons: straight chain and branched alkanes and alkenes, benzene

Structures: structure representations, full (displayed) structural formulae showing all the bonds, shortened structural formulae, 3D representations using wedge/dashed line diagrams, skeletal formulae, sigma and pi-bonding in alkanes and alkenes, delocalised pi-bonding in benzene; bond lengths and strengths in alkanes, alkenes, benzene

Nomenclature: IUPAC nomenclature, naming structural isomers, E-Z

Physical properties: eg increase in boiling point with chain length, separation by fractional distillation, hydrophobicity

Chemical reactions: free radical substitution in alkanes, electrophilic addition of water, halogens, hydrogen halides and sulfuric acid in alkenes, stability of carbocations, symmetric and asymmetric alkenes, electrophilic addition in benzene, nitration of benzene, mechanisms, reactions of commercial importance, eg free radical polymerisation of alkenes, hydration of ethene

2 Know the properties of simple functional group compounds

Simple functional group compounds, non-carbonyl: halogenoalkanes, alcohols, amines

Simple carbonyl compounds: aldehydes, ketones, carboxylic acids, esters, acyl chlorides, amides

Properties of non-carbonyl compounds: nomenclature; halogenoalkanes – nucleophilic substitution of halogenoalkanes (OH^-, NH_3, primary amines), SN1 and SN2 mechanisms of nucleophilic substitution, elimination reactions; alcohols – primary, secondary and tertiary alcohols, solubility of alcohols, reactions of alcohols, eg with sodium, oxidation with hot copper (II) oxide, oxidation with acidified dichromate (VI), oxidation of primary, secondary and tertiary alcohols; primary, secondary and tertiary amines, amines as bases, amines as nucleophiles, reaction of amines with halogenoalkanes; synthesis of commercially important organic compounds, eg PVC, CFCs and HCFCs

Properties of carbonyl compounds: nomenclature; aldehydes and ketones – oxidation of aldehydes with Tollens' reagent, Benedict's or Fehling's reagents, acidified dichromate (VI), reduction of aldehydes and ketones ($NaBH_4$, $LiAlH_4$), nucleophilic addition of HCN to aldehydes and ketones, addition-elimination reactions of aldehydes and ketones, eg reaction with 2,4-dinitrophenylhydrazine, hydrazine, oxime; carboxylic acids – carboxylic acids as acids, weak acidity of carboxylic acids, reaction with alcohols to form esters; esters as solvents, flavours and fragrances; acyl chlorides – reaction of acyl chlorides, eg with water, alcohols, phenol, ammonia and amines; mechanisms; preparation of amides, eg from carboxylic acids, acyl chlorides and acid anhydrides; hydrolysis of amides; synthesis of commercially important polyamides, eg nylon and Kevlar; other commercially important organic compounds, eg polyester

3 Understand the importance of isomerism

Isomerism: structural, chain, positional, functional group; stereoisomerism, geometric, optical

Importance: three-dimensional structures and representations, recognition of isomers, different properties of isomers, eg different boiling points of chain and positional isomers, different reactions of functional group isomers, lower melting points of Z (cis) isomers, cis and trans (E and Z) fats, natural occurrence of particular optical isomers, optical isomers of sugars, optical isomers of amino acids, different therapeutic effects of optical isomers of drugs, difference between starch and cellulose

4 Be able to carry out reactions involving organic compounds

Organic compounds: common organic compounds, eg alkanes, alkenes, halogenoalkanes, alcohols, amines, aldehydes, ketones, carboxylic acids, esters, amides

Reactions: reactions mentioned, eg derivatisation of aldehydes and ketones, dehydration of heptanol, esterification, making nylon, making aspirin; safety requirements

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 name hydrocarbons correctly in relation to their structure [RL2,6]	**M1** construct a range of representations of hydrocarbons, illustrating the bonding and spatial arrangement of hydrocarbon molecules	**D1** analyse the types of reactions undergone by different classes of hydrocarbons, in terms of the bonding in the hydrocarbons
P2 describe the physical and chemical properties of industrially important hydrocarbons [RL2,6]	**M2** provide mechanisms for reactions of hydrocarbons	**D2** explain the products of addition of hydrogen halides to asymmetric alkenes
P3 describe the reactions of a range of non-carbonyl functional group compounds [RL2,6]	**M3** plan multi-step syntheses of organic molecules	**D3** collate and present data on reactions of functional group compounds which allow a comprehensive range of syntheses to be planned
P4 predict the products of a range of commercially important reactions, involving carbonyl compounds [RL2,6]		
P5 examine the commercial importance of different types of isomers [CT2,3]	**M4** discuss the chemical/ therapeutic importance of isomerism	**D4** explain the importance of the conditions chosen for the reactions carried out practically.
P6 carry out reactions involving organic compounds safely [EP].	**M5** describe the reactions carried out practically in terms of the functional groups involved.	

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Throughout the delivery of this unit, learners should undertake practical work and keep records of work done. Performing the practical work safely and reporting its outcomes and the factors which influence these outcomes is assessed. This may also form part of the assessment of Unit 4: *Scientific Practical Techniques* or Unit 22: *Chemical Laboratory Techniques*.

Learners need to make models, draw full and shortened structural formulae and use chemical drawing packages, if available, to become familiar with the structures and names of a range of hydrocarbons: alkanes; alkenes; benzene. Card-matching activities are particularly useful. If possible, learners should see a range of petroleum fractions in order to form opinions about their viscosity and volatility. A visit to a working refinery would be useful. Learners need to become familiar with the IUPAC names for organic molecules – matching structures to names and naming structures. To understand the versatility of the IUPAC system, simple branched hydrocarbons should be introduced as well as alkenes with the double bond between different carbons in the chain. E and Z isomers of a simple alkene, like but-2-ene, should be introduced.

Hybridisation of the s and p orbitals of carbon should be explained in order for learners to understand the three-dimensional shapes of the molecules. There are some useful computer simulations of hybridisation. Learners need to be familiar with the nature of sigma and pi bonds and the delocalisation in the benzene ring. Evidence for the accepted structure of benzene should be explored. Learners need to be familiar with the C-C bond length in alkanes, in the double bonds of alkenes and in benzene. Learners need to understand the shapes of molecules in three dimensions as well as the representations on the page.

Learners should draw graphs of boiling point against carbon number for unbranched alkanes and compare boiling points of alkanes and alkenes of similar chain length. The lack of solubility of hydrocarbons in water should be emphasised. Viscosity may be introduced. The economic importance of combustion of alkanes should be stressed.

Tutors should introduce the mechanisms of free radical substitution of alkanes, electrophilic addition for alkenes and electrophilic substitution of benzene. More able learners should be able to draw mechanisms and all learners should be able to predict the products of reactions. Simple test-tube reactions may be carried out for alkenes, eg decolourisation of bromine water and reaction with concentrated sulfuric acid. The most able learners will become comfortable with the terms used to describe the reaction types and be able to relate these to the bonding in the molecules. More able learners should draw mechanisms for asymmetric elecrophilic addition of hydrogen halides to alkanes.

Throughout the delivery of the unit, learners should be encouraged to keep lists of reactions that they have been introduced to and to put these on a synthesis map, where appropriate.

The functional groups listed in the *Unit content* should be introduced in a logical order with their nomenclature, reactions and interesting physical properties, eg solubility in the case of alcohols. Economically important reactions should be highlighted. All new reactions should be listed and added to the ongoing synthesis map.

Learners should be encouraged to recognise and to name isomers. Once learners recognise isomers, they should be encouraged to suggest examples of different types of isomers. The different properties of the isomers should be introduced – differences in melting and boiling point; rotation of plane polarised light in the case of optical isomers. Learners could research or draw conclusions from presented data about the commercial importance of different types of isomers, eg branched and unbranched alkanes in lubricating oil; trans (E-) fats. Specifically, learners should research the different functions and reactivity of optical isomers as there are a number of well-documented examples.

Learners should present the results of practical work undertaken, giving mechanisms for and explanations of the reactions where possible. Often, learners follow given methods without understanding why certain chemicals are added or temperatures are used. More able learners should be able to explain the conditions for the reactions studied. Safety requirements should be included in the reactions as appropriate to the centre.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to unit and programme of assignments
Alkanes – naming straight and branched chain alkanes. Plot graphs of boiling point against chain length. Free radical substitution of alkanes.
Alkenes – bonding in alkenes, compared with alkanes. Naming alkenes. Electrophilic addition – examples; mechanism. Matching names to structures shown on cards.
Assignment on relating names to structure. **Assignment 1: Structure and Names of Hydrocarbons (P1, M1)**
Benzene – structure and bonding – compare data on bond strength and bond length in alkanes, alkenes and benzene. Mechanism of nitration of benzene.
Research and present information on properties of hydrocarbons for assignment. **Assignment 2: Physical and Chemical Properties of Hydrocarbons (P2, M2, D1, D2)**
Halogenoalkanes – naming. Nucleophilic substitution SN1 and SN2. Elimination versus substitution.
Alcohols – primary, secondary, tertiary – card game matching names to structure. Reactions – with sodium, oxidation; carry out oxidation with primary, secondary and tertiary alcohols.
Amines – basic character – measure pH of solution. Reaction with halogenoalkanes.
Assignment on reactions of halogenoalkanes, alcohols and amines. **Assignment 3: Reactions of Non-carbonyl Functional Group Compounds (P3)**
Aldehydes and ketones – similarity of reactions – preparation of at least one derivative, eg 2,4 DNP or oxime. Aldehydes and ketones – differences – oxidation of aldehydes with Tollens', Fehling's and acidified dichromate – theory and practice. Reduction of aldehydes and ketones to primary and secondary alcohols.
Carboxylic acids – ethanoic acid as a weak acid – conductivity and pH – typical acid reactions. Esterification reactions – preparation of a range of esters.

Topic and suggested assignments/activities and/assessment
Naming esters. Commercial uses of esters.
Amides – preparation, hydrolysis. Making nylon.
Work for Assignment 4, predicting products of reactions.
Constructing multi-step syntheses; use of a synthesis map. **Assignment 4: Reactions of Carbonyl Compounds and Multi-step Syntheses (P4, M3, D3)**
Structural isomerism – chain, positional and functional group – recognising. Isomers – drawing isomers – researching different properties of selected isomers – using models – using molecular modelling software. Cis and trans isomers – different MPts of cis and trans isomers. Cis and trans fats. Optical isomers – simple models – sugars – amino acids – drugs. Research the effects of different optical isomers.
Assignment 5: Isomerism (P5, M4)
Writing about practical work. **Assignment 6: Organic Reactions (P6, M5, D4)**
Review of unit and programme of assignments.

Assessment

For P1, learners should be presented with full (displayed) structural formulae of alkanes, alkenes and a substituted benzene and should name the compounds correctly.

For M1, learners should be given names of at least three alkenes, three alkanes and benzene or a substituted benzene. They should provide full structural formulae, shortened structural formulae, skeletal formulae and either a three-dimensional image or a wedge/dashed line diagram for each molecule. The nature of the carbon-carbon bonds should be clear.

For P2, learners should describe how boiling point changes with carbon number for a range of straight chain alkanes. They should compare the boiling point of an alkane with an alkene of a similar size. The typical reactions of alkanes, alkenes and benzene should be described. This allows less able learners to collate data from class notes, books and the internet.

To achieve M2, learners should provide mechanisms for free radical substitution, eg of methane by chlorine, electrophilic addition of a suitable molecule, eg bromine to ethane, and nitration of benzene. These should not be cut and pasted from the internet; they should be either hand drawn or produced with a chemical drawing package.

To achieve D1, learners should describe the bonding present in alkanes, alkenes and benzene and analyse the types of reaction undergone in relation to the bonding present, using suitable examples.

For D2, learners should explain the products of an electrophilic addition reaction of hydrogen halides, eg HCl and HBr, to at least two asymmetric alkenes.

Learners should present evidence of collation of typical reactions of the non-carbonyl functional groups, listed in the Unit content to achieve P3.

For P4, learners should be presented with starting materials and conditions and predict the product correctly for the reactions involving each of the carbonyl compounds, listed in the *Unit content*.

To achieve M3, learners should be presented with at least two starting molecules and corresponding target molecules and plan synthesis routes involving two or more steps for each. In order to plan syntheses efficiently, a well-organised list of reactions is essential. Alternatively, a detailed synthesis map could be used.

To achieve D3, learners should provide either a well-organised list or detailed synthesis map. The synthesis map may include non-carbonyl compounds.

For P5, learners must examine the different types of isomerism and their commercial importance. Learners should give examples of chain, positional, functional group, geometric and optical isomers. They should explain why it is commercially important to understand about isomerism. This could be done conveniently by looking at the consequences of not being aware of isomerism.

To achieve M4, learners should select a well-documented example of optical isomers which have different chemical/therapeutic properties.

Throughout the unit, learners will have been carrying out reactions. To achieve P6, they should provide the results/notes from these reactions, a witness testimony of working safely and a safety assessment of at least one of the practical exercises undertaken – a portfolio of practical work.

To achieve M5, learners should describe at least three of the reactions carried out in detail, identifying the functional groups and the typical reactions groups that are involved.

For D4, learners should identify the reagents used and the temperature and time chosen in the given methods and explain why these have been chosen in at least three reactions.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Structure and Names of Hydrocarbons	You have been asked by the local oil refinery to write notes which will help the plant operators understand the nature of the molecules in the oil fractions.	Write notes explaining different types of formulae for hydrocarbons, including representations in three dimensions.
P2, M2, D1, D2	Physical and Chemical Properties of Hydrocarbons	The refinery and adjoining petrochemical plant would like you to present information on the physical and chemical properties of hydrocarbons to the operators.	Prepare a presentation which shows the physical properties and typical reactions of alkanes, alkenes and benzene, including considering the mechanisms.
P3	Reactions of Non-carbonyl Functional Group Compounds	The petrochemical plant wants you to prepare a leaflet detailing the typical reactions of non-carbonyl functional group compounds.	List as many reactions of non-carbonyl functional group compounds as you can, showing starting materials, reagents and conditions and products. Present these neatly, in the form of a leaflet.

Criteria covered	Assignment title	Scenario	Assessment method
P4, M3, D3	Reactions of Carbonyl Compounds and Multi-step Syntheses	The operators at the chemical plant have been studying organic chemistry excitedly. They have set you some tasks to check that you know as much as they do!	Predict the products or reactions and plan at least two, two-step syntheses. Present a detailed portfolio of reactions or a synthesis map.
P5, M4	Isomerism	A sensational article about trans fats has appeared in the local paper. The author of the article has made mistakes which have been picked up by a reader. The editor has asked you to write notes for him, explaining about different types of isomerism and its commercial importance.	Using suitable examples, explain the different types of isomerism. Write about the commercial importance of isomerism and the therapeutic properties of different optical isomers of a drug.
P6, M5, D4	Organic Reactions	To help the new technician in your centre, you have been asked to provide a portfolio of the reactions that you have carried out in the course of this unit.	Collect a portfolio relating to reactions you have carried out, including observations of safe working and risk assessment. Explain how altering the conditions affects the products of reactions for three reactions.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC in Applied Science sector suite. This unit has particular links with the units shown below in the BTEC Applied Science suite of qualifications:

Level 3
Scientific Practical Techniques
Chemistry for Biology Technicians
Chemical Laboratory Techniques

Essential resources

Learners should have access to an appropriate laboratory, books, computers and the internet.

Employer engagement and vocational contexts

Where possible, learners should visit a refinery, petrochemical plant or other plant which produces organic chemicals or pharmaceuticals. It would also be useful to visit a laboratory which tests physical or chemical properties of hydrocarbons. Visiting speakers from those organisations would be helpful.

Indicative reading for learners

Textbooks

Beavon R and Jarvis A – *Periodicity, Quantitative Equilibria and Functional Group Chemistry* (Nelson Thornes, 2001) ISBN 978017448291 8

Chapman B and Jarvis A – *Organic Chemistry, Energetics, Kinetics and Equilibrium* (Nelson Thornes, 2003) ISBN 9780748776566

Facer G – *Make the Grade in AS and A2 Chemistry* (Nelson Thornes, 2003) ISBN 9780748772810

Facer G – *Edexcel AS Chemistry, 2nd Edition* (Hodder Education, 2008) ISBN 9780340957608

Facer G – *Edexcel A2 Chemistry, 2nd Edition* (Hodder Education, 2009) ISBN 9780340957615

Fullick A and Fullick P – *Chemistry: Evaluation Pack* (Heinemann Advanced Science) (Heinemann Educational Secondary Division, 2000) ISBN 9781405877589

Hill G and Holman J – *Chemistry in Context, 5th Edition* (Nelson Thornes, 2000) ISBN 9780174482765

Hill G and Holman J – *Chemistry in Context: Laboratory Manual and Student Guide, 5th Edition* (Nelson Thornes, 2000) ISBN 9780174483076

Hill B and Hunt A – *Edexcel Chemistry for AS* (Hodder Murray, 2008) ISBN 9780340949085

Lewis E and Berry M – *AS and A Level Chemistry* (Longman, 2000) ISBN 9780582337336

Lewis R and Evans W – *Chemistry, 3rd Edition* (Palgrave Macmillan, 2006) ISBN 978023000011 7

Lister T – *Industrial Chemistry Case Studies* (Royal Society of Chemistry, 1999) ISBN 9780854049257

Pearson Education – *Chemical Storylines: Chemical Storylines AS, 3rd Edition* (Heinemann, 2008) ISBN 9780435631475

Journals

Chemistry Review

Chemical Science (RSC)

Chemistry World (RSC)

Journal of Chemical Education

Websites

www.chemguide.co.uk	Guide to chemistry
www.chem.ucalgary.ca/courses/351/Carey5th/Carey.html	Organic Chemistry Online Learning Centre
www.rsc.org/ChemistryWorld/	Chemistry news online
www.s-cool.co.uk/alevel/chemistry.html	Chemistry revision

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Creative thinkers	[CT2,3] examining the commercial importance of different types of isomerism
Reflective learners	[RL2,6] naming hydrocarbons correctly in relation to their structure describing the physical and chemical properties of industrially important hydrocarbons describing the reactions of a range of non-carbonyl functional group compounds predicting the products of a range of commercially important reactions, involving carbonyl compounds
Effective participators	[EP3] carrying out reactions involving organic compounds safely

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	[IE1] explaining the commercial importance of optical isomerism
Creative thinkers	[CT1,3] collating and presenting data on reactions of functional group compounds which allow a comprehensive range of syntheses to be planned
Reflective learners	[RL5,6] explaining the products of addition of hydrogen halides to asymmetric alkenes describing the reactions carried out practically in terms of the functional groups involved explaining the importance of the conditions chosen for the reactions carried out practically
Self-managers	[SM3] collating and presenting data on reactions of functional group compounds which allow a comprehensive range of syntheses to be planned

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	searching for information entering data writing documents in relation to the requirements of assignment briefs
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	reflecting on the way that an assignment has been tackled
Manage information storage to enable efficient retrieval	saving information in suitable files in suitable folders
Follow and understand the need for safety and security practices	keeping food and drink away from computers not using someone else's login explaining how safety is addressed in the context of the tasks explaining why the it usage policy forbids certain actions
Troubleshoot	carrying out checks to identify the source of a problem encountered, eg missing file of work
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using books, internet searches, class notes and the results of experiments to meet the requirements of an assignment task
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching articles on optical isomerism and making judgements about their suitability in relation to grading criterion M4
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	collating results of practical work carried out researching and collating safety data on chemicals finding images of organic molecules in three dimensions collecting data on reactions using chemical drawing packages
Bring together information to suit content and purpose	selecting and combining information to meet the requirements of an assignment task, such as producing a portfolio of practical work or a synthesis map
Present information in ways that are fit for purpose and audience	presenting information on reactions carried out in a way that meets the requirements of P6, M5 and D4
Evaluate the selection and use of ICT tools and facilities used to present information	writing reflections on the way that assignments have been presented
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	sending emails to tutors with appropriate information attached demonstrating to tutors that email has been used appropriately responding to feedback on assignments.

Skill	When learners are ...
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	analysing data on the properties of hydrocarbons
Identify the situation or problem and the mathematical methods needed to tackle it	plotting suitable graphs for physical properties of hydrocarbons
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking that the scales of graphs are appropriate
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	describing physical properties of industrially important hydrocarbons
Draw conclusions and provide mathematical justifications	identifying trends in the physical properties of hydrocarbons
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing isomerism interacting with industrial speakers making presentations about properties of organic chemicals
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading text and equations describing the reactions of organic compounds reading internet articles about isomerism, perhaps in relation to controversial or emotive subjects such as trans fats or thalidomide
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing about the reactions of hydrocarbons in relation to the bonding of the compounds producing laboratory reports about organic reactions explaining the importance of the conditions chosen for reactions.