

## Module overview

### The approach

This module is equivalent in extent to three of the earlier modules C1–C3 or C4–C6.

There are three broad aims:

- to extend the coverage of key themes in modern chemistry (organic chemistry, energy changes and chemical equilibrium)
- to explore selected ideas about science further in chemical contexts (valid measurement, explanations in terms of models, sustainable development)
- to illustrate modern applications of chemistry (analysis and synthesis including large-scale industrial synthesis).

In this way the module features key characteristics of the *Science*, *Additional Science*, and *Additional Applied Science* courses in *Twenty First Century Science*.

### The topics

The textbook presents the content of the specification in four topics:

- The first topic introduces organic chemistry using alkanes, alcohols, and esters to show that series of compounds can be understood in terms of their functional groups.
- The second topic covers energy changes and reversible reactions, showing how chemists explain phenomena in terms of models on a molecular scale, notably explanations in terms of the energy needed to break bonds and dynamic equilibrium.
- The third topic features qualitative analysis by chromatography and quantitative analysis by titration with further development of concepts of valid measurement.
- The final topic explores the principles of green chemistry, showing how the chemical industry is reinventing processes to make the manufacture of chemicals more sustainable.

The 'chemistry in action' examples in the textbook are not examinable but are included to show how the ideas developed in the text are put to work in the twenty-first century.

### Practical work

Practical work covers observation of organic reactions, organic synthesis, and chemical analysis, thus developing both procedural understanding and laboratory skills.

### ICT resources

Electronic resources for this module include:

- a PowerPoint presentation to illustrate the work of analysts
- seven short video clips featuring analytical techniques and the work of analysts
- four short video clips about chemical synthesis on a laboratory scale

### Skills assessment

Possible investigations arise from the practical work on chemical analysis and the study of catalysis.

The applications of analysis and the features of green chemistry provide a wide range of opportunities for case studies.

### Health and safety

Health and safety advice is included in the guidance notes for each activity.

### Advance preparation

The work on organic chemistry is greatly enriched if students have access to molecular models.

A few chemicals may need to be ordered specially for this module such as a slightly wider range of organic chemicals and the locating agent for AC7.13.

## Module maps

## Topic 1 The chemistry of carbon compounds

| GCSE Science   | Module story   | Science ideas and explanations   | GCSE Additional Science   |
|--|--|--|---|
| <p>Hydrocarbons feature in C1 <i>Air quality</i> and in C2 <i>Material choices</i></p> <p>Natural and synthetic flavourings feature in C3 <i>Food matters</i> (but with no details of their chemical composition).</p> <p>There is a brief mention of fats as ingredients of a healthy diet in C3 <i>Food matters</i>.</p> <p>Ethene molecules appear in C4 <i>Material choices</i> but without reference to double bonds.</p> | <p><b>The alkanes</b></p> <p>↓</p> <p><b>The alcohols</b></p> <p>↓</p> <p><b>Carboxylic acids</b></p> <p>↓</p> <p><b>Esters</b></p> <p>↓</p> <p><b>Fats and oils</b></p> | <p>Molecular structure. Representations of molecules. Physical properties. Chemical properties: burning and inertness to common aqueous reagents.</p> <p><b>Using balanced equations to represent organic reactions.</b></p> | <p>Covalent bonding and the weak forces between molecules are introduced in C5 <i>Chemicals of the natural environment</i>.</p> <p>Writing balanced equations is introduced in C4 <i>Chemical patterns</i>.</p> |
|  | <p>Names and structures of alcohols. Physical properties compare to alkanes. Chemical reactions: burning and <b>the reaction with sodium</b>.</p>                        | <p>The reaction of sodium with water features in C4 <i>Chemical patterns</i>.</p>  |   |
|  | <p>Names and structures of organic acids. Occurrence, taste, and smell of some acids. Reactions as acids.</p>  | <p>The carboxylic acid group appears in amino acids mentioned in C5 <i>Chemicals of the natural environment</i>.</p>   |   |
|  | <p>The smell of esters. Formation of esters. <b>Laboratory preparation of an ester and the techniques involved.</b></p>  | <p>The ionic theory of acids and their characteristic reactions are covered in C6 <i>Chemical synthesis</i>.</p>   |   |
|  | <p>Fats and oils as esters of glycerol and fatty acids. Single and double bonds. Saturated and unsaturated molecules.</p>  | <p>The stages in a chemical synthesis are introduced in C6 <i>Chemical synthesis</i>.</p>  |   |

## Module maps

## Topic 2 How much? How fast? How far?

| GCSE Science | Module story  | Science ideas and explanations   | GCSE Additional Science  |
|--------------|---|--|--|
|              | <p><b>Energy changes and chemical reactions</b></p> <p style="text-align: center;">↓</p> <p><b>How fast?</b></p> <p style="text-align: center;">↓</p> <p><b>Reversible changes and dynamic equilibria</b></p> | <p>Exothermic and endothermic reactions. The energy needed to break bonds. The energy given out when bonds form. <b>Calculating overall energy changes from data.</b></p> <p>Molecular collisions. Activation energy in terms of the energy needed to break bonds..</p> <p>Examples of reversible processes. Dynamic equilibrium. Strong and weak acids. Explaining the difference between strong and weak acids in terms of chemical equilibrium.</p> | <p>Factors affecting rates of reaction are covered in C6 <i>Chemical synthesis</i>. This module also introduces simple collision theory.</p> <p>The distinction between strong and weak acids in terms of ionic theory is briefly mentioned in C6 <i>Chemical synthesis</i>.</p> |

## Module maps

## Topic 3 Chemical analysis

| GCSE Science   | Module story  | Science ideas and explanations  | GCSE Additional Science  |
|--|---|---|--|
| <p>The results of chemical analysis to monitor air quality feature largely in C1 <i>Air quality</i>.</p>   | <p><b>Stages in analysis</b></p> <p>↓</p> <p><b>Chromatography</b></p> <p>↓</p> <p><b>Titration</b></p> <p>↓</p> <p><b>Evaluating results</b></p> | <p>Qualitative and quantitative methods. Analytical procedures. Sampling. Quality standards</p> <p>Procedures for paper and thin-layer chromatography. Stationary and mobile phases. Aqueous and non-aqueous solvents. Reference materials. The use of locating agents. <math>R_f</math> values.</p> <p>Gas chromatography. Retention times. Simple interpretation of chromatograms.</p> <p>Stages in carrying out a quantitative analysis. Standard solutions and how to prepare them. <b>Concentration calculations.</b> Titrations using a pipette and burette. Interpretation of titration results either using a given formula or <b>with reacting masses and the balanced equation.</b></p> <p>Estimating the uncertainty in results from a series of titrations.</p> | <p>The qualitative use of emission spectra to identify elements is covered in C4 <i>Chemical patterns</i>.</p> <p>Writing balanced equations is introduced in C4 <i>Chemical patterns</i>.</p> <p>Titration using only burettes to test for purity of chemicals feature in C6 <i>Chemical synthesis</i>.</p> |
| <p>The interpretation of scientific data taking into account measurement uncertainty is introduced in C1 <i>Air quality</i> and developed in C2 <i>Material choices</i>.</p> |   |   |  |

## Module maps

## Topic 4 Green chemistry

| GCSE Science  | Module story   | Science ideas and explanations  | GCSE Additional Science  |
|---|--|---|--|
| <p>The synthesis of polymers from petrochemicals features in C2 <i>Material choices</i></p>   | <p><b>The work of the chemical industry</b></p> <p style="text-align: center;">↓</p> | <p>Examples of bulk and fine chemicals. Regulation covering environmental protection and health and safety.</p> <p>The main features of a chemical process in industry (feedstocks, energy changes, synthesis, separation of products, handling of by-products and wastes, checking purity).</p>  | <p>There is an introduction to the chemical industry in module C6 <i>Chemical synthesis</i>.</p>   |
| <p>The uses of catalysts in catalytic converters is covered in C1 <i>Air quality</i>.</p>   | <p><b>Innovations in green chemistry</b></p> <p style="text-align: center;">↓</p>    | <p>Features of green chemistry that can contribute to, or help to assess, the sustainability of a process: nature of the feedstock, atom economy, amounts of by-products and wastes, energy inputs and outputs, environmental impact, health and safety risks, benefits. Catalysts and their effect on the activation energy for a reaction.</p> <p><b>Calculation of yields.</b></p> | <p>Writing balanced equations is introduced in C4 <i>Chemical patterns</i>. Calculating yields from balanced equations is covered in C6 <i>Chemical synthesis</i>.</p> |
| <p>Sustainable development in the uses of raw materials features in C2 <i>Material choices</i>.</p> <p>C3 <i>Food matters</i> explores sustainability in the context of farming and food.</p> | <p><b>Three routes to ethanol</b></p>  | <p>Large- scale uses of ethanol. Production of ethanol from ethane, by fermentation and from waste biomass. Interpretation of data on the sustainability of the processes.</p>  | <p>The effect of enzymes on reaction rates is covered in B4 <i>Homeostasis</i></p>   |

## Further notes

### Integrating modules C6 and C7

The following listing of lessons shows that it is possible to integrate modules C6 and C7 into a single teaching scheme. All the lessons for both modules are included, but it is clear that this approach makes it possible to cover the ground in fewer lessons, especially with students able to make effective use of private study.

This could be a help where separate sciences are taught in the time allowed for two GCSEs.

#### **Acids and alkalis**

C6 lesson 2 Acids and alkalis

C6 lesson 11 Neutralisation

C6 lesson 12 Explaining neutralization

#### **Reversible reactions and dynamic equilibrium**

C7 lesson 11 Reversible reactions

C7 lesson 12 Dynamic equilibrium

C7 lesson 13 Forward and back reactions

#### **Chemistry of carbon compounds**

C7 lesson 1 The alkanes

C7 lesson 2 Alcohols

C7 lesson 3 Reactions of carboxylic acids

C7 lesson 4 Properties of carboxylic acids

C7 lesson 5 Making esters

C7 lesson 7 Fats and oils

#### **Rates of reaction**

C6 lesson 4 Surface area and rates

C6 lesson 5 Concentration and rates

C6 lesson 6 Temperature changes and catalysts

C7 lesson 26 Catalysts

#### **Energy changes, bonding and collision theory**

C7 lesson 8 Exothermic or endothermic?

C7 lesson 9 Energy changes and bonding

C6 lesson 7 Rates and collision theory

C7 lesson 10 Activation energies

#### **Analysis**

C7 lesson 14 Sampling for analysis

C7 lesson 15 Checking up on food colours

C7 lesson 16 Find the forgery

C7 lesson 17 Gas chromatography

C7 lesson 18 Concentration

C7 lesson 19 Using pipettes and burettes

C6 lesson 3 Testing purity

C7 lesson 20 Analysing vinegar

C7 lesson 21 Valid analytical measurement

#### **Laboratory scale synthesis**

C6 lesson 8 Salts from acids

C6 lesson 9 Synthesis of a health salts

C6 lesson 10 Yields

C7 lesson 6 Preparation of an ester

C7 lesson 22 Synthesis of a weedkiller

#### **The chemical industry and green chemistry**

C6 lesson 1 Bulk and fine chemicals

C7 lesson 23 Chemicals on a large scale

C7 lessons 24 and 25 Green chemistry

C7 lesson 27 Three routes to ethanol

C7 lesson 28 Which is greener?