



National Unit Specification: general information

UNIT Consumer Chemistry (SCQF 6)

CODE FE4F 12

COURSE Chemistry (Revised)

SUMMARY

This Unit develops a knowledge and understanding of Organic Chemistry within the context of everyday consumer products. The relationship between the structure of organic compounds and their physical and chemical properties is explored. Key functional groups and types of organic reaction are covered. The Unit will equip candidates with the scientific background necessary to evaluate the scientific and technological claims in order to make informed choices and decisions. The Unit provides candidates with the opportunity to solve problems and to apply critical thinking in new contexts.

OUTCOMES

- 1 Demonstrate and apply knowledge and understanding related to *Consumer Chemistry*.
- 2 Demonstrate skills of scientific experimentation and investigation within the context of *Consumer Chemistry*.

Administrative Information

Superclass: RD

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National Unit Specification: general information (cont)

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RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- ◆ Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- ◆ the Intermediate 2 Chemistry course at grade B

and

- ◆ Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

1 credit(s) at Higher (6 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

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Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Demonstrate and apply knowledge and understanding related to *Consumer Chemistry*.

Performance Criteria

- (a) Make accurate statements about *Consumer Chemistry* facts, concepts and relationships.
- (b) Use knowledge of *Consumer Chemistry* to solve problems.
- (c) Use knowledge of *Consumer Chemistry* to explain observations and phenomena.

OUTCOME 2

Demonstrate skills of scientific experimentation and investigation in the context of *Consumer Chemistry*.

Performance Criteria

- (a) Use a range of data-handling skills in a scientific context.
- (b) Use a range of skills related to the evaluation of scientific evidence.

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EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- ◆ Alcohols
- ◆ Carboxylic acids
- ◆ Fruit Flavours
- ◆ Fats and Oils
- ◆ Proteins
- ◆ Chemistry of cooking
- ◆ Oxidation of food
- ◆ Soaps and emulsions
- ◆ Fragrances
- ◆ Skincare products

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided within in the appendix to the specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: chemical formulae, balanced chemical equations, diagrams depicting laboratory apparatus, line graphs, scatter graphs, bar and pie charts, tables, diagrams and text. Candidates must be able to write molecular formulae, full and shortened structural formulae for straight and branched chain aliphatic alcohols, aldehydes, ketones, carboxylic acids, carboxylic acid salts and esters containing no more than eight carbon atoms in their longest chain. IUPAC naming rules must be used for these compounds. Candidates should also be familiar with the term 'isomers' as used to refer to molecules with the same molecular formula but different structural formulae.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

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This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the course specification.

This Unit allows candidates to develop knowledge and understanding of Organic Chemistry within the context of everyday consumer products. The relationship between the structure of organic compounds and their physical and chemical properties is developed in details with key functional groups and types of reaction being covered in detail. The Unit will equip candidates with the scientific background necessary to evaluate the scientific and technological claims in order to make informed choices and decisions. The Unit provides candidates with the opportunity to solve problems and to apply critical thinking in new contexts.

Whilst completing this Unit candidates will be exposed to a large variety of organic molecules both natural and synthetic. The emphasis should be on developing an understanding that the functional groups present in these molecules are central in determining the reactions and properties of substances.

Functional Group	Encountered in
<i>hydroxyl</i>	<i>alcohols, terpenes</i>
<i>carboxyl</i>	<i>carboxylic acids, amino acids</i>
<i>ester link</i>	<i>esters, fats & edible oils</i>
<i>amino</i>	<i>amino acids</i>
<i>amide link</i>	<i>proteins</i>
<i>carbonyl</i>	<i>aldehydes, ketones and terpenes</i>
<i>carboxylate ion</i>	<i>salts, soaps</i>
<i>carbon double bond</i>	<i>fats and edible oils, terpenes, proteins</i>

Candidates must be able to write molecular formulae, full and shortened structural formulae for straight and branched chain aliphatic alcohols, aldehydes, ketones, carboxylic acids, carboxylic acid salts and esters containing no more than eight carbon atoms in their longest chain. IUPAC naming rules must be used for these compounds. Candidates should also be familiar with the term 'isomers' as used to refer to molecules with the same molecular formula but different structural formulae.

In the contexts of flavour molecules, edible oils, essential oils and proteins, candidates will encounter larger and more complex molecules in which the 'carbon backbone' can often include cyclic and/or aromatic features. At Higher level, candidates are required only to consider effects related to the presence of the functional groups named in the table above. Candidates are not expected to be able to name these more complex molecules.

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This Unit offers a diverse and rich vein of contexts and opportunities for practical work as highlighted in the 'Possible contexts and activities' column of the content tables. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams. By developing a greater understanding of the chemistry behind such substances as food preservatives, candidates are better able to make informed choices and decisions in their everyday lives.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Prior knowledge of the nature of the types of van der Waals attractions and of the ability of substances to act as oxidising or reducing agents is assumed. These topics are covered in the Higher Unit, 'Periodicity, Polarity and Properties'.

General advice on approaches to learning and teaching is contained in the course specification.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly chemical phenomena in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the core skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The appendix to this Unit Specification contains an extensive list of 'Possible Contexts and Activities' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key ICT skills including; accessing information and providing/creating information.

The Unit appendix contains an extensive range of practical laboratory exercises which provide candidates with the opportunity to working co-operatively with others.

Problem solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) & (c) and also through Outcome 2, PCs (a) & (b).

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GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that a holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation and investigation can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments for may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements

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The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the breadth and depth of content expected. The right-hand column gives possible contexts and activities which could be used to develop knowledge, understanding and skills. Further details on many of the activities mentioned in the final column can be obtained from **National Qualifications Online**, part of the Learning and Teaching Scotland online service. Where such online support exists the  symbol appears in the text.

Content	Notes	Possible Contexts and Activities
1) Alcohols		
(a) Ethanol production	Ethanol can be produced by the fermentation of glucose. Enzymes in yeast catalyse fermentation. There is a limit to the ethanol concentration which can be achieved by fermentation. Distillation can be used to obtain higher ethanol concentrations. In order to satisfy the industrial demand for ethanol, it is also formed by the catalytic hydration of ethene.	Ethanol can be produced by fermentation within the lab.  The concentration of ethanol in a sample can be measured using a standard method used by HM Revenue and Customs. 25 cm ³ of water are added to 50 cm ³ of the solution being tested. The mixture is distilled, with the first 50 cm ³ of distillate being collected. The density of the distillate is measured and this value is converted into the concentration of alcohol using a look-up table. Details of this method in addition to volumetric and colorimetric methods are available. 
(b) Alcohols	An alcohol can be identified from the hydroxyl group and the '-ol' name ending. The presence of the hydroxyl group makes alcohols polar and gives rise to hydrogen bonding. Straight-chain and branched-chain alcohols, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain alcohols, structural formulae can be drawn and molecular formulae written.	A number of alcohols can be examined to establish common properties. The miscibility of alcohol in water and the pH of the resultant solutions could be tested.

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<p>(c) Uses of alcohols</p>	<p>Alcohols are effective solvents. Smaller alcohols evaporate easily, making them ideal for cleaning purposes. Their high flammability, and the very clean flames with which they burn has resulted in alcohols being used as fuels.</p>	<p>The flammability of meths in camping stoves can be demonstrated whilst methanol can be discussed as a fuel in drag racing and speedway.</p> <p>A spectacular demonstration of the flammability of alcohols is provided by the ‘whoosh bottle’ demonstration. A mixture of alcohol and air in a large polycarbonate bottle is ignited. The resulting rapid combustion reaction, often accompanied by a dramatic ‘whoosh’ sound and flames, demonstrates the large amount of chemical energy released in the combustion of alcohols. </p> <p>Equally dramatic are the ‘alcohol gun’ experiment  or the ‘flaming pumpkin’. </p> <p>A more mysterious element can be introduced with the ‘non-burning £5 note’ experiment. </p> <p>The heat energy release when alcohols burn can be measured. </p> <p>Examine a number of products such as screen wipes, disinfectant wipes and hand gels which contain isopropyl alcohol (propan-2-ol).</p>
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2) Carboxylic acids		
(a) Carboxylic acids	<p>Carboxylic acids can be identified from the carboxyl group and the '-oic' name ending. Straight-chain and branched-chain carboxylic acids, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain carboxylic acids, structural formulae can be drawn and molecular formulae written. Carboxylic acids react with bases to form salts containing the carboxylate ion.</p>	<p>Vinegar offers candidates an introduction to carboxylic acids using a familiar example.</p> <p>To obtain a qualitative measure of the concentration of ethanoic acid in different vinegars, a modified version of the film-canister rocket experiment can be used.  A marble chip is attached to the inside of the lids of a number of 35mm film canisters using a little reusable poster tack. Equal volumes of vinegars of differing types are poured into the film cans so that they are one third full. The lids are placed onto the cans and the cans all inverted at the same time. The ethanoic acid reacts with the marble liberating carbon dioxide gas which builds up until the lid seal breaks and the can shoots into the air like a rocket. The order in which the vinegar 'rockets' take off is a measure of the concentration of ethanoic acid in each.</p> <p>The concentration of ethanoic acid in vinegars can be determined quantitatively either by volumetric titration, or by measuring the volume of carbon dioxide liberated when an excess of a carbonate salt is added to vinegar.</p> <p>Many carboxylic acids have unpleasant smells. (Great care must be taken in handling undiluted carboxylic acids as they are highly corrosive.) Many candidates may describe their smell as 'like vomit'. It can be worthwhile commenting on the accuracy of their description as vomit contains carboxylic acids known as 'fatty acids' released from fats and oils during digestion.</p>

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(b) Uses of carboxylic acids	Vinegar is a solution of ethanoic acid. Vinegar is used in household cleaning products designed to remove limescale (a build up of insoluble carbonates on plumbing fixtures) and as a preservative in the food industry.	To demonstrate both the acidic nature of ethanoic acid, and its use as a food preservative, pickled eggs can be produced by placing boiled eggs (still in their shells) into jars containing vinegar. The acid will dissolve the shell to leave a pickled egg in vinegar. Pickles (food preserved in vinegar) can be stored for a long time because the low pH prevents the growth of harmful bacteria and fungi.
3) Fruit Flavours		
(a) Esters	An ester can be identified from the ester group and by names containing the '-yl -oate' endings. An ester can be named given the names of the parent alcohol and carboxylic acid or from structural formulae. Structural formulae for esters can be drawn given the names of the parent alcohol and carboxylic acid or the names of esters. Esters have characteristic smells.	A 'smelling' session is a fun way of reinforcing the use of the 'fruity' type of scent/flavour associated with these molecules. 'Foam Fruit' type sweets, pear drops and other fruit flavoured sweets often have distinctive ester scents. Examples of esters responsible for fruit smells include; 3-methyl-1-butyl ethanoate=banana, methyl butanoate=apple, benzyl butanoate =cherry, benzyl ethanoate=peach, methyl salicylate=wintergreen, octyl ethanoate=orange, propyl ethanoate=pear.
(b) Making Esters	Esters are formed by the condensation reaction between a carboxylic acid and an alcohol. The ester link is formed by the reaction of a hydroxyl group with a carboxyl group. In condensation reactions, the molecules join together with the elimination of a small molecule, in this case water.	Esters can be quickly synthesised on a test-tube scale by candidates.  If candidates work in pairs, and a small selection of different alcohols and carboxylic acids are available, it is possible for each pair to synthesise a different ester. The class can then 'sniff' (appropriate safety precautions) each of the esters made to see which fruit smells can be recognised. Websites provide extensive lists of the esters found in fruit.

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<p>(c) Uses of esters</p>	<p>Esters are used as flavourings and fragrances. Esters are also used as non-polar industrial solvents.</p>	<p>Ethyl ethanoate is one of a number of solvents used to extract caffeine from coffee and tea. De-caffeinated products produced with ethyl ethanoate are often described on the packaging as ‘naturally decaffeinated’ because ethyl ethanoate is a chemical found naturally in many fruits.</p> <p>Caffeine can be extracted from tea by candidates using an aqueous solution of sodium carbonate and ethyl acetate and a rough percentage of caffeine in the tea leaves calculated. ☞</p> <p>Esters are also used as solvents for dyes, inks, paints and varnishes. Applications where candidates will have encountered ester type smells from non-food products include; car spray paints, some permanent marker pens, some whiteboard pens, nail varnish removers etc The ease with which esters evaporate leads to high concentrations of esters in the air. Further information on current moves to reduce the use of esters as solvents can be found by searching for ‘VOC reduction’ or ‘low VOC’ on an internet search engine.</p>
<p>(d) Hydrolysis of esters</p>	<p>Esters can be hydrolysed to produce a carboxylic acid and an alcohol. Given the name of an ester or its structural formula, the hydrolysis products can be named and their structural formulae drawn. The parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester. In a hydrolysis reaction, a molecule reacts with water breaking down into smaller molecules.</p>	<p>An ester is added to distilled water. After 30 minutes, the pH of the mixture can be tested to demonstrate that an acid is forming.</p> <p>Old bottles of perfume can also be an interesting illustration of ester hydrolysis as the fruity notes in fragrances have frequently hydrolysed leaving the unpleasant stench of carboxylic acids.</p>

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4) Fats and oils		
(a) Edible fats and oils	Fats and oils are a concentrated source of energy. They are essential for the transport and storage of fat soluble vitamins in the body. Fats and oils are esters formed from the condensation of glycerol (propane-1,2,3-triol) and three carboxylic acid molecules. The carboxylic acids are known as 'fatty acids' and are saturated or unsaturated straight chain carboxylic acids, usually with long chains of carbon atoms.	<p>Candidates can be given the opportunity to examine examples of a number of edible fats and oils which could include examples of fish oils, vegetable oils and animal fats.</p> <p>Vegetable oil samples can be burned to demonstrate that they are stores of chemical energy.</p> <p>Carrying out a demonstration fat-fire underlines the considerable energy released when fats and oils are oxidised in addition to underlining the risks associated with cooking techniques using deep oil baths. ☹</p> <p>Candidates can also consider the wider use of edible oils as, for example, the use of edible oils as fuels and lubricants for some agricultural machinery in order to prevent any risk of harmful mineral oils contaminating future food stuffs.</p>
(b) The melting points of fats and oils	The lower melting points of oils compared to those of fats is related to the higher degree of unsaturation of oil molecules. The low melting points of oils is a result of the effect that the shapes of the molecules have on close packing, hence on the strength of van der Waals' forces of attraction.	<p>The degree of unsaturation of fats and oils can be determined qualitatively by counting the number of drops of bromine water that can be decolourised by equal quantities of oil, or by a very simple titration in which the fat is dissolved. ☹</p> <p>Alternatively, iodine values can be determined by standard methods including the use of Wij's reagent. This solution of Iodine monochloride adds rapidly to the carbon-carbon double bonds present. The unreacted iodine monochloride was then treated with an excess of aqueous potassium iodide, forming iodine. The liberated iodine is determined by titration with sodium thiosulfate.</p>

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5) Proteins		
(a) Function of proteins	Proteins are the major structural materials of animal tissue. Proteins are also involved in the maintenance and regulation of life processes. Enzymes are proteins.	The shapes of protein molecules can be viewed with a range of free-of-charge browser plug-ins such as Chime or Jmol. 
(b) Amino acids	Amino acids, the building blocks from which proteins are formed, are relatively small molecules which all contain an amino group (NH ₂), and a carboxyl group (COOH). The body cannot make all the amino acids required for body proteins and is dependent on dietary protein for supply of certain amino acids known as essential amino acids.	<p>There are around twenty common amino acids. Only eight amino acids are regarded as being essential for humans although a further two are required in childhood.</p> <p>The amino acids in fruit juices can be identified by paper chromatography. </p> <p>There is also an activity on the amino acid aspartame in artificial sweeteners in 'In Search of More Solutions' Janet Taylor, Royal Society of Chemistry 1994</p>
(c) Amide links	Proteins are made of many amino acid molecules linked together by condensation reactions. In these condensation reactions, the amino group on one amino acid and the carboxyl group on a neighbouring amino acid join together, with the elimination of water. The link which forms between the two amino acids can be recognised as an amide link (CONH). Proteins which fulfil different roles in the body are formed by linking differing sequences of amino acids together. The amide links within proteins are also known as peptide links.	Candidates can investigate the detection of protein in synthetic urine samples in a practical activity. 

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(d) Hydrolysis of protein	During digestion, enzyme hydrolysis of dietary proteins can produce amino acids. The structural formulae of amino acids obtained from the hydrolysis of proteins can be identified from the structure of a section of the protein.	Paper chromatography of the amino acid mixture produced by the hydrolysis of hair or egg whites.
6) Chemistry of Cooking		
(a) Flavour in food	Many of the flavours in foods are due to the presence of volatile molecules. By examining the functional groups present in molecules, candidates can suggest whether they are likely to be water or oil soluble. The size and functional groups present can be taken into account in predicting their relative boiling point and hence probable volatility.	<p>To illustrate the role of volatile molecules in flavour, an experiment based on tasting foods with your nose blocked can be used. Strawberry jam works well. A blindfolded taster is fed a small amount of strawberry jam with a teaspoon. While holding his/her nose, the taster can only detect the sweetness of the jam (which is detected with the tongue). but will be unable to tell the flavour of the jam which is caused by volatile molecules detected by the nose. On releasing his/her nose, s/he will be able to tell the flavour of the jam. Other foods which can be used in this experiment include apple, parsnip, and even different flavours of crisp. In this variation the taster is given a plain crisp to taste but, without telling them, a flavoured crisp is held under their nose. The taster will report that the crisp they are tasting has the flavour of that held under their nose. 🍷</p> <p>A major issue in cooking is to retain molecules responsible for flavour in the food — overcooking can result in loss of these molecules. One destination for lost flavour molecules is in the cooking water. This will occur if the flavour molecules are water-soluble. This is the case for asparagus, for example, which should be cooked in oil or butter in which the flavour</p>

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		<p>molecules are less soluble. In broccoli or green beans, the flavour molecules are more soluble in oil than in water and should be cooked in water. </p> <p>‘The Chemistry of Flavour’ Kitchen Chemistry, Ted Lister and Heston Blumenthal, Royal Society of Chemistry contains a number of problem solving exercises allowing candidates to make predictions of best cooking methods using the structural formulae of the molecules responsible for flavour in different foods. </p> <p>Examples of flavour molecules are provided on websites. </p> <p>When using internet search engines to search for flavour compounds, using both the UK and US spelling of ‘flavour/flavor’ will locate the maximum number of sites.</p>
(b) Changes in protein structure upon heating	<p>Within proteins, the long chain molecules may be twisted to form spirals, folded into sheets, or wound around to form other complex shapes. The chains are held in these forms by intermolecular bonding between the side chains of the constituent amino acids. When proteins are heated, during cooking, these intermolecular bonds are broken allowing the proteins to change shape (denature). These changes alter the texture of foods.</p>	<p>Kitchen Chemistry, Ted Lister and Heston Blumenthal, Royal Society of Chemistry 2005 has an excellent video explaining how different temperatures are required for cooking meats with different levels of connective tissue. Joints containing a lot of connective tissue become tender if cooked at over 60 °C as the collagen forming the tough connective tissue, denatures. The tender lean meat found in cuts such as fillet steaks, should not be cooked at too high a temperature, because in this case the protein molecules start to bunch together resulting in the meat becoming tougher. </p> <p>The effect of temperature on modifying protein structures can also be explored using egg whites. In uncooked egg white, the protein molecules are globular. During cooking, the protein is denatured and the protein chains unwind and, as they can now form intermolecular bonds with neighbouring protein molecules, a network of interconnected proteins</p>

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		forms causing the egg white to solidify.
7) Oxidation of Food		
(a) Oxidation of alcohols	<p>Alcohols can be classified as primary, secondary or tertiary. Primary alcohols are oxidised, first to aldehydes and then to carboxylic acids. Secondary alcohols are oxidised to ketones. When applied to carbon compounds, oxidation results in an increase in the oxygen to hydrogen ratio. In the laboratory, hot copper(II) oxide or acidified dichromate (VI) solutions can be used to oxidise primary and secondary alcohols. Tertiary alcohols cannot be oxidised.</p>	<p>The action of CuO as an oxidising agent for alcohols can be shown by placing a small amount of ethanol in an evaporating basin. A 2p coin is then heated to just below red heat in a bunsen and then wafted in the air allowing the surface to become coated in black copper(II) oxide. The warm coin is then carefully lowered into the ethanol. Instantly the bright shiny surface of the coin is restored as the CuO is reduced to copper. The process of heating the coin-forming the oxide-and reducing the oxide in alcohol is repeated until little liquid is left in the dish. At this point, if pH indicator is added it shows that an acid has formed whilst the distinctive smell of ethanal can be detected.</p> <p>In an alternative experiment, samples of primary, secondary and tertiary alcohols can be warmed with acidified dichromate (VI) to illustrate that only the primary and secondary will be oxidised. Ethanol can be oxidised by acidified sodium dichromate in a test-tube reaction, firstly to form ethanal (acetaldehyde), and with further oxidation, ethanoic acid (acetic acid). 📖</p> <p>Using a microscale well-plate, candidates add acidified dichromate(VI) to primary, secondary and tertiary alcohols to observe the difference in their oxidation reactions. This experiment can be done by candidates in 20 minutes. The colour change of the dichromate(VI) indicates where reaction is occurring. Primary, secondary and tertiary alcohols can be distinguished by the rate of reaction, though no attempt is made to identify the products. 📖</p>

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<p>(b) Aldehydes and Ketones</p>	<p>Many flavour and aroma molecules are aldehydes. Aldehydes and ketones both contain the carbonyl functional group. Aldehydes and ketones can be identified from the ‘-al’ and ‘-one’ name endings respectively. Straight-chain and branched-chain aldehydes and ketones, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain aldehydes and ketones, structural formulae can be drawn and molecular formulae written. Aldehydes, but not ketones, can be oxidised to carboxylic acids. Fehling’s solution, Tollens’ reagent and acidified dichromate solution can be used to differentiate between an aldehyde and a ketone.</p>	<p>Aldehydes are key components in whisky. Much of the flavour is developed as oxygen diffuses into the cask forming aldehydes.</p> <p>The toxicity of aldehydes can result in unfortunate symptoms such as severe headaches.</p> <p>Aldehydes and ketones can be differentiated by testing with acidified dichromate or Tollen’s reagent. </p> <p>In the ‘giant silver mirror’ experiment a solution of ammoniacal silver nitrate is reduced by aldehydes to silver, which forms a silver mirror on the inside of a one litre large flask. </p>
<p>(c) Antioxidants</p>	<p>Oxygen reacts with edible oils giving the food a rancid flavour. Antioxidants are molecules which will prevent these oxidation reactions taking place. Ion-electron equations can be written for the oxidation of many antioxidants.</p>	<p>In crisp manufacture, potatoes are typically fried under an atmosphere of steam and packaged under nitrogen.</p> <p>www.understandingfoodadditives.org has many animations and good, jargon free text and a number of downloadable classroom activities.</p> <p>There is also an A-level practical investigation on the oxidation of fats and oils available from the University of York. </p> <p>The concentration of antioxidants in foods can be measured by a variety of means. Vitamin C (antioxidant) levels in fruit juices can be compared semi-quantitatively using a very simple method by measuring the number of drops of fruit juice needed to reduce one drop of iodine solution to iodide using starch as an indicator.  This simple method can be used in investigative work exploring the effect that cooking</p>

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		<p>methods have on the antioxidants in foods.</p> <p>For more quantitative results, one possible method is to use a microscale redox back titration. In this experiment a measured amount of fruit drink is added to an excess of iodine solution. The ascorbic acid in the drink reacts quantitatively with some of the iodine. The excess iodine is then titrated against standard thiosulfate solution. 📖</p> <p>In a more straightforward redox titration, the level of Vitamin C in a vitamin tablet can be determined by direct redox titration with an acidified permanganate (VII) solution. 📖</p>
8) Soaps and Emulsions		
(a) Making soap	<p>Soaps are produced by the alkaline hydrolysis of fats and oils. Fats and oils are esters. The hydrolysis of fats and oils produces fatty acids and glycerol in the ratio of three moles of fatty acid to one mole of glycerol. The fatty acid molecules released are neutralised by the alkali to form water soluble ionic salts called soaps.</p>	<p>There are a number of soap making experiments which have been developed to reduce the time taken for soap to form, and to use less corrosive alkalis.</p> <p>One method, producing soap from castor oil, takes approximately 40 minutes. 5 cm³ of ethanol is added dropwise to 2 cm³ of castor oil. 10 cm³ of 5 mol l⁻¹ sodium hydroxide is added, and the solution warmed in a waterbath containing near-boiling water for five minutes. 10 cm³ of saturated sodium chloride solution is then added to the beaker and the mixture stirred. The mixture is cooled in a cold water bath (or an ice bath if available). Soft, white lumps of the soap will gradually form in the mixture. Leave for a few minutes to improve the yield. During this time the soap may rise to the surface and form a soft crust on cooling. 📖</p> <p>One of the quickest soap preparations takes under five minutes. In this method around 2g of mutton fat is dissolved in 8 cm³ of ethanol in a boiling tube. One pellet of KOH is</p>

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		added, and the mixture boiled in a water bath for 2 minutes during which the cloudy mixture becomes clear. When the contents of the tube are poured into a beaker containing saturated NaCl solution the soap precipitates and floats on the surface.
(b) Cleansing action of soaps	Cleaning with water alone has little effect when stains consist of non-polar substances, such as grease and sweat. Soap ions have a long non-polar tail, readily soluble in non-polar compounds (hydrophobic), and an ionic carboxylate head which is water soluble (hydrophilic). During cleaning, the hydrophobic tails dissolve in a droplet of oil or grease, whilst the hydrophilic heads face out into the surrounding water resulting in ball-like structure. The non-polar substances, such as oil and grease, are held inside the ball and suspended in water.	<p>Many web animations are available showing this process.</p> <p>An experiment can be used to demonstrate the detergent action of soaps. In this experiment, very finely divided MnO_2 or very finely divided charcoal plays the part of 'dirt'. 50 cm^3 of water is placed in one 100 cm^3 measuring cylinder, and 50 cm^3 of soap solution in another. A pinch of simulated 'dirt' is added to each, and the two cylinders shaken. The two cylinders are set aside for some time. In the control cylinder containing water, the 'dirt' settles down on the bottom of the cylinder, whilst in the soap solution the powder remains suspended.</p>
(c) Emulsions in food	An emulsion contains small droplets of one liquid dispersed in another liquid. Emulsions in food are mixtures of oil and water. To prevent oil and water components separating into layers, a soap-like molecule known as an emulsifier is added. Emulsifiers for use in food are commonly made by reacting edible oils with glycerol to form molecules in which either one or two fatty acid groups are linked to a glycerol backbone rather than the three normally found in edible oils. The one or two hydroxyl groups present in these molecules are hydrophilic whilst the fatty acid chains are hydrophobic.	<p>Emulsifiers are added to a very large range of different foods including sauces, bread, biscuits, ice cream, low fat spread and even dried pastas where they help to prevent pasta pieces sticking to each other during cooking.</p> <p>Candidates can investigate the formation of emulsions in foods using the RSC practical experiments from section 3.2 of Inspirational Chemistry. This practical is very straightforward and does not take very long, although if candidates shake the boiling tubes too vigorously then the mixtures can take a while to separate. Candidates place about 2 cm^3 of vegetable oil and about 2 cm^3 of water into a boiling tube. The tube is stoppered and shaken. The oil and water separate into two layers. Candidates then experiment with adding a small quantity of substances such as mustard</p>

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		<p>powder, sugar, flour, salt, egg white, egg yolk and washing up liquid to determine which act as emulsifiers. Eggs have a salmonella risk and only eggs bearing the lion symbol should be used. Raw egg should be handled as little as possible, and a disposable pipette should be used to transfer it to the boiling tubes. The results can be discussed in terms of the molecules present in these substances. 🖨</p> <p>The code E471 is one of the most common 'E-numbers' on food packaging and indicates that the food contains an emulsifying agent consisting of mono- and di-glycerides of fatty acids.</p>
9) Fragrances		
(a) Essential oils	<p>Essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants. They are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods. Essential oils are mixtures of organic compounds. Terpenes are key components in most essential oils.</p>	<p>Candidates can use steam distillation apparatus to extract essential oils from lavender, rosemary, citrus fruit, pine needles etc</p> <p>If quickfit-type apparatus is unavailable, steam distillation can be carried out using an ordinary boiling tube, some glass wool and a one-holed bung fitted with an L-shaped delivery tube. A wad of glass wool soaked in water is placed at the bottom of the boiling tube. A second 'plug' of dry glass wool, lodged about two-thirds of the way up the boiling tube, supporting some lemon peel, lavender or rosemary. The glass wool soaked in water at the bottom of the boiling tube is gently heated, causing steam to rise up through the plant material and pass down the delivery tube. A cold-wet paper towel can be wrapped around the tube, and fastened with an elastic band to help keep the tube cool. The distillate is collected in a small beaker or boiling tube sitting in a tub of ice cold water. Within five minutes, the tube or beaker will contain some scented distillate.</p>

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(b) Terpenes	Terpenes are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units. They are components in a wide variety of fruit and floral flavours and aromas. Terpenes can be oxidised within plants producing some of the compounds responsible for the distinctive aroma of spices.	Terpenes are responsible for the distinctive flavours of spices such as cloves, cinnamon and ginger. Terpenes can be extracted from many materials in the lab. A common experiment is the extraction of limonene from citrus fruits. Limonene can be extracted from oranges using ethyl ethanoate as a solvent (an example of solvent extraction- see content statement above). [Making Sense of Terpenes: An Exploration into Biological Chemistry, Kevin W. Glaeske and Paul R. Boehlke, The American Biology Teacher, Vol. 64, No. 3 (Mar., 2002), pp. 208-211 (article consists of 4 pages) Published by: National Association of Biology Teachers]
10) Skin Care Products		
(a) Effect of ultraviolet light	Ultraviolet radiation (UV) is a high-energy form of light, present in sunlight. Exposure to UV light can result in molecules gaining sufficient energy for bonds to be broken. This is the process responsible for sunburn and also contributes to aging of the skin. Sun-block products prevent UV light reaching the skin.	UV Photography reveals the effects of ‘photoaging’, or aging of skin caused by light. There are many websites showing this effect. UV sensitive polymer beads are now available from many educational suppliers. These beads change colour when exposed to UV light. They can provide a fun and cheap way of allowing candidates to experiment with the effectiveness of different sun-block molecules.
(b) Free radical reactions	When UV light breaks bonds free radicals are formed. Free radicals have unpaired electrons and, as a result, are highly reactive. Free radical chain reactions include the following steps: initiation, propagation and termination.	A spectacular demonstration of a free radical chain reaction is provided by the H_2/Cl_2 reaction. Initiation can be provided by a photographic flash unit, demonstrating that light energy is required to generate the initial free radicals.  It can easily be shown that bromine will decolourise in the presence of an alkane faster in light than in the dark.

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(c) Free-radical scavengers	Many cosmetic products contain free radical scavengers; molecules which can react with free radicals to form stable molecules and prevent chain reactions. Free radical scavengers are also added to food products and to plastics.	Adverts for anti-aging products can be examined to identify the scientific basis of the claim. Melatonin and Vitamin E are examples of natural free radical scavengers.
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