Curriculum Links

Activity 2B – Hydrolysis of biofuel feedstocks

The Department for Education is conducting a review of the primary and secondary National Curriculum. The links below relate to the statutory programmes of study for science in the National Curriculum, 2007 and specific sections of common science qualifications offered in UK schools.

Key stage 3

1.1 Scientific thinking
b. critically analysing and evaluating evidence from observations and experiments.
1.2 Applications and implications of science
a. exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.
2.1 Practical and enquiry skills
Pupils should be able to:

- use a range of scientific methods and techniques to develop and test ideas and explanations
- assess risk and work safely in the laboratory, field and workplace
- plan and carry out practical and investigative activities, both individually and in groups.

3.4 The environment, Earth and universe
c. human activity and natural processes can lead to changes in the environment.

Key stage 4

1 How science works
1.1 Data, evidence, theories and explanations Pupils should be taught:
a. how scientific data can be collected and analysed
b. how interpretation of data, using creative thought, provides evidence to test ideas and develop theories
1.2 Practical and enquiry skills Pupils should be taught to:
a. plan to test a scientific idea, answer a scientific question, or solve a scientific problem
b. collect data from primary or secondary sources, including using ICT sources and tools
c. work accurately and safely, individually and with others, when collecting first-hand data
d. evaluate methods of collection of data and consider their validity and reliability as evidence.
1.3 Communication skills Pupils should be taught to:
a. recall, analyse, interpret, apply and question scientific information or ideas
b. use both qualitative and quantitative approaches
1.4 Applications and implications of science Pupils should be taught:
a. about the use of contemporary scientific and technological developments and their benefits, drawbacks and risks
b. to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions
2.2 Chemical and material behaviour In their study of science, the following should be covered:
a. chemical change takes place by the rearrangement of atoms in substances
c. new materials are made from natural resources by chemical reactions
d. the properties of a material determine its uses.
2.3 Energy, electricity and radiations In their study of science, the following should be covered:
a. energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use
2.4 Environment, Earth and universe In their study of science, the following should be covered:
a. the effects of human activity on the environment can be assessed using living and non-living indicators
b. the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present

Curriculum Links

AQA Chemistry and Science GCSE

Unit C1.4 Crude oil and Fuels C1.4.3 Hydrocarbon fuels

e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.

C1.5 Other useful substances from crude oil

evaluate the advantages and disadvantages of making ethanol from renewable and non-renewable sources.

Additional guidance:

Candidates should be able to compare the environmental impact of producing ethanol from renewable and non-renewable sources.

AQA Biology and Additional Science GCSE

B2.3 Photosynthesis

f) Some glucose in plants and algae is used: ■ to produce cellulose, which strengthens the cell wall

AQA Science B GCSE

3.4.2.3 Generation and distribution of electricity

Candidates need to:

1. Define the terms renewable and non-renewable in the context of energy sources.
2. Know that fossil fuels (natural gas, oil and coal) release energy when they are burned, which can be used to generate electricity for our homes.
3. Explain how nuclear fuels and renewable energy sources (wind, solar, hydroelectric, wave, tidal, biomass and geothermal) may be used as alternatives to fossil fuels.
5. Explain the problems of using nuclear fuels (problems of radioactive emissions, disposal of waste) and of using renewable energy sources (unreliability and possible effects on the environment).

Within this context, candidates should be able to use scientific data and evidence to discuss, evaluate or suggest implications of the following:

■ the environmental impact over time of energy production by comparing the advantages and disadvantages of using alternative energy sources

■ the economic impact of using alternative energy sources

AQA Environmental Science GCSE

A2.4 What alternative energy technologies are available?

Scientists have developed alternative technologies to harness energy from sources other than fossil fuels. Environmental scientists use their knowledge to assess these alternatives for their efficiency and potential environmental impact.

Scientists have also developed methods of electricity generation from renewable resources that may be used instead of fossil fuels.

Candidates should know and understand that:

• renewable energy resources are usually sustainable:
• not depleted by use including wind power
• capable of rapid replacement including biofuels
• most renewable energy resources:
• use kinetic energy to turn generators, which produce electricity (exceptions include solar water heating, photovoltaics, geothermal and biofuels)
• usually need larger areas than thermal power stations to yield the same amount of energy
• may be unreliable or cannot provide a constant supply of energy
• may detract from the appearance of a land/seascape (A1)
• may affect wildlife populations or habitat (B1)

Agricultural scientists have developed plant crops, together with the use of animal and plant waste to produce renewable biofuels.

Curriculum Links

Candidates should know and understand that:
- biofuels, eg biogas, bioethanol, biodiesel, are also renewable and can:
  - be burned to produce heat but release carbon dioxide
  - be used as vehicle fuel
  - be 'carbon neutral' or 'green' as carbon dioxide taken out of the air by photosynthesis when energy crops grow is returned when the fuel is burnt so that no extra is added to the atmosphere (B2)
  - be a waste product eg from sewage plants, poultry farms (A1)
  - be environmentally damaging when land is cleared, and biodiversity (B1)and food-producing farmland are lost (A1)
  - *have a lower energy density than fossil fuel*

Environmental scientists use their knowledge of chemistry, physics and biology to consider both the advantages and disadvantages of various energy resources. They consider a number of factors before making conclusions and recommendations.
Candidates should be able to:
- describe: biofuels
- in terms of:
  - efficiency
    - —predictability
    - —intermittency
    - —*energy density*
  - potential environmental impact including:
    - —emissions to air/water
    - —mining/quarrying land take
    - —disturbance to sediment patterns/water flow
    - —hazardous waste
    - —disruption of wildlife
    - —noise/radio disturbance
    - —loss of landscape value

Opportunities to investigate using scientific knowledge and skills:
- the amount of energy produced by different vegetable oils/alcohols
- the rise in temperature in a compost heap over time
- public attitudes towards different energy producing technologies

OCR Biology A 21st Century GCSE
Module B7: Further Biology B7.5 New technologies
2. understand that bacteria and fungi can be grown on a large scale (fermentation) to include production of: d. enzymes for commercial products, such as washing powders and to make biofuels

OCR Physics and Science A 21st Century GCSE
Module P3: Sustainable energy P3.1 How much energy do we use?
1. understand that the demand for energy is continually increasing and that this raises issues about the availability of energy sources and the environmental effects of using these sources
2. recall the main primary energy sources that humans use: fossil fuels (oil, gas, coal), nuclear fuels, biofuels, wind, waves, and radiation from the Sun
4. understand that power stations which burn fossil fuels produce carbon dioxide which contributes to global warming and climate change

OCR Biology B Gateway GCSE
Module B6: Beyond the Microscope Item B6d: Biofuels
Assessable learning outcomes both tiers: standard demand
Describe different methods of transferring energy from biomass, to include:
- burning fast growing trees
- fermenting biomass using bacteria or yeast.

Given data, evaluate different methods of transferring energy from biomass.
Describe the advantages of using biofuels, to include:

• alternative sources to fossil fuels
• no increase in greenhouse gas levels
• no particulates produced.
Recall that a mixture of petrol and alcohol:
• is called gasohol
• is used for cars in countries such as Brazil.
Assessable learning outcomes Higher Tier only: high demand
Explain why the burning of biofuels does not cause a net increase in greenhouse gas levels if:
• they are burnt at the same rate as the biomass is being produced
• areas of land are not cleared of other vegetation in order to grow crops for biofuels.
Explain how, in some areas, the use of large areas of land to produce biofuels is resulting in:
• habitat loss
• extinction of species.
Understand why gasohol is more economically viable in countries that have ample sugar cane and small oil reserves.

Item B6g: enzymes in action
Suggested practical and research activities
Immobilise enzymes in alginate beads and investigate the effect on a substrate.
Assessable learning outcomes both tiers: standard demand
Describe how enzymes can be immobilised in gel beads by:
• mixing the enzyme with alginate
• dropping the mixture into calcium chloride solution.
Explain the advantages of immobilising enzymes, to include:
• the mixture not becoming contaminated with the enzyme
• immobilised enzymes in alginate beads can be used in continuous flow processing.
Assessable learning outcomes Higher Tier only: high demand
Recall how some enzymes can be immobilised:
• in gel beads

OCR Chemistry and Additional Science B Gateway GCSE
Module C3: Chemical Economics Item C3g: Batch or continuous?
Suggested practical and research activities to select from
Assessable learning outcomes Foundation Tier only: low demand
Describe the differences between a batch and a continuous process.
Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.
Assessable learning outcomes both tiers: standard demand
Explain why batch processes are often used for the production of pharmaceutical drugs but continuous processes are used to produce chemicals such as ammonia.
Assessable learning outcomes Higher Tier only: high demand
Evaluate the advantages and disadvantages of batch and continuous manufacturing

Edexcel Chemistry GCSE
Unit C3: Chemistry in Action Topic 5 Organic chemistry
5.1 Describe how ethanol is produced during the fermentation of carbohydrates, including:
a that the fermentation mixture is kept warm and under anaerobic conditions
b that yeast provides an enzyme for this reaction
5.7 Evaluate the factors which are relevant to the choice of method used in the manufacture of ethanol, including:
a the relative availability of sugar cane or sugar beet and crude oil
b the quality of the final product and whether it needs further processing

Curriculum Links

Edexcel Biology GCSE
Unit B3: Using Biology Topic 3 Biotechnology
3.19 Demonstrate an understanding of the advantages and disadvantages of replacing fossil fuels with biofuels, including the facts that biofuels are renewable and that their production uses carbon dioxide but that growing the crops to make them requires land and may affect the availability of land for growing food.

SQA Intermediate Chemistry
Prescribed practical activity: Hydrolysis of starch
Prescribed practical activity: testing for sugars and starch

SQA Standard Grade Science
Topic 3: Energy and its Uses Renewable Sources of Energy
1 Fossil fuels and nuclear fuels are non-renewable, but waves, wind, hydroelectricity and the sun are renewable sources of energy.
2 As the stocks of fossil fuels are depleted these alternative sources of energy will become more important.
Credit Level
3 Other renewable sources of energy include sugar alcohol and geothermal heat.
In sugar-growing countries, sugar can be fermented into alcohol which can be used as a fuel.
4 There are advantages and disadvantages in the use of each alternative or renewable energy source, to include: cost, the technology involved, visual pollution, and reliability of the energy source.

SQA Standard Grade Biology
Topic 4: Sub-Topic d – Investigating Enzymes
Topic 7: Biotechnology Sub-Topic a – Living Factories b- problems and profit with waste

SQA Standard Grade Chemistry
Topic 15: Carbohydrates and Related Substances

Cambridge Biology iGCSE (with significant similarity to Coordinated and Combined Science iGCSE)
Section II: Organisation and maintenance of the organism 5. Enzymes
- Define enzymes as proteins that function as biological catalysts
- Investigate and describe the effect of changes in temperature and pH on enzyme activity

Cambridge Chemistry iGCSE (with significant similarity to Physical science, Coordinated and Combined Science iGCSE)
7. Chemical reactions 7.1 Speed of reaction
• Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the speeds of reactions
• Describe a practical method for investigating the speed of a reaction involving gas evolution
14.8 Macromolecules 14.8 (b) Natural macromolecules
• Describe complex carbohydrates in terms of a large number of sugar units, considered as HO OH, joined together by condensation polymerisation
• Describe the acid hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars
• Describe the fermentation of simple sugars to produce ethanol (and carbon dioxide)

Curriculum Links

Cambridge Physics iGCSE (with significant similarity to Coordinated and Combined Science iGCSE)
1. General physics 1.6 Energy, work and power 1.6 (b) Energy resources
• Distinguish between renewable and non-renewable sources of energy
• Give advantages and disadvantages of each method in terms of cost, reliability, scale and environmental impact

Cambridge Environmental Management iGCSE
5. Action on the lithosphere 5.2 technologies and viability of alternative energy sources
solar, wind, wave, geothermal,hydro-electric, biomass
19 Managing agriculture 19.2 harvesting energy from living resources to provide power
biomass, biogas (methane), fuel from organic waste

Key stage 5

AQA Biology A-level
Unit 1 BIOL1 Biology and disease
3.1.3 Biological molecules such as carbohydrates and proteins are often polymers and are based on a small number of chemical elements. Monosaccharides are the basic molecular units (monomers) of which carbohydrates are composed. The structure of α-glucose and the linking of α -glucose by glycosidic bonds formed by condensation to form maltose and starch. Sucrose is a disaccharide formed by condensation of glucose and fructose. Lactose is a disaccharide formed by condensation of glucose and galactose. Biochemical tests using Benedict's reagent for reducing sugars and non-reducing sugars. Iodine/potassium iodide solution for starch.
3.1.2 Enzyme Properties. The properties of enzymes relating to their tertiary structure. Description and explanation of the effects of temperature, competitive and non-competitive inhibitors, pH and substrate concentration.
Unit 5 BIOL5 - Control in cells and organisms
3.5.6 The sequence of bases in DNA determines the structure of proteins, including enzymes

OCR Biology A-level
3.2 AS Unit F212: Molecules, Biodiversity, Food and Health Module 1 Biological Molecules
Candidates should be able to:
(j) describe, with the aid of diagrams, the molecular structure of alpha-glucose as an example of a monosaccharide carbohydrate;
(k) state the structural difference between alpha- and beta-glucose;
(l) describe, with the aid of diagrams, the formation and breakage of glycosidic bonds in the synthesis and hydrolysis of a disaccharide (maltose) and a polysaccharide (amylose);
(m) compare and contrast the structure and functions of starch (amylose) and cellulose;
(o) explain how the structures of glucose, starch (amylose), glycogen and cellulose molecules relate to their functions in living organisms;
(r) describe how to carry out chemical tests to identify the presence of the following molecules: protein (biuret test), reducing and non-reducing sugars (Benedict's test), starch (iodine solution) and lipids (emulsion test);
(s) describe how the concentration of glucose in a solution may be determined using colorimetry
2.1.3 Enzymes Candidates should be able to:
(a) state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms;
(b) state that enzyme action may be intracellular or extracellular;
(d) describe and explain the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity;
(e) describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally;

Curriculum Links

OCR Chemistry A A-level
How Science Works 6a, 7b:
Desirability of renewable fuels by 'rich' countries may lead to problems of food supply for countries supplying the 'crops for fuel'. (i) the problem of an over-reliance on non-renewable fossil fuel reserves and the importance of developing renewable plant based fuels, ie alcohols and biodiesel (see also 2.4.2)

OCR Chemistry B Salters A-level
Unit F331: Chemistry for Life Developing Fuels. Organic functional groups
Applications
(x) understand the benefits and risks associated with using fossil fuels and alternative fuels (biofuels, hydrogen, nuclear) and discuss the choices involved in making decisions about ensuring a sustainable energy supply.

CCEA Biology A-level
1.2 Understand the structure of enzymes:
enzymes as globular proteins and the concept of the active site and specificity;
the role of cofactors and coenzymes.
SQA Higher Chemistry
Prescribed practical activity: Factors affecting enzyme activity
AQA Environmental Studies A-level
A2 Unit 3 – ENVS3 Energy Resources and Environmental Pollution 3.3.1 Energy
Renewable energy resources
Examples should be used to illustrate the factors affecting the ease of use of renewable energy resources and therefore their likely use in the future
Energy density: biofuels have medium energy densities
Ease of storage: Energy can be stored as potential energy of water in reservoirs and chemical energy in biofuels
Future energy supplies New technologies
New technologies may increase the amount of energy available for use by
• increasing the amount of energy available from existing energy resources
• allowing new resources to be exploited
Atmospheric pollution

- incomplete combustion of fossil fuels and biofuels

AQA Science in Society A-level
Unit 1 AS Exploring key scientific issues 3.1.3 Transport issues
Technical ways of reducing the impact of transport on local air quality and on greenhouse gases.
The advantages and disadvantages of different fuels, to include: fossil fuels, bio-fuels, fuel cells and hydrogen.
Fuels are valuable because they are concentrated sources of energy. There is a finite amount of fossil fuel (coal, oil, natural gas) on Earth. Other energy sources (wind, wave, biomass such as wood) are renewable. They can be replaced in the same sort of time scale as they are used.

Unit 3 A2 Exploring key scientific issues 3.3.5 Energy futures The context
The context for this topic is the challenge of reconciling the growing demand for energy resources worldwide, especially the demand for electricity, with the policy imperative to cut down the emission of carbon dioxide and other greenhouse gases. People want the benefits of a readily available supply of electricity but must balance this against the cost of each method of generation and its environmental impact.
Renewable sources of energy are naturally and continually replenished; they include wind, solar power, geothermal, hydropower, and various forms of biomass.