2.3 The Wider Impact of Chemistry

Chemical synthesis and the production of energy

The energy problem

Energy production is a major issue affecting all aspects of modern life. Worldwide demands are increasing greatly but our main source, fossil fuels, is being rapidly depleted. Burning fossil fuels releases carbon dioxide into the atmosphere and oceans. The level of carbon dioxide in the atmosphere has increased by around 300 to 400 ppm (parts per million) in the last 100 years. This has led to global warming, through an increase in the greenhouse effect. Also, oceans are becoming more acidic with serious biological effects. Because global warming is increasing, and the supply of fossil fuels is decreasing, alternative sources are being sought. Some sources that interest chemists are hydrogen, biomass, solar energy and nuclear fuel.

Hydrogen

Hydrogen is a clean fuel that, when consumed in a fuel cell, does not produce carbon dioxide, only water. These qualities make it an attractive fuel option for transportation and electricity generation applications. It doesn't occur naturally on Earth, however, so it has to be produced. At the moment this is expensive and uses fossil fuels. The most common methods today are natural gas reforming (a thermal process), and electrolysis. However, research is being done to make it through other methods including solar-driven and biological processes.

Biomass

Biomass energy is energy generated or produced by living, or once-living, organisms. The most common biomass materials used for energy are plants, wood and waste. Burning plant-derived biomass releases carbon dioxide, but the carbon dioxide being generated by burning the fuel is compensated for by that absorbed by the material during photosynthesis. Therefore, the whole process is said to be **carbon neutral**.

Solar power

Solar power refers to capturing the energy from the Sun and converting it into electricity. It is a clean, renewable source of energy, but the cost of its collection, conversion and storage is still high. It is also weather-dependent, since solar panels are dependent on sunlight to effectively gather solar energy. However, technology in the solar power industry is constantly improving.

Nuclear power

Nuclear power has been used in this country for many years. It produces no polluting gases, does not contribute to global warming and has very low fuel costs. However, public perception of the industry is negative because large scale accidents have been catastrophic. Additionally, waste is radioactive and safe disposal is very difficult and expensive.

The role of green chemistry

Green Chemistry aims to make the chemicals and products that we need with as little impact on the environment as possible. In order to do this, we need to:

- use renewable raw materials such as plant-based compounds wherever possible
- use as little energy as possible and get this from renewable sources rather than from fossil fuels that will run out; energy efficiency should be increased
- use methods which have high atom economy, so there is little waste
- develop better catalysts, e.g. enzymes, to carry out reactions at lower temperatures and pressures, saving energy and avoiding the expense of constructing strong plants
- make products that are biodegradable at the end of their useful lives
- avoid the use of toxic materials and ensure that there are no undesirable by-products; avoid using solvents that are bad for the environment.

Links with other parts of the specification

In this topic you will have to apply the principles that you have studied in parts of 1.7(b), 2.1(a), 2.2(e), 2.5(a), 2.6(e) and 2.7(b) to situations and problems you might find in the production of energy and chemicals. You could be supplied with data relevant to the situation and the marks you gain will depend on how you analyse and evaluate the situation or problem. You will need to have a basic understanding of:

- how equilibrium and kinetics can oppose each other in industrial processes
- the importance of catalysts, including enzymes, in industrial processes
- the benefits and drawbacks relating to the use of fossil fuels
- the importance of carbon neutrality in chemical processes
- the use and environmental effects of halogenoalkanes, such as CFCs
- the industrial preparation of ethanol from ethene or by fermentation.

Enzymes

Enzymes are biological catalysts. They usually catalyse specific reactions and work best close to body temperature. They are exceptionally efficient and give a far greater increase in reaction rates than inorganic catalysts.

Some of the benefits are:

- lower temperatures and pressures can be used, saving energy and costs
- they operate in mild conditions and do not harm fabrics or food, so are safe to use
- they are biodegradable, so disposal is not a problem
- they often allow reactions which form pure products to take place, with no side reactions, removing the need for complex separation techniques.

There are problems however:

- Enzyme activity is affected by temperature (it increases until the protein denatures).
- Enzyme activity is affected by pH (different enzymes have differing optimum pH levels).
- Enzymes can be difficult to be removed from liquid products.

CFCs and fossil fuels

It is important to remember the different effects on the environment that these have.

Burning fossil fuels produces CO_2.

- CO_2 is a **greenhouse gas** and so contributes to global warming.
- It is also responsible for the formation of acid rain. Acid rain is formed from the oxides of sulphur and nitrogen, which are by-products of burning fossil fuels.
- It does **not** contribute to ozone depletion.

CFCs **are** responsible for making holes in the **ozone** layer. These holes allow UV rays from the sun to reach the earth's surface and cause skin cancer. Their use is now tightly regulated.

Industrial preparation of ethanol

CO_2 is not produced in the hydration of ethene. However, it must be remembered that fossil fuels are burned to achieve the temperature required for the process. Additionally, ethene is produced from the cracking of fractions, obtained from distillation of natural gas and oil.

CO_2 is produced in the process of fermentation, but plants have used CO_2 in photosynthesis to produce the sugars.