The Identification and Production of Materials

1. Which of the following is a significant industrial source of ethylene?
    a. Polymerisation of polyethylene
    b. Hydration of ethanol
    c. Cracking of long hydrocarbons
    d. Fermentation of sugar

2. Carbon-14 is an unstable isotope because:
    a. It has more neutrons than protons
    b. Its nucleus has an atomic number greater than 83
    c. It has a half-life of about 6000 years
    d. The neutron to proton ratio is too great

3. A student prepared a solution of potassium iodide. She then added a very small quantity of bromine water to the original solution. After some time she noticed a deposit of iodine crystals on the bottom of the beaker. Which of the following best explains the student's observations?
    a. The oxidation state of the iodine has gone from 0 to -1 so the iodine has been oxidised.
    b. The oxidation state of the iodine has gone from 0 to -1 so the iodine has been reduced
    c. The oxidation state of the iodine has gone from -1 to 0 so the iodine has been oxidised
    d. The oxidation state of the iodine has gone from -1 to 0 so the iodine has been reduced

4. Which of the following metal ions would be displaced from a solution by the addition of powdered iron?
    a. Aluminium
    b. Sodium
    c. Nickel
    d. Zinc

5. Cellulose is a condensation polymer.
    a. Name ONE industrial use of the polymer **1**
    b. Briefly describe its production **2**

6. Assess the potential of ethanol as an alternative fuel. In your answer you should assess the impacts and applications of the chemistry on the environment and identify future directions for research. **8**

1. c
2. d
3. c
4. c
5.
    a. Industrially, cellulose is used in the manufacture of fibres such as cotton and paper or partially synthetic polymers such as cellulose nitrate
    b. Cellulose is produced naturally in plants by the condensation polymerisation of glucose monomers eliminating water molecules. Long chains of up to 1400 monomer units can be formed
6. Ethanol is not currently viable as an alternative fuel for mass consumption. At the moment, methods of producing ethanol are expensive compared with the price of obtaining non-renewable supplies such as coal, oil and natural gas. This was clearly illustrated by the failed Brazilian attempt to use ethanol in the 1970s and 1980s. However, as supplies of fossil fuels decline and/or taxes imposed on their use increase, or if cheaper alternative methods of producing ethanol from biological sources are found, then ethanol may become more competitive.

    The most common source of ethanol is from the addition of water to ethylene (a by-product of catalytic cracking of crude oil). However, ethanol obtained by this method is less efficient than other fuels eg petrol, which produces more energy per gram and costs less to extract. The main advantage of ethanol as a fuel produced this way is that it produces a cleaner burn (that is, less soot is produced).

    Ethanol can also be produced by fermentation of glucose and it is this form that it is often seen as a "greener" fuel. The advantage of this method is that it does not use fossil fuels but rather takes glucose from naturally concentrated sources such as sugar cane and sugar beet. The burning of ethanol has the potential to be greenhouse-neutral in that only the CO2 removed from the atmosphere by the plant is returned.

    However, the disadvantages of this method far outweigh the advantages. The growing of cane occupies large amounts of land for the amount of ethanol obtained and may require clearing of much more land. Energy inputs which are greenhouse-unfriendly including mechanical planting and harvesting, burning cane for harvesting, and more importantly, the energy required to distil the ethanol from the fermentation mixture is very high due to the high heat capacities of water and ethanol. The wastes from large fermentation plants are also extensive and difficult to dispose of.

    Future research that could enhance current technology include improving the efficiency of solar powered distillation processes, genetic engineering of bacteria to increase the concentration of alcohol produced in fermentation to higher than 15%, and developing mechanisms for the decomposition of cellulose to produce glucose economically. New technologies might focus on looking for alternative pathways to produce ethanol directly from cellulose.