

# 2003 HSC Examination Paper

## Sample Answers

### Section I Part A

- (ii) Describe TWO tests that can be used to distinguish between some of the following classes of organic compounds: alkanes, alkenes, alkanols and aldehydes.
- 1** **B** The other alternatives are organic molecules.
- 2** **D** Curium has an atomic number (96) beyond that of uranium (92). The others are not transuranic because they come before uranium in atomic number.
- 3** **B**
- (i) Describe ONE precaution you take to minimise hazards, or to dispose of reagents and products, during your practical work.
- 4** **B** The ozone layer lies about 25 km above the Earth's surface. It lies within the stratosphere which occupies the part of the atmosphere from about 15 to 50 km above the Earth's surface.
- 5** **A** Filtration (S) cannot be used to separate dissolved substances and a separating funnel (R) is used to separate immiscible liquids.
- 6** **C** MM (propanol) = 60 g mol<sup>-1</sup>, ∴ ΔH<sub>c</sub> = 60 × 33.6 = 2016 kJ mol<sup>-1</sup>.
- 7** **C** X is a basic metal oxide and will therefore react with an acid. Z is an acidic non-metal oxide and will therefore react with a base. V is amphoteric and will react with both acids and bases.
- 8** **A** H<sub>2</sub>SO<sub>4</sub> is diprotic and will ionise to produce twice the concentration of H<sup>+</sup>.  

$$\text{H}_2\text{SO}_4 \rightarrow 2\text{H}^+ + \text{SO}_4^{2-} \therefore [\text{H}^+] = 2 \times (5 \times 10^{-4}) = 1 \times 10^{-3} \text{ mol L}^{-1}$$

$$\text{pH} = -\log(1 \times 10^{-3}) = 3.0$$
- 9** **A** Branches are ordered alphabetically in the name and the carbon atoms are numbered from the end closest to the branches.
- 10** **A** Answer (B) is a prediction and is therefore not based on the *data alone*. Answers (C) and (D) are possible explanations for the data and are therefore not based on the data alone. Answer (A) could be a valid statement based on the data with close examination of the data.

- 11 B** The double bond opens up and carbons link up to form a long chain. Every second carbon atom will contain a  $-\text{CH}_3$  branch and a  $-\text{COOCH}_3$  branch.

- 12 D** The molecular formula gives the number of atoms of each element.

The graph shows:

$$n(\text{C}) = \frac{24 \text{ g}}{12 \text{ g}} = 2; n(\text{F}) = \frac{76 \text{ g}}{19 \text{ g}} = 4; n(\text{Cl}) = \frac{71 \text{ g}}{35.45 \text{ g}} = 2$$

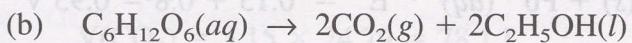
- 13 D** A more active metal will displace another metal's ion in solution. Z is the most active because it displaces  $\text{Y}^{2+}$  and is not displaced by X. Y is the least active because it is displaced by X and Z.

- 14 C** Rinsing the flask with a base will result in too many moles of base in the flask. More moles of acid will be needed to neutralise it. Rinsing the burette with water will dilute the acid. More moles of acid will be needed to neutralise the base. Therefore the number of moles of base will appear higher than it actually is and the calculation of its concentration will appear higher than it actually is.

- 15 A** The buffer acts to keep the pH relatively constant when an acid is added to the solution, which it does in graph A. However, over a certain volume of acid added the buffer can no longer cope and the pH begins to drop as the solution becomes acidic.

## Section I Part B

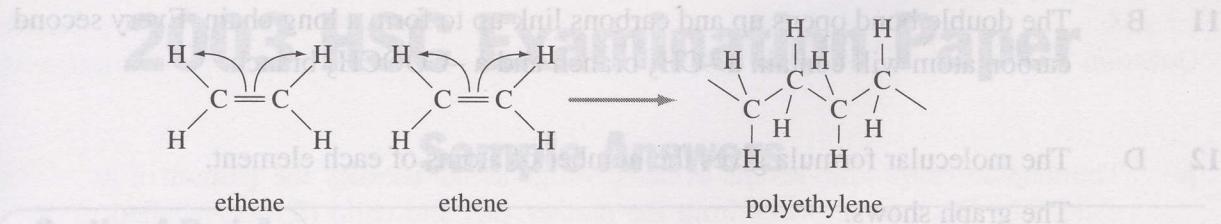
- 16 (a)** A teaspoon of yeast was mixed with a sugar solution in a conical flask with cotton wool at the mouth. This was weighed and placed in an incubator at  $35^\circ\text{C}$  for a week. The apparatus was removed from the incubator every day to be reweighed.



- 17 (a)** Ethanol  
**(b)** Ethylene is changed from a gas to a liquid under pressure and heated in the presence of a catalyst to produce polyethylene.

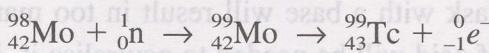
The double bond within ethylene opens out and a covalent bond forms between molecules linking them together in a long chain. This is addition polymerisation.

- 21** A weak base or acid should be used to neutralise an acid or base spill. Any excess will be weak and therefore cause little damage. A substance like sodium hydrogencarbonate

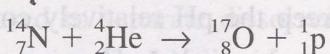


- (c) Polymerisation is a random process. Few or many monomers may link together to form some long and some very long chains.

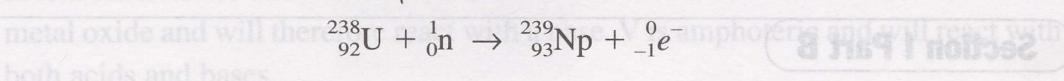
- 18** Commercial isotopes can be produced in both nuclear reactors and particle accelerators like cyclotrons. In a nuclear reactor, target nuclei are introduced into the reactor where they are bombarded by neutrons. These are absorbed by the atoms nucleus. The medical isotope technetium-99 is produced in a nuclear reactor.



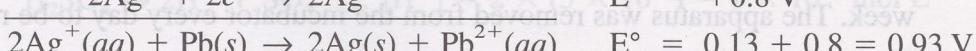
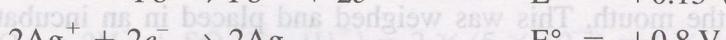
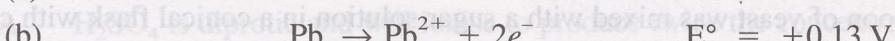
Neutron-poor isotopes are made in a particle accelerator like a cyclotron. These use electric and magnetic fields to increase the speed of charged particles so that when they collide with the target nucleus, fusion occurs. Oxygen-17 is produced in a cyclotron by bombarding nitrogen-14 with accelerated alpha particles.



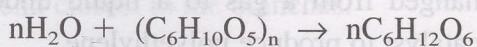
Transuranic elements, those elements with an atomic number greater than uranium, have been made in both reactors and cyclotrons. The target nuclei are usually already large nuclei such as uranium, plutonium or lead. Neptunium-239 is a transuranic element made in a reactor.



- 19** (a) Silver electrode



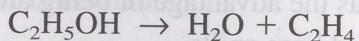
- 20** Biomass is a fuel source made up of cellulose and lignin from plants. The cellulose component can be converted to glucose by acid hydrolysis.



Glucose can then be fermented to ethanol using yeast.



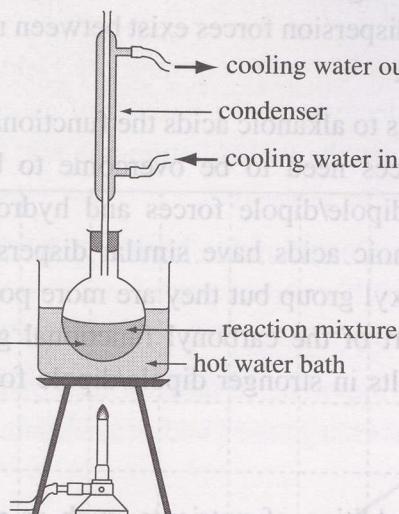
The ethanol can be used as a fuel on its own or dehydrated to ethylene.



Ethylene can be used as a starting material to produce polyethylene and other plastics. The problem with using biomass is that cellulose needs to be grown. This may result in a large amount of land clearing. The acid hydrolysis of cellulose is very inefficient and polluting and not currently economically viable.

- 21** (a) Butylpropanoate and water

- (b)



- (c) The reactants are volatile and yet need to be heated to reach their activation energy. Refluxing cools the reactant gases and condenses them returning them to the reaction mixture for continued heating. The gases would otherwise escape before they reacted.

- 22** (a)  $\text{C}_2\text{H}_6\text{O}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$

$$(b) n(\text{C}_2\text{H}_6\text{O}) = \frac{72.5}{46.0} = 1.576 \text{ mol}$$

$$n \text{ CO}_2 \text{ produced} = 2 \times n(\text{C}_2\text{H}_6\text{O}) = 3.15 \text{ mol}$$

$$V(\text{CO}_2) = 3.15 \times 24.79 = 78.1 \text{ L}$$

- 23** (a)  $\text{Ba}(\text{OH})_2(aq) + 2\text{HNO}_3(aq) \rightarrow \text{Ba}(\text{NO}_3)_2(aq) + 2\text{H}_2\text{O}(l)$

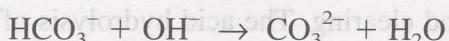
$$(b) n(\text{Ba}(\text{OH})_2) = 0.12 \times 0.025 = 0.003 \text{ mol}$$

$$n(\text{HNO}_3) \text{ needed to neutralise} = 0.003 \times 2 \text{ (from equation)} = 0.006 \text{ mol}$$

$$c(\text{HNO}_3) = \frac{0.006}{0.0183} = 0.33 \text{ mol L}^{-1}$$

- 24** A weak base or acid should be used to neutralise an acid or base spill. Any excess will be weak and therefore cause little damage. A substance like sodium hydrogencarbonate

is ideal as it can be used in a powdered form. A solid is easier to control and mop up later than a solution. It also has the advantage of being amphiprotic and can therefore be used to neutralise both acid and base spills.



- 25** The boiling point of alkanes, alkanols and alkanoic acids all increase with increasing molecular mass because the increasing mass is due to increasing carbon chain length. The longer the carbon chain the more dispersion forces exist between molecules and the more energy is needed to separate them.

As you go from alkanes to alkanols to alkanoic acids the functional group becomes more polar. Only weak dispersion forces need to be overcome to boil alkanes. However alkanols have these as well as dipole/dipole forces and hydrogen bonds due to the hydroxyl functional group. Alkanoic acids have similar dispersion forces and similar hydrogen bonds due to the hydroxyl group but they are more polar molecules owing to the double-bonded oxygen as part of the carbonyl functional group. This gives more polarity to the molecule and results in stronger dipole/dipole forces. These require the most energy to overcome.

- 26** Eutrophication results from the addition of nutrients, such as phosphates and nitrates from fertilisers, into waterways. These cause a bloom in algal populations which subsequently use up the dissolved oxygen in the water and eventually block out sunlight from all but surface waters. Both of these factors lead to the demise of the algae. The dead algae provide the right conditions for decay bacteria and cyanobacteria to thrive and release toxins into the waterway leaving it devoid of animals and plants and unusable by humans for many years.

Eutrophication can be monitored by directly measuring levels of phosphate in the water. Levels exceeding 60 ppm indicate that eutrophication has begun, as do levels of nitrogen above 600 ppm. The N:P ratio has been found to be a less reliable indicator. Ratios higher than 10:1 N:P are thought to be evidence of eutrophication but this ratio cannot be used in isolation. Dissolved oxygen (DO) and biochemical oxygen demand (BOD) may be easier to measure and therefore more suitable for the monitoring of eutrophication.

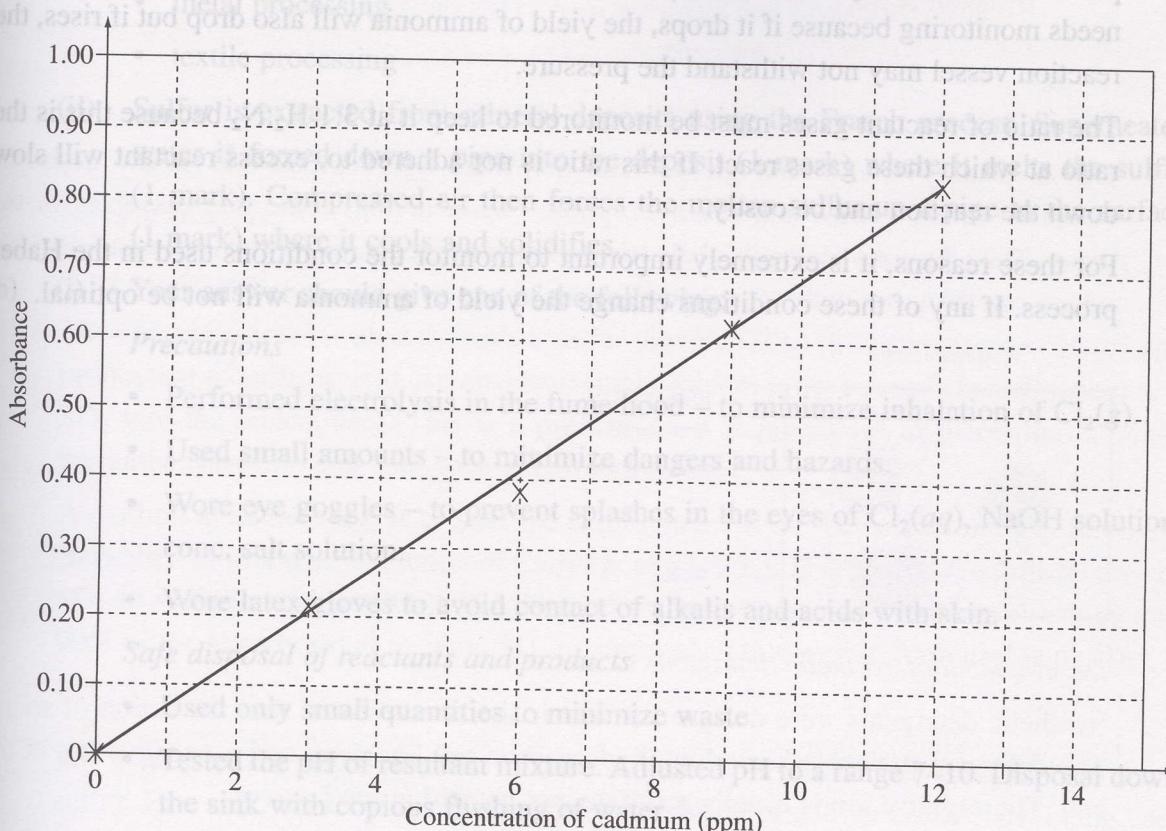
- 27** (a)  $n(\text{BaSO}_4) = \frac{1.8}{233.37} = 7.7 \times 10^{-3} \text{ mol}$
- $$n(\text{SO}_4^{2-}) = n(\text{BaSO}_4) = 7.7 \times 10^{-3}$$
- $$m(\text{SO}_4^{2-}) = 7.7 \times 10^{-3} \times 96.07 = 0.74 \text{ g}$$
- $$\% \text{ mass SO}_4^{2-} = \frac{0.74}{1.0} \times 100 = 74\%$$
- (b) The fertiliser may not have been completely soluble in water. Acid should have been used to help dissolve it.

Using barium chloride to precipitate sulfate is reliable because barium chloride is soluble but barium sulfate is insoluble.

The most unreliable aspect of this procedure probably involved the technique used to collect the precipitate. Barium sulfate is very fine and much of it would have passed through filter paper if it was used. This would have resulted in a lower than true value for the mass of barium sulfate. If a sintered glass funnel had been used to filter the precipitate a better result would have been obtained, but some precipitate may have passed through this as well.

The result would have been more reliable if repeat trials had been conducted and averaged.

**28 (a)**

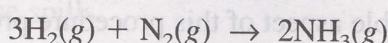


(ii) The three products were identified in the following ways:

- (b) The most likely source of cadmium pollution is the sewage treatment plant.

Water is flowing toward the ocean. Site 3 recorded the highest levels (0.55) so that cadmium could have originated from either the industrial plant or the sewage treatment plant. However, if it was the industrial plant then site 2 would have recorded the highest levels because it is closer to the industrial plant and the cadmium would not have been diluted. In fact the recording at site 2 was quite low (0.15). It could not have originated further upstream from the sewage treatment plant because the recording at site 1 was the lowest (0.08).

**29** The Haber process is the process of producing ammonia from gaseous hydrogen and nitrogen.



Because the system can come to equilibrium and is exothermic, conditions need to be monitored and kept at levels that favour the formation of ammonia.

Temperature needs monitoring to maintain it at about  $500^\circ\text{C}$ . If it falls below this the reaction rate becomes too low and if it rises above this the equilibrium shifts in reverse and the yield of ammonia drops. An iron oxide catalyst is used to raise the reaction rate at this moderate temperature.

A high pressure of 350 atmospheres is used to optimise the yield of ammonia because its production is accompanied by a decrease in the number of gaseous molecules. Pressure needs monitoring because if it drops, the yield of ammonia will also drop but if rises, the reaction vessel may not withstand the pressure.

The ratio of reactant gases must be monitored to keep it at 3:1  $\text{H}_2:\text{N}_2$  because this is the ratio at which these gases react. If this ratio is not adhered to, excess reactant will slow down the reaction and be costly.

For these reasons, it is extremely important to monitor the conditions used in the Haber process. If any of these conditions change the yield of ammonia will not be optimal.

**26** Eutrophication results from the addition of nutrients, such as phosphates and nitrates, from fertilisers, into waterways. These cause a bloom in algal populations which subsequently use up the dissolved oxygen in the water and eventually block out sunlight from all but surface waters. Both of these factors lead to the demise of the algae. The dead algae provide the right conditions for decay bacteria and cyanobacteria to thrive and release toxins into the waterway leaving it devoid of animals and plants and unusable by humans for many years.

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## Option Topics

# 2003 HSC Examination Paper

### Sample Answers

#### **Question 30 Industrial Chemistry**

- (a) (i) Your answer should give one of the following:
- manufacture of fertilisers
  - manufacture of soaps and detergents
  - metal processing
  - textile processing
- (ii) Sulfur is extracted from mineral deposits using the Frasch process. Superheated water is forced down a pipe into the deposit (1 mark) where it melts the sulfur (1 mark). Compressed air then forces the molten sulfur up a pipe to the surface (1 mark) where it cools and solidifies.
- (b) (i) Your answer should give one of the following:

*Precautions*

- Performed electrolysis in the fume hood – to minimize inhalation of  $\text{Cl}_2(g)$ .
- Used small amounts – to minimize dangers and hazards.
- Wore eye goggles – to prevent splashes in the eyes of  $\text{Cl}_2(aq)$ , NaOH solution, conc. salt solution.
- Wore latex gloves to avoid contact of alkalis and acids with skin.

*Safe disposal of reactants and products*

- Used only small quantities to minimize waste.
- Tested the pH of resultant mixture. Adjusted pH to a range 7–10. Disposal down the sink with copious flushing of water.

- (ii) The three products were identified in the following ways:

*Chlorine gas  $\text{Cl}_2(g)$  and chlorine water (1 mark)*

Identified by its yellow-green colour and distinctive ‘swimming pool’ smell. Moist litmus placed near the electrode went red then was bleached white. Another way is to shake some chlorine water with sodium iodide (NaI) solution and a few millilitres of trichloroethane as a solvent. The  $\text{I}^{-}(aq)$  is oxidized to  $\text{I}_2$  which dissolves in the organic solvent to give a pink-purple solution.

*Sodium hydroxide solution (1 mark)*

Produced at the cathode. Add a few drops of phenolphthalein to the brine solution. Pink colouration around the cathode indicates the hydroxide ion.

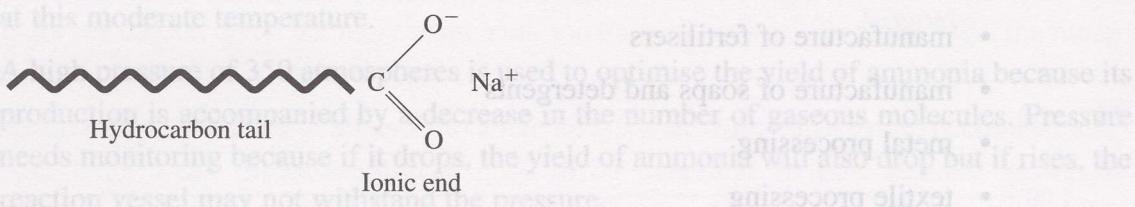
**29** *Hydrogen gas* (1 mark)

Clear bubbles which form at the cathode. Collect a test tube of the gas by downward displacement of water. When a lighted taper is placed into the gas, it explodes with a 'pop'.

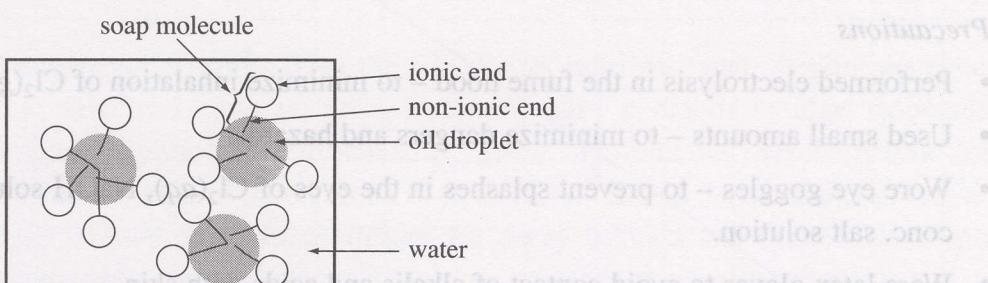
(c) *Structure of soap* (1 mark)

Soap is the long chain salt of a fatty acid.

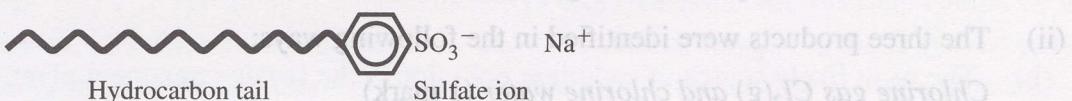
Its structure has a long hydrocarbon chain tail with a negatively charged ionic acid end. A positive metal ion, usually sodium, completes the molecule.

*Cleansing action of soap* (2 marks)

Dirt is usually mixed with grease. The non-ionic hydrocarbon end of the molecule dissolves in the grease and the hydrophilic (water-loving) ionic end dissolves in the water. Thus the soap molecules help to emulsify the grease, making it into small droplets which can then mix with water and be washed away.

*Development of synthetic detergents* (2 marks)

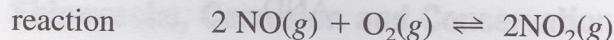
Synthetic detergents were designed to mimic the structure and thus the action of soaps. The detergent molecule has a long hydrocarbon tail like soap and a negative ion at the end. The negative ion is usually a sulfate, not an acid group however.



The first soaps had a branched hydrocarbon tail but were not biodegradable in the environment. The development of a straight-chain tail like the structure of regular soaps led to the second generation of detergents being biodegradable.

- (d) (i) Temperature change (1 mark) is the only factor that changes the value of an equilibrium constant.
- (ii) Two methods that could be used to increase the yield of nitrogen dioxide are
- Increase the pressure (1 mark) of the gases
  - Lower the temperature (1 mark)

(iii)



moles initially      0.25      0.12      0

moles at equilibrium      0.25 - 2x      0.12 - x      2x

Since  $0.25 - 2x = 0.05$ ,  $x = 0.1$  and moles L<sup>-1</sup> at equilibrium:

$$K = \frac{[\text{NO}_2]^2}{[\text{NO}]^2[\text{O}_2]} = \frac{0.05}{(0.02)^2} = 800 \text{ (mol L}^{-1})^{-1}$$

$$K = \frac{(0.2)^2}{(0.05)^2 (0.02)} = \frac{0.04}{5 \times 10^{-5}} = 800 \text{ (mol L}^{-1})^{-1}$$

(e)

The general answer to this question requires the student to:

- select an environmental problem in a named acid production (1 mark)
- state how this problem has been solved or addressed (1 mark)
- assess how effective the remedy has been (1 mark)

These should then be repeated for the base.

Sample answers:

*Acid production*

The contact process is used to oxidise sulfur dioxide (SO<sub>2</sub>) to sulfur trioxide (SO<sub>3</sub>) in the production of sulfuric acid. An environmental problem is the release of small amounts of SO<sub>2</sub> into the atmosphere. This is a problem as it is poisonous to plants and animals, increases corrosion and adds to acid rain and smog.

A method to address this is to pass the exiting gases from the contact process through a 'scrubber' to mix with a solution of Caro's acid (H<sub>2</sub>SO<sub>5</sub>). This powerful oxidizer converts SO<sub>2</sub> to sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). This is an excellent way to address the problem as over 90% of the already small residual SO<sub>2</sub> is removed in this way to form usable product.

OR

The source sulfur material in the manufacture of sulfuric acid was once just elemental sulfur. However, use of waste gases from the roasting of sulfide ores is now being used for almost half the source material.

For example, roasting of Zn ore:  $\text{ZnS} + \frac{3}{2} \text{O}_2 \rightarrow \text{ZnO} + \text{SO}_2(g)$

The roasting of ores produces large amounts of dangerous sulfur dioxide gas. This is now effectively contained and used as a cheap starting material for sulfuric acid production and has reduced gaseous pollution in the metal ore roasting industry.

OR

Sulfur exists as a pollutant in natural gas and petroleum. As these fuels burn they produce SO<sub>2</sub>(g) which is a pollutant in industrial areas and cities. From the 1970s onward, it has been possible to extract sulfur from the natural gas and petroleum to use as a cheap starting material for sulfuric acid production. This has led to a greatly reduced amount of acid rain and smog in industrial areas.

## AND

*Base production*

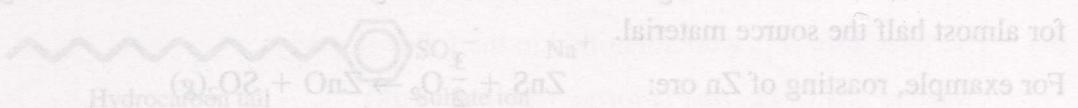
In the mercury cell for the electrolytic production of sodium hydroxide ( $\text{NaOH}$ ) from salt brine, liquid mercury is used as the cathode. Sodium metal forms at this cathode and dissolves in the mercury. The mercury is transferred to the denuding chamber to react with water and produce  $\text{NaOH}$ . However, small amounts of mercury are lost in wastewater. This can cause severe environmental damage because it accumulates in the aquatic food chain. This problem has been addressed by the development and use of the diaphragm cell. This uses a steel cathode and separation of the products is achieved using a diaphragm. The mercury pollutant has been completely eliminated with the use of the newer diaphragm cells.

## OR

In the production of sodium hydroxide ( $\text{NaOH}$ ) using a diaphragm cell, asbestos has been used most widely for the diaphragm separating the two half-cells. When the diaphragm needs replacing, workers would be exposed to the asbestos fibres that cause asbestososis. Waste asbestos in used diaphragms was also difficult to dispose of in environmentally acceptable ways. In a type of cell developed recently, the diaphragm is replaced by a semi-permeable membrane that allows the passage of  $\text{Na}^+$  ions but not  $\text{OH}^-$  ions. This has completely eliminated the danger to workers caused by asbestos and, in addition, the concentration of  $\text{NaOH}$  produced by this cell is more concentrated than that from the diaphragm cells.

*Development of synthetic detergents (2 marks)*

Synthetic detergents were designed to OR mimic the structure and thus the action of soaps. Internally, they consist of a long-chain hydrocarbon tail and a polar head containing a negative ion at the head and a positive ion at the tail.



The first soaps had a branched hydrocarbon tail but were not biodegradable in the environment. The branched nature of the tail did not allow the soap to break down easily, leading to the second generation of detergents being biodegradable.

## OR

(i) Temperature change (1 mark) is the only factor that changes the value of an equilibrium constant.

(ii) Two methods that could be used to increase the yield of nitrogen dioxide are

- Lower the temperature (1 mark)