

2006 HSC Examination Paper

Sample Answers

Section I Part A

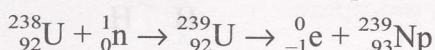
- 1** C Large hydrocarbon molecules are cracked to produce ethylene. Although glucose can be fermented to form ethanol, which can be dehydrated to ethylene, this is not the main industrial source.
- 2** A
- 3** B The other three alternatives have either nuclei with more than 82 protons or nuclei with a proton:neutron ratio outside the zone of stability.
- 4** C $\Delta H = -mC\Delta T$
 $= -300 \times 4.18 \times 20.5$
 $= -25.707 \text{ kJ per } 1.15 \text{ g ethanol}$
 $= -1028.3 \text{ kJ per mol ethanol}$
- 5** B 1,1-dichloropropane, 1,2-dichloropropane, 1,3-dichloropropane and 2,2-dichloropropane.
- 6** B Each monomer weighs 180 and there are five monomers, so total = 900. When two monomers link together a water molecule is lost, therefore four water molecules are lost, weighing 72. Net weight = $900 - 72 = 828$.
- 7** A
- 8** B HCl is a stronger acid than CH_3COOH and 0.1 mol L^{-1} is considered to be dilute.
- 9** C Equivalence point is defined as the point at which there are chemically equivalent amounts of acid and base present. H^+ is acid and OH^- is base.
- 10** C $n(\text{P}_2\text{O}_5) = \frac{1.42}{141.94} = 0.01 \text{ mol}$.
 $0.01 \text{ mol P}_2\text{O}_5$ produces $0.01 \times 2 \text{ mol H}_3\text{PO}_4$
 $n(\text{NaOH})$ required to neutralise $0.02 \text{ mol H}_3\text{PO}_4 = 3 \times 0.02 = 0.06 \text{ mol}$.
 $V(\text{NaOH}) = \frac{0.06}{0.30} = 0.2 \text{ L}$
- 11** D Arrhenius proposed that an acid is a substance that ionises in solution to produce hydrogen ions. He went further to say that acids were strong if they ionised completely and weak if they ionised partially.
- 12** A Catalysts increase the rate of a reaction by reducing the activation energy. They do not increase the yield of a product as they increase the rate of both forward and reverse reactions equally in equilibrium reactions.
- 13** D
- 14** D 0.391 is the average of samples 1, 2, 4 and 5. Sample 3 is an outlier as it is distinctly different to the other readings. All readings were given to three significant figures and the average cannot be more accurate than the least accurate figure used in its calculation.

- 15 A** The production of ammonia from nitrogen and hydrogen is exothermic. Therefore a lower temperature will produce a higher yield. As 4 moles of gas react to produce 2 moles of ammonia product, a high pressure favours the formation of ammonia.

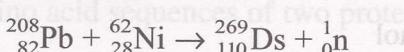
(d) The structure of the amino acid glycine

Section I Part B

- 16** The first three transuranic elements were produced by neutron bombardment in a nuclear reactor. Uranium-235 is used to provide neutrons and uranium-238 is used as the target to produce the transuranic element, neptunium:



Transuranic elements 96 and beyond have been produced in particle accelerators such as linear accelerators and cyclotrons. These devices accelerate positive particles such as protons, alpha particles or nuclei of larger atoms into heavy nuclei. For example the recently produced transuranic element, Darmstadtium, was produced by bombarding lead nuclei with nickel:

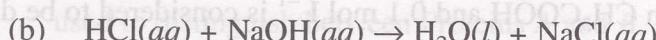


Linear accelerators accelerate positive particles in a straight line made alternately positive and negative so that the positive particles are being attracted from the front and repelled from behind. Cyclotrons also use the positive-negative field process but in addition use magnetic fields to keep the particles moving in a spiral path.

17 (a) $\text{pH} = -\log_{10}[\text{H}^+]$

$$= -\log_{10}(0.2)$$

$$= 0.7$$



$$n(\text{H}^+) = 0.2 \times 0.050$$

$$= 0.01 \text{ mol}$$

$$n(\text{OH}^-) = 0.01 \times 0.020$$

$$= 0.0002 \text{ mol}$$

$$n(\text{H}^+) \text{ in excess after addition of base} = 0.01 - 0.0002 = 0.0098 \text{ mol}$$

$$c(\text{H}^+) = \frac{0.0098}{0.070}$$

$$= 0.14 \text{ mol L}^{-1}$$

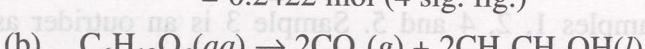
$$\text{pH} = -\log(0.14)$$

$$= 0.85$$

18 (a) $m(\text{CO}_2) = 381.05 - 370.39 = 10.66 \text{ g}$

$$n(\text{CO}_2) = \frac{10.66}{44.01}$$

$$= 0.2422 \text{ mol (4 sig. fig.)}$$

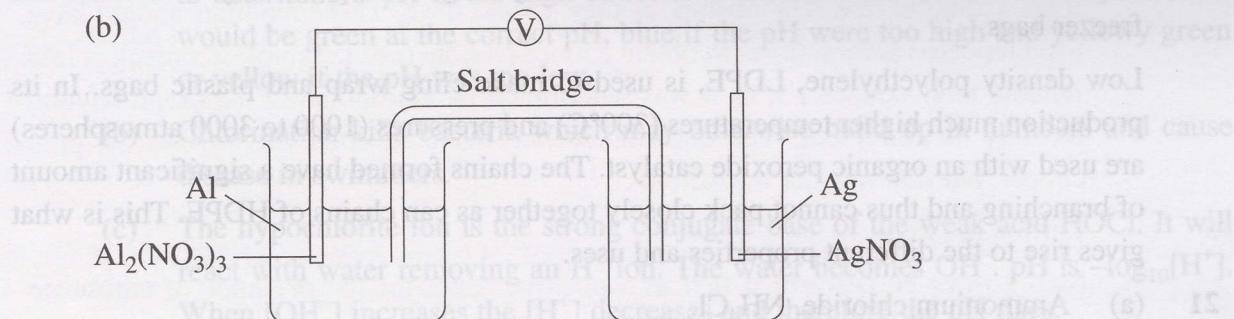


$$n(\text{C}_6\text{H}_{12}\text{O}_6) = \frac{n(\text{CO}_2)}{2} = 0.1211 \text{ mol}$$

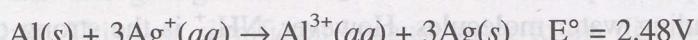
$$\begin{aligned} m (\text{C}_6\text{H}_{12}\text{O}_6) &= 0.1211 \times 180.156 \\ &= 21.82 \text{ g (4 sig.fig.)} \end{aligned}$$

19 (a) Aluminium and silver

(b)



(c)



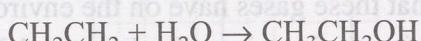
(d) Step 1: The student could have ensured that the conditions were standard. The temperature in the room should be controlled to 25°C, pressure 101.3 kPa and all solutions at a concentration of 1.0 mol L⁻¹.

Step 2: The student could have cleaned the electrodes before use with emery paper to remove any corrosion.

Step 3: The student could have placed one half-cell as a porcelain pot within the other half-cell. The porcelain acts as a more effective salt bridge than filter paper soaked in electrolyte solution.

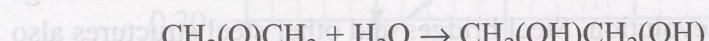
20 Ethylene, CH₂CH₂, contains an electron-dense double bond. The molecule is therefore unsaturated and will react readily with many substances forming new, often useful materials and potentially, fuels.

Ethylene is converted to ethanol by heating it with steam at 300°C at high pressure using a phosphoric acid catalyst.



Ethanol is useful as an industrial solvent. Although the ethanol added to petrol and used as a fuel blend presently comes from the fermentation of sugars from crops, ethanol could possibly be sourced from ethylene in the future if this was found to be more economic.

Ethylene will react with oxygen to form ethylene oxide in the presence of a silver catalyst at 250°C. This can be converted to ethylene glycol by reacting it with dilute sulfuric acid.



Ethylene glycol is useful as an automotive antifreeze and in the production of plastics.

Ethylene is the monomer from which the polymer polyethylene is made. Polyethylene is the most widely used plastic. There are two types of polyethylene, high and low density. High-density polyethylene, HDPE, is produced at low pressure and a temperature of

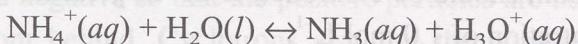
15 60°C with a Ziegler–Natta catalyst (a mixture of titanium(III) chloride and triethylaluminium). The catalyst attaches to the monomer, which links to other ethylene monomers, forming a very long chain. The chain formation stops when two such activated chains collide. HDPE is used to make garbage bins, plastic toys and boxes and freezer bags.

16 Low density polyethylene, LDPE, is used to make cling wrap and plastic bags. In its production much higher temperatures (300°C) and pressures (1000 to 3000 atmospheres) are used with an organic peroxide catalyst. The chains formed have a significant amount of branching and thus cannot pack closely together as can chains of HDPE. This is what gives rise to the different properties and uses.

- 21 (a) Ammonium chloride, NH_4Cl .

- (b) When ammonium chloride is dissolved in water it dissociates into its ions, NH_4^+ and Cl^- .

Cl^- is the weak conjugate of the strong acid, HCl , and as such will not react with the surrounding water molecules. However, NH_4^+ is the strong conjugate acid of the weak base ammonia, NH_3 . As such it will react with water to form ammonia and the hydronium ion.



Hydronium gives the salt its acidic nature.

- 22 There is both quantitative and qualitative evidence for the increasing amounts of sulphur oxides in the atmosphere since the Industrial Revolution. Levels of gases can be quantitatively measured by analysing the gases trapped in bubbles of Antarctic ice. As ice forms in Antarctica it traps bubbles of air which become samples of the atmosphere from the past. This procedure has been particularly useful for measuring levels of CO_2 and nitrogen oxides back to the Industrial Revolution and beyond. It has been less successful with sulphur oxides as these tend to react over time and leave less evidence than other gases. However, there is enough quantitative evidence to show increasing levels of sulphur oxides over the past 200 years.

Qualitative evidence comes from the effect that these gases have on the environment and the observation that these effects have been increasing since the Industrial Revolution. SO_3 gas reacts with water in the atmosphere forming sulfuric acid, $\text{H}_2\text{SO}_4(aq)$. This falls to earth as acid rain. Acid rain reacts with carbonates, found in limestone, marble and cement render, dissolving them.

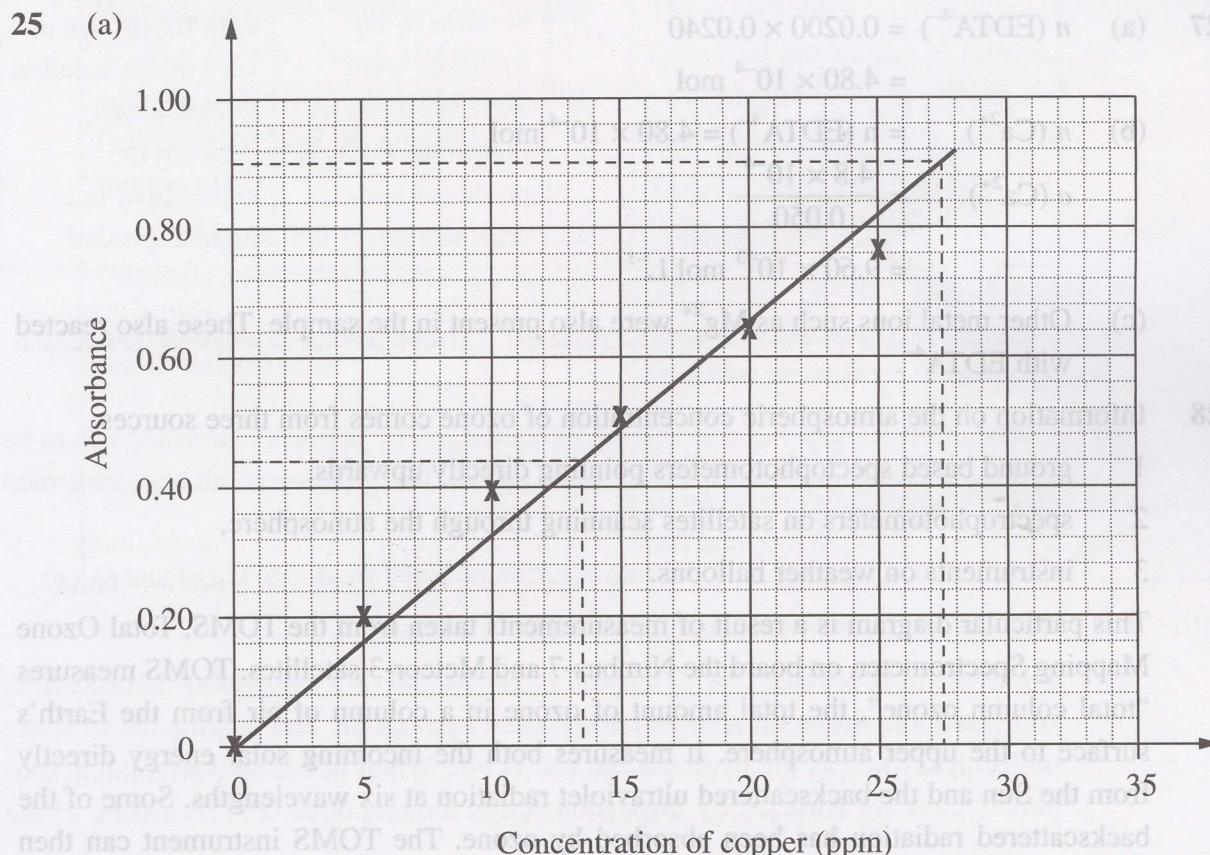


This has caused increasing levels of destruction to historically important buildings and statues made of calcium carbonate. There are records of the destruction of these buildings stretching back to the Industrial Revolution. Steel bridges and other steel structures also show evidence of damage due to acid rain because acids react with iron, dissolving it.



Both the quantitative and qualitative evidence indicates that the oxides of sulphur have been increasing in the atmosphere since the Industrial Revolution.

- 23** (a) Bromothymol blue is the best choice. Methyl orange would remain yellow if the pH were to rise a little above 7.6 or fall below 7.0. Phenolphthalein would remain colourless under these conditions. Therefore neither of these indicators allows you to determine if pH is too high or too low. On the other hand Bromothymol blue would be green at the correct pH, blue if the pH were too high and yellowish green or yellow if the pH was too low.
- (b) Chlorination kills bacteria which may otherwise build up in numbers and cause disease in swimmers.
- (c) The hypochlorite ion is the strong conjugate base of the weak acid HOCl. It will react with water removing an H^+ ion. The water becomes OH^- . pH is $-\log_{10}[H^+]$. When $[OH^-]$ increases the $[H^+]$ decreases and therefore the pH rises.
- 24** (a) $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$
- (b) Haber developed a method of producing ammonia by reacting together hydrogen gas and nitrogen gas at $400^\circ C$ and 250 atmospheres pressure with an Fe_3O_4 catalyst. This was significant because prior to his discovery the world relied on obtaining ammonia from natural sources of guano, principally from Chile. When Haber made his discovery in 1908, his home country Germany was preparing to enter a war which would become World War 1. Germany could not wage war without a reliable source of ammonia to fertilise crops to feed the German people and to produce nitric acid used to make explosives. Chile would cut off supply of guano as it was an ally of England. Haber's discovery allowed Germany to wage a war that they very nearly won; therefore his discovery was very significant at that time in world history.



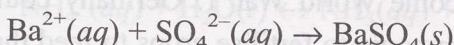
- (b) The concentration of copper present in sample 1 is 13–14 ppm.
 The concentration of copper present in sample 2 is 27–28 ppm.
 Neither estimate is particularly valid as the original absorbance readings did not form a straight line relationship, as they should have. These readings should have been repeated several times to obtain a more reliable result. Sample 2's result is less reliable than sample 1's, as it was determined by extrapolating the graph beyond the last measurement. The absorbance may have levelled off beyond 25 ppm copper, but this was not measured.

- 26** (a) Carbon dioxide.
 (b) Step 1 must be performed first as a positive result for the presence of carbonate produces bubbles which do not affect the reliability of future tests.

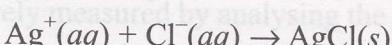


The excess acid does not affect the following tests and nitric acid will not precipitate chloride or sulfate ions. A precipitate at this stage would also make it harder to see the results of future tests.

Step 2 must be performed second because both Ba^{2+} and Ag^+ will precipitate sulfate but only Ag^+ will precipitate chloride.



Therefore Ba^{2+} must be added first to identify if sulfate ions are present. Chloride will not precipitate at this stage. In the final stage the Ag^+ will precipitate the chloride present.



- 27** (a) $n(\text{EDTA}^{4-}) = 0.0200 \times 0.0240$
 $= 4.80 \times 10^{-4} \text{ mol}$
- (b) $n(\text{Ca}^{2+}) = n(\text{EDTA}^{4-}) = 4.80 \times 10^{-4} \text{ mol}$
 $c(\text{Ca}^{2+}) = \frac{4.8 \times 10^{-4}}{0.050}$
 $= 9.60 \times 10^{-3} \text{ mol L}^{-1}$
- (c) Other metal ions such as Mg^{2+} were also present in the sample. These also reacted with EDTA^{4-} .

- 28** Information on the atmospheric concentration of ozone comes from three sources:
- 1 ground based spectrophotometers pointing directly upwards,
 - 2 spectrophotometers on satellites scanning through the atmosphere,
 - 3 instruments on weather balloons.

This particular diagram is a result of measurements taken from the TOMS, Total Ozone Mapping Spectrometer, on board the Nimbus-7 and Meteor-3 satellites. TOMS measures “total column ozone”, the total amount of ozone in a column of air from the Earth’s surface to the upper atmosphere. It measures both the incoming solar energy directly from the Sun and the backscattered ultraviolet radiation at six wavelengths. Some of the backscattered radiation has been absorbed by ozone. The TOMS instrument can then

compare the backscattered radiation to the incoming radiation which has not been absorbed, at identical wavelengths, and determine the amount of ozone above the Earth's surface.

Ozone concentrations are measured in Dobson Units, DU. The average amount of ozone in the stratosphere over the past 20 years has been about 300 DU. A concentration below 220 DU is referred to as a hole in the ozone.

Twenty years ago the level of ozone above Antarctica was about 270 DU. Over the past 20 years ozone levels have fluctuated but have generally been dropping. 230 DU were measured in 1990 and 216 in 1996. Some higher levels were recorded between 1996 and 2006, (275 DU was recorded in 2000), but very low levels of 102 DU in the spring of 2005 and 85 DU in 2006 indicate that ozone levels may still be falling even though CFCs have been banned for many years.

Options Topics**2006 HSC Examination Paper****Sample Answers****Question 29 Industrial Chemistry**

- (a) (i) The following risk assessment is for the electrolysis of a dilute solution of sodium chloride.

Substance/equipment	Identify the risk	Assess the risk	Control the risk
H ₂ (g) produced by the reaction	Hydrogen gas is explosive	Low risk of explosion due to the small amounts produced	To minimise the risk of an explosion, collect only one test tube of gas for the pop-test to confirm the gas as H ₂
Cl ₂ (g) could be produced in the reaction	Chlorine gas is toxic by inhalation	Low risk of producing Cl ₂ because dilute solutions were used; high risk of poisoning if Cl ₂ is produced and breathed in	To minimise the risk associated with Cl ₂ (g) use a very dilute solution of NaCl, and perform the experiment in a fume cupboard

[Note: the ‘control’ column addresses the requirement to show how the experimental procedure is influenced by the identified risks.]

- (ii) Observations: A gas was collected at the cathode. The pop test confirmed this to be hydrogen gas. A gas was collected at the anode. The glowing splint test confirmed this to be oxygen gas.
 Conclusion: Electrolysis of a dilute solution of NaCl produces H₂(g) and O₂(g).
- (b) (i) The molecules shown are anionic detergent molecules.
 (ii) Micelles form because the detergent molecule has a hydrophobic hydrocarbon “tail” and a hydrophilic anionic “head”. The hydrophilic end is attracted to water molecules, whereas the hydrophobic end is not. When added to water, the hydrophobic ends are attracted by dispersion forces to each other, and formation of the

micelle minimises the unfavoured interaction between these parts of the molecules and water.

- (iii) When oil is added to water containing anionic detergents, and the mixture is agitated, an emulsion forms. The hydrophobic ends of the detergent molecules are attracted to the oil droplets and surround them, becoming dissolved in the oil droplets (bonded by dispersion forces). The hydrophilic ends of the detergent molecules are attracted to water molecules, and bond to them by dipole–ion interactions. Agitation ensures that the oil droplets are fully surrounded by detergent molecules. The result is spherical micelles, and the dispersion of the oil droplets throughout the water (i.e. an emulsion). The oil droplets remain dispersed because of repulsion between micelles, due to the negative charges on their surfaces.
- (c) Natural supplies of fertiliser are shrinking relative to demand for them. Many nutrients such as N, P, and S are required by plants to ensure proper growth. When crops grow in a particular place, they use some of the available nutrients in the soil. After a number of crop cycles the soil becomes barren (unable to support plant growth) unless the nutrients are replaced using fertilisers. One natural fertiliser is the droppings of seabirds, called guano, high in N and P. However, supplies of natural fertiliser are shrinking, and global population increase has resulted in an increasing need for food production, and hence for fertiliser. There are many issues associated with this.

Issues associated with shrinking natural fertiliser deposits	Evaluation of progress made to address these issues
<p>Without fertiliser, soils become unable to support crop growth and thus a country's ability to feed its population is threatened, and the possibility of famine exists.</p>	<p>These issues are addressed by the industrial production of fertiliser, for example ammonium sulfate, and ammonium nitrate. For example:</p>
<p>Dwindling natural reserves of essential materials such as fertilisers can lead to conflict between resource-rich and -poor nations.</p>	$\text{N}_2(g) + 3\text{H}_2(g) \leftrightarrow 2\text{NH}_3(g)$ $2\text{NH}_3(g) + \text{H}_2\text{SO}_4(aq) \rightarrow (\text{NH}_4)_2\text{SO}_4(aq)$ <p>This is an excellent way of helping to minimise famine and resource-based conflict. However it is essential that poorer nations can afford to purchase fertiliser, and much more work needs to be done on its fair distribution using foreign aid and grants.</p>

Issues associated with shrinking natural fertiliser deposits	Evaluation of progress made to address these issues
<p>Increased reliance on natural fertilisers puts pressure on ecosystems – for example, mining operations to obtain it can destroy habitat, pollute water bodies, and release atmospheric pollutants such as CO_2.</p>	<p>Environmental Impact Analyses (EIAs) are used to predict the effect of mining on ecosystems, and to develop strategies for rehabilitating affected areas when mining has ceased. They can be very successful in reducing the impact of pollution from mining, but are not as successful in minimising habitat loss. Progress in this area needs to be much more rapid, and needs to be taken much more seriously by governments and mine operators to ensure that maximum biodiversity is maintained.</p>
<p>Increased fertiliser production requires increased industrial activity, which consumes more fuel (e.g. the Haber–Bosch process requires 400°C), releasing more pollutants such as CO_2.</p>	<p>Progress to reduce emissions of e.g. CO_2 has been mixed. A number of countries have committed to the Kyoto Protocol, whereas others, such as Australia and the USA, have not. Governments have put incentives in place for companies to minimise CO_2 emissions, and there is ongoing research in all developed countries into alternative energy sources. However progress has not been rapid enough in this area and much more work needs to be done to minimise the extent and effects of global warming.</p>

- (d) (i) Sulfur.
- (ii) $\text{SO}_3(g)$ is mixed with concentrated sulfuric acid to form oleum:
- $$\text{SO}_3(g) + \text{H}_2\text{SO}_4(l) \rightarrow \text{H}_2\text{S}_2\text{O}_7(l)$$
- This is done because dissolving SO_3 directly into water to produce H_2SO_4 is very exothermic, and results in formation of a sulfuric acid mist which is dangerous and difficult to handle. The oleum formed in the above reaction can be safely mixed with water to form sulfuric acid:
- $$\text{H}_2\text{S}_2\text{O}_7(l) + \text{H}_2\text{O}(l) \rightarrow 2\text{H}_2\text{SO}_4(l)$$
- (b) (i) The sulfuric acid thus produced has a concentration of about 18 M.
- (iii) The second step in the Contact process is the conversion of $\text{SO}_2(g)$ into $\text{SO}_3(g)$. It is an equilibrium reaction, and is exothermic:
- $$2\text{SO}_2(g) + \text{O}_2(g) \leftrightarrow 2\text{SO}_3(g) + \text{heat}$$

To res According to Le Chatelier's principle the conditions required to maximise the yield of SO_3 are: low temperature (because the forward reaction is exothermic); high pressure (because the forward reaction produces fewer moles of gas); and an excess of oxygen gas (shifting the equilibrium position to the right to consume oxygen). Rates of chemical reactions are increased by high temperatures (increasing collision frequency and energy), high pressures (increasing collision frequency) and use of a catalyst. In step 2 of the Contact process:

- A high yield is obtained at atmospheric pressure, and so high pressures are not used. This makes the process cheaper and safer.
- An excess of $\text{O}_2(g)$ is used to increase the yield because oxygen gas is relatively cheap to obtain by fractional distillation of air.
- A temperature of about 600°C is used as a compromise: too high and it reduces the yield, too low and it reduces the rate. This compromise temperature gives the best combination of rate and yield.
- Finely divided $\text{V}_2\text{O}_5(s)$ is used as a catalyst to increase the rate further. It provides an alternative mechanism with a lower activation energy. Its high surface area increases the sites available for the reaction to take place. It is present in three separate beds, each at a slightly lower temperature. The gaseous mixture is passed over each in turn, to increase the yield of SO_3 .

To restore the lead cannon balls they must be removed and immersed in dilute hydrochloric acid to dissolve any carbonate encrustations. The balls would then be soaked in an EDTA solution at a basic pH. This dissolves lead compounds as it bonds strongly to Pb^{2+} ions.

Electrolysis is used to remove any chloride and sulfate ions left the lead structure as well.

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