

2001 HSC Examination Paper

Sample Answers

Section I Part A

- 1 D Ethene (ethylene) is the monomer used in the production of the polymer poly(ethene) (polyethylene). No molecules are lost in the process.
- 2 A Biomass is largely composed of plant matter. Plant matter is largely composed of cellulose and lignin.
- 3 C Catalytic cracking is the chemical process whereby large hydrocarbon molecules are broken down into smaller, more useful molecules using an inorganic catalyst such as Al_2O_3 . When an alkane is cracked, at least one alkene must be formed.
- 4 B Cellulose is a polymer made up of beta-D glucose monomers. When linked together, every second monomer must be inverted.
- 5 A A pH of 6.0 is slightly acidic. CO_2 , found naturally in the atmosphere, reacts with water forming the weak acid, H_2CO_3 .
- 6 C When a solution containing bromothymol blue is blue the pH must be higher than 7.5. When a solution containing phenolphthalein is colourless the pH must be lower than 8.5.
- 7 A The base NaOH turns the red indicator to purple. The acid HCl causes no colour change. Ammonia is basic. The other three options are acidic.
- 8 B $n(\text{S}) = \frac{8.00}{32.07} = 0.25 \text{ mol}$
0.25 mol of S produces 0.25 mol $\text{SO}_2(g)$
 $V(\text{SO}_2) = 0.25 \times 24.47 = 6.12 \text{ L}$
- 9 D Le Chatelier's principle explains shifts in a system already in equilibrium due to changes in concentration or temperature.
- 10 C The second equation is not an equilibrium system. Therefore a change in SO_4^{2-} concentration will not cause a shift and the concentration of the hydrogen ion will not change.

- 11 B
- 12 D AAS is only used to determine low metal ion concentrations.
- 13 A To get an accurate mass of precipitate, it must be dried thoroughly. Any moisture present will add to the mass giving an unreliable result.
- 14 B The contaminated water must pass through the filter. The filter with the highest surface area would be most effective.

Fat or oil	Lauric	Palmitic	Stearic	Oleic	Linoleic
Butter	2-3	23-26	10-13		
Lard	1-2	22-30	12-18	11-19	6-7

Section I Part B

- 16 Cobalt-60 is used in medicine as a treatment for cancer. This isotope decays by beta emission and also releases gamma rays. Gamma radiation kills cancer cells because it is able to penetrate quite deeply into body tissue and is high enough in energy to destroy the DNA within cells.

Cobalt-60 has a half-life of 4 to 6 years, which is long enough so that it doesn't need replacing often in the equipment, but is short enough that the source of the radiation emits enough energy to be effective in killing cells.

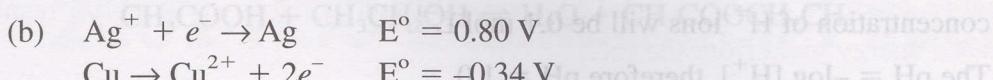
- 17 (a) Heat was lost by radiation from the gauze and the beaker.
 (b) A heat shield could be placed around the apparatus to reduce heat loss to the environment.

The spirit burner could be raised so that the flame is closer to the beaker of water and the gauze not used. This should also reduce heat loss.

$$\begin{aligned}
 \text{(c)} \quad \Delta H (\text{water}) &= m C \Delta T \\
 &= 250.0 \times 4.18 \times 40 \\
 &= 41\,800 \text{ J} \\
 \text{(ii)} \quad \text{moles of ethanol} &= \frac{2.3}{46.1} = 4.99 \times 10^{-2} \text{ mol} \\
 \Delta H (\text{ethanol}) &= \frac{-41.8 \text{ kJ}}{4.99 \times 10^{-2} \text{ mol}} \\
 &= -838 \text{ kJ mol}^{-1}
 \end{aligned}$$

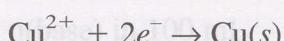
End of paper

- 18** (a) The student should draw a line connecting the two solutions, representing a salt bridge.



Cell voltage
 $= 0.80 - 0.34$
 $= +0.46 \text{ V}$

- (c) The generator applies the voltage in the opposite direction and electrons flow to the copper electrode. Copper ions are reduced at the copper electrode.



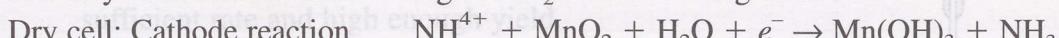
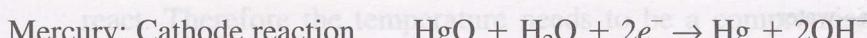
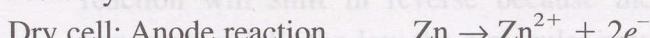
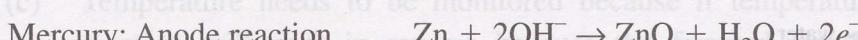
The solid copper forms on the electrode, increasing its mass.

- 19** Mercury button cell compared to dry cell

Both cells have a zinc anode. However the cathode in the mercury cell is C and HgO , while in the dry cell it is C and MnO_2 .

Both cells use a paste-type electrolyte, KOH in the mercury cell and NH_4Cl in the dry cell.

The anode and cathode reactions are different in each cell:



The dry cell has had a great impact on society being the first fully portable battery. They are also robust and easy to store. For these reasons they allowed portability of torches, radios and battery operated toys. However, the mercury button cell has also had a large influence on society. Because of its small size, it has allowed miniaturisation of calculators, cameras and watches.

One of the problems with the dry cell is that the voltage drops during use and it is therefore only useful for infrequent use, for example in torches used occasionally during a blackout. The mercury cell provides a constant voltage over a long period so that no frequent changing of cells is necessary. For these reasons it is useful in hearing aids and watches.

Both cells are relatively inexpensive, the dry cell more so, making them available to the general public.

Neither cell causes any serious environmental damage. The dry cell contains small amounts of zinc, a heavy metal, and the mercury cell contains mercury which is toxic. However, the amounts are so small that they can be disposed of along with household garbage.

20 (a) pH meter

- (b) HCl is a strong acid and therefore ionises fully. In a 0.1 mol/L solution, the concentration of H^+ ions will be 0.1 mol L^{-1} .

$$\text{The pH} = -\log [\text{H}^+], \text{ therefore pH} = 1.0.$$

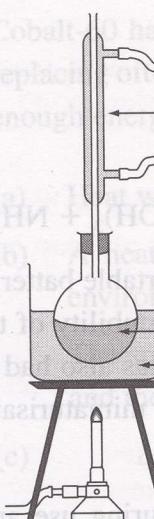
Citric acid is a weak acid and does not completely ionise; that is, it ionises less than HCl does. Therefore in a 0.1 mol/L solution the concentration of H^+ ions will be less than 0.1 mol L^{-1} and the pH more than 1.0.

21 (a) Neutralisation or acid base

- (b) Conductivity begins high as $\text{Ba}(\text{OH})_2$ solution contains a high concentration of Ba^{2+} and OH^- ions which are free and mobile and therefore conduct current. As the acid is added to the solution, the H^+ ions neutralise the OH^- to water molecules and the SO_4^{2-} ions join with the Ba^{2+} ions forming a precipitate.

The concentration of mobile ions falls until the equivalence point is reached. This is the low point on the graph and it indicates the point when there is the smallest concentration of mobile ions. The graph then indicates a steady rise in conductivity. This is due to the excess H_2SO_4 being added. As the acid is added the concentration of H^+ and SO_4^{2-} ions rises steadily.

22



Add together 20 mL glacial acetic acid, 20 mL ethanol and a few drops of concentrated sulfuric acid in a reaction flask. Add a few glass boiling chips to disperse the heat and prevent the mixture from bumping.

Heat in a hot water bath under reflux for 40 minutes. The hot water bath provides a constant heating temperature of 100°C around the flask. A Bunsen flame could not be used directly because the flame is too hot and the reactants are volatile and flammable and may be ignited by the flame.

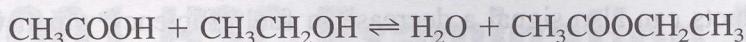
The mixture needs to be heated to increase the rate of reaction and increase the yield of the ester product.

The sulfuric acid is added to act as a catalyst.

23

24

The reason for heating under reflux is that the reactants are volatile and so they vaporise, but are returned to the mixture to continue heating when they would otherwise escape.



- 23** (a) A base is a proton acceptor.

$$\begin{aligned}\text{(b)} \quad n(\text{HCl}) &= 0.1000 \times 0.0244 \\ &= 0.00244 \text{ mol}\end{aligned}$$

$n(\text{base}) = 0.00244 \text{ mol}$, because the acid/base mole ratio is 1:1 from the equation $\text{HCl} + \text{NaX} \rightarrow \text{H}_2\text{O} + \text{NaCl}$

$$\begin{aligned}n(\text{base}) \text{ in } 100 \text{ mL} &= 0.00244 \times 5 \\ &= 0.0122 \text{ mol}\end{aligned}$$

$$\begin{aligned}M (\text{base}) &= \frac{1.00}{0.0122} \\ &= 82.0 \text{ g mol}^{-1}\end{aligned}$$

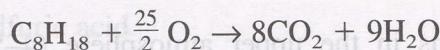
- 24** (a) Ammonia is used in the production of fertilisers.

(b) When ammonia gas is liquefied, the concentration of the gas is reduced. The equilibrium will shift forward to partially counteract the change, increasing the yield of ammonia.

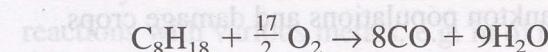
(c) Temperature needs to be monitored because if temperature rises too high the reaction will shift in reverse because the forward reaction is exothermic. If temperature falls too low the molecules may not have enough activation energy to react. Therefore the temperature needs to be a compromise such that there is a sufficient rate and high enough yield.

Pressure needs to be monitored to keep it high. A high pressure causes an increased rate of the forward reaction because there are more moles of gas reactant than product. The forward reaction counteracts an increase in pressure.

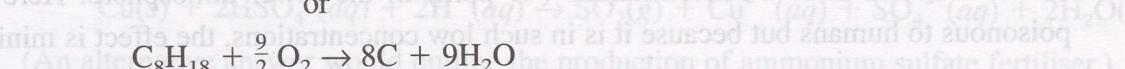
- 25** Combustion is the reaction of a fuel with oxygen to release energy. When a plentiful supply of oxygen is available, complete combustion occurs. Carbon dioxide and water are the only products.



The products need to be monitored because if oxygen becomes limiting, alternative substances are produced that are more harmful to the environment and human population than carbon dioxide.



or



Carbon monoxide (CO) is a poisonous gas and can therefore affect human health. Carbon (soot) is carcinogenic to humans and can be irritating to the lungs. Both of these alternative products can also signal a decrease in fuel efficiency which will result in a decreased energy yield from the fuel.

The pH = $-\log [H^+]$, therefore pH = 1.0

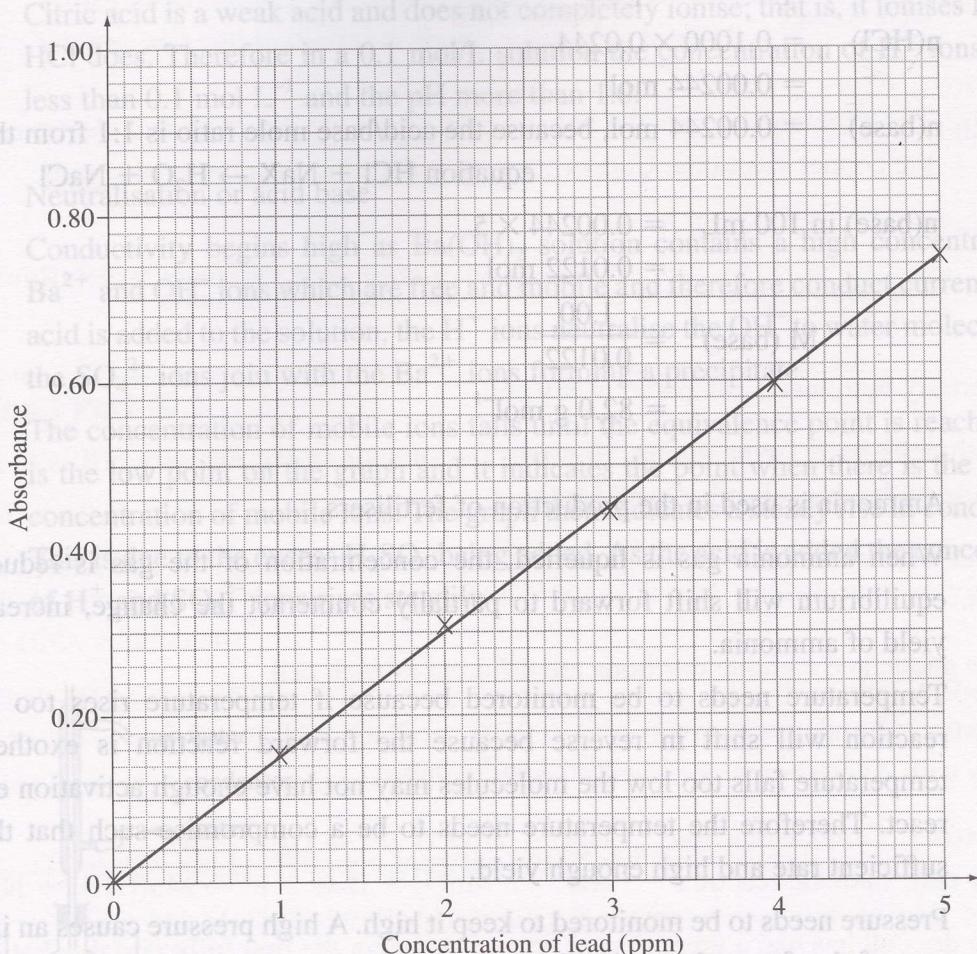
26 (a) Citric acid is a weak acid and does not completely ionise; that is, it ionises less than 100%. As the concentration of citric acid increases, the pH decreases.

21 (a) NaCl is a strong electrolyte. It dissociates completely into Na⁺ and Cl⁻ ions. The concentration of Na⁺ ions is equal to the concentration of Cl⁻ ions.

(b) Conductivity increases with increasing concentration of Ba²⁺ and SO₄²⁻ ions. The conductivity of an acid is proportional to the concentration of hydrogen ions.

22 (a) The concentration of lead in the front garden is higher than in the back garden. This is due to proximity to the main road.

(b) The concentration of lead in the front garden and around the mail box compared to the back garden and back fence are due to proximity to the main road.



(b) 1.5 ppm

(c) That the higher levels of lead in the front garden and around the mail box compared to the back garden and back fence are due to proximity to the main road.

27 Ozone is found in high concentrations in the upper atmosphere (4–5 ppm in the stratosphere). Here it is important to the environment as it absorbs UV-B radiation from the sun. This form of radiation would be damaging to the environment and human health if it were to pass through the atmosphere to earth. It would cause increased melanomas and cataracts in humans, reduce phytoplankton populations and damage crops.

Ozone is found in low concentrations (<1 ppm) in the lower atmosphere. Here it is poisonous to humans but because it is in such low concentrations, the effect is minimal.

The mixture needs to be heated to increase the rate of reaction and increase the yield of the ester product.

The sulfuric acid is added to act as a catalyst.

Question 29**Options Topics****2001 HSC Examination Paper****Sample Answers****Question 28****Industrial Chemistry**

- (a) (i) Electrolysis is the process in which electricity is used to produce a chemical reaction that does not occur spontaneously.
(ii) In the electrolysis of molten sodium chloride, sodium metal and chlorine gas are the only products.

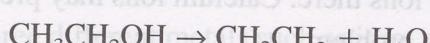
When concentrated aqueous sodium chloride is electrolysed, due to the presence of water, sodium hydroxide forms instead of sodium metal and hydrogen gas is also produced as well as chlorine gas.

- (b) (i) $\text{CO}(g) + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$
(ii) Cooling the reaction vessel would lead to more phosgene forming as the forward reaction is exothermic. Therefore, according to Le Chatelier's principle, lowering the temperature would be counteracted by the equilibrium shifting to the right.

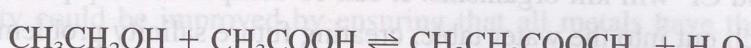
Also, if the temperature is kept below 8°C the phosgene condenses to a liquid that can be drawn off, further pushing the equilibrium to the right.

- (c) Sulfuric acid is important owing to its many applications and uses.

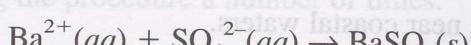
Concentrated sulfuric acid has a strong affinity for water making it a good dehydrating agent. This is useful in the production of ethylene from ethanol.



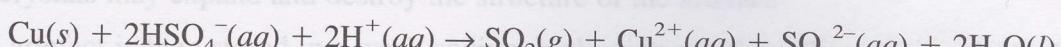
Sulfuric acid is used in the production of esters in which it acts as a catalyst to increase the rate of the reaction that is otherwise slow.



The presence of ions such as Ba^{2+} and Pb^{2+} in water can be tested by precipitating them with sulfuric acid.



Because it is a strong acid which readily ionises, sulfuric acid can be used as an electrolyte in lead-acid batteries. It also has useful properties as an oxidising agent in reactions with various metals, e.g. in oxidising copper to copper ions.



(An alternative answer would outline the production of ammonium sulfate fertiliser.)

- (d) (i) Saponification

(ii) 5 mL canola oil is added to 20 mL 4.0 M NaOH in a 500-mL beaker. The mixture is heated gently for 30 minutes on a hot plate. Water is added from time to time so that the volume of the mixture remains the same. 10 g NaCl is added to precipitate the soap formed. The mixture is further heated for 3 minutes. Soap is recovered from the mixture by filtration.

(iii) Safety risk: NaOH is corrosive and can burn the skin. To minimise the risk gloves and safety glasses must be worn when handling NaOH. Heat the mixture in a fume cabinet to avoid breathing fumes that may contain NaOH.

(e) The Solvay process involves reacting ammonia with concentrated brine in a Solvay tower. The process is exothermic, therefore the system is cooled by cold water pipes to achieve a greater yield. This ammoniacal brine is reacted with carbon dioxide and water to form hydrogencarbonate and ammonium ions. The solid compound sodium hydrogencarbonate crystallises within the tower forming sodium hydrogencarbonate which is filtered and washed to remove ammonium and chloride ions. The sodium hydrogencarbonate is heated strongly in a furnace to decompose it to sodium carbonate.

Environmental considerations

Ammonia and carbon dioxide are recycled and need monitoring. Ammonia can be toxic in closed areas. Carbon dioxide may contribute to global warming.

Heat: If cooling water is released into the ocean, there is little problem as heat is dissipated easily. However when released into lakes, the warm water can lead to eutrophication by reducing the dissolved oxygen in the water and must first be cooled in a cooling tower.

Calcium chloride: This can be dumped in the ocean because the calcium and chloride ions will not affect the balance of ions there. Calcium ions may precipitate out carbonate in the ocean but this is not a large problem.

CaCl_2 cannot be dumped in inland lakes because Ca^{2+} will contribute to hardening of the water and Cl^- will kill organisms. It can be dumped in deep pits as CaCl_2 solid but this may leach out into the water table, creating future salinity problems.

Evaluation: Although it has been shown that serious considerations need to be made when locating a Solvay processing plant, it can be done and still protect the environment. The best solution is a location near coastal waters.

The Solvay process is being phased out as improved methods of developing sodium carbonate are found.