SSABSA
SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA
EXTERNAL EXAMINATION 2006

2006 CHEMISTRY

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET 1

17 pages, 4 questions

Wednesday 15 November: 1.30 p.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (17 pages)
Question Booklet 2 (14 pages)
Question Booklet 3 (14 pages)
one SACE registration number label

Approved dictionaries and calculators may be used.

Instructions to Students

1. You will have 10 minutes to read the paper. You must not write in your question booklets or use a calculator during this reading time but you may make notes on the scribbling paper provided.

2. You will be expected to extract information such as atomic number and relative atomic mass from the periodic table on page 3 of Question Booklet 1, which you may remove from this booklet before the examination begins. Tables showing the relative activities of metals and SI prefixes are on the back of page 3.

3. This paper consists of twelve questions, four in Question Booklet 1, four in Question Booklet 2, and four in Question Booklet 3:

   Question Booklet 1 (Questions 1 to 4)
   Answer ***all parts*** of Questions 1 to 4 in the spaces provided in this question booklet.
   You may write on page 17 if you need more space to finish your answers.

   Question Booklet 2 (Questions 5 to 8)
   Answer ***all parts*** of Questions 5 to 8 in the spaces provided in Question Booklet 2.
   You may write on page 14 of Question Booklet 2 if you need more space to finish your answers.

   Question Booklet 3 (Questions 9 to 12)
   Answer ***all parts*** of Questions 9 to 12 in the spaces provided in Question Booklet 3.
   You may write on page 14 of Question Booklet 3 if you need more space to finish your answers.

4. There is no need to fill all the space provided; clearly written, well-expressed answers are required. If you delete part or all of an answer you should clearly indicate your final answer.

5. The total mark is 200. The twelve questions are of approximately equal value.

6. Attach your SACE registration number label to the box at the top of this page. Copy the information from your SACE registration number label into the boxes on the front covers of Question Booklet 2 and Question Booklet 3.

7. At the end of the examination, place Question Booklet 2 and Question Booklet 3 inside the back cover of Question Booklet 1.

STUDENT'S DECLARATION ON THE USE OF CALCULATORS

By signing the examination attendance roll I declare that:

- my calculators have been cleared of all memory;
- no external storage media are in use on these calculators.

I understand that if I do not comply with the above conditions for the use of calculators I will:

- be in breach of the rules;
- receive zero marks for the examination;
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as SSABSA determines.

PERIODIC TABLE OF THE ELEMENTS

1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminium 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.90	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (97)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	57[1] La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium 226.0	89[2] Ac Actinium (227)	104 (261)	105 (262)	106 (263)												

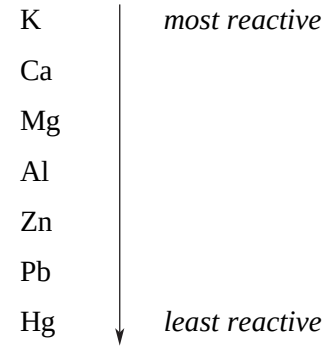
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinide Series[2]	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237.0	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (255)	103 Lr Lawrencium (260)

You may remove this page from the booklet by tearing along the perforations.

PLEASE TURN OVER

You may refer to the following table, which shows the relative activities of a number of metals, when answering questions that involve metals:

Metal Activity



You may refer to the following table, which shows SI prefixes, their symbols and their values, when answering questions that involve the conversion of units:

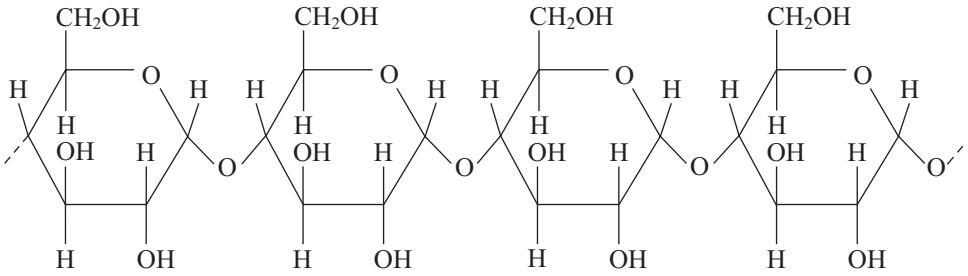
SI prefix	Symbol	Value
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

QUESTION 1

Starch can be used as a raw material for the production of industrial solvents.

(a) The first step in the production is the hydrolysis of starch to form glucose.

(i) The structural formula of a section of starch is shown below:



Draw a structural formula of the glucose monomer produced from starch.

(2 marks)

(ii) The conversion of starch into glucose occurs by enzyme-catalysed hydrolysis. Write an equation for the conversion of starch into glucose.

(2 marks)

(iii) An increase in temperature alters the rate of production of glucose by enzyme-catalysed hydrolysis.

(1) Explain why a small increase in temperature causes the rate of production of glucose to increase.

_____

_____

_____

_____ (2 marks)

(2) Explain why a large increase in temperature causes the rate of production of glucose to decrease.

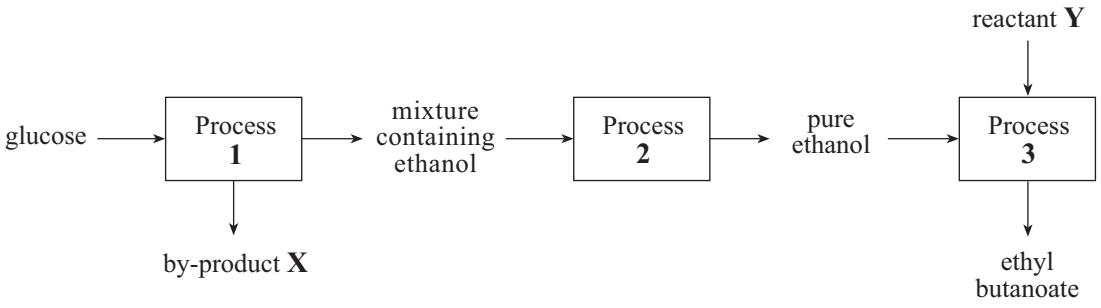
_____

_____

_____

_____ (2 marks)

(b) The conversion of glucose into the solvent ethyl butanoate is shown in the flow chart below:



(i) Name Process **1** shown in the flow chart above.

_____ (1 mark)

(ii) Identify by-product **X**.

_____ (1 mark)

(iii) Name Process **2**.

_____ (1 mark)

(iv) Draw the structural formula of ethyl butanoate.

(2 marks)

(v) Write the molecular formula of reactant **Y**.

_____ (2 marks)

(vi) Name the type of reaction that occurs in Process **3**.

_____ (1 mark)

(vii) A trace of concentrated sulfuric acid is added in Process **3**.

State the purpose of adding the concentrated sulfuric acid.

_____

_____ (1 mark)

TOTAL: 17 marks

QUESTION 2

Aura is a satellite that orbits the Earth. It collects data about molecules in the troposphere and the stratosphere.

(a) The concentrations of the oxides of sulfur and nitrogen in the troposphere are measured to determine their contribution to the formation of acid rain.

(i) (1) Write an equation for the reaction of SO_2 with water.

(2 marks)

(2) This reaction leads to the formation of acid rain.

Explain how the reaction of SO_2 with water lowers the pH of rainwater.

(2 marks)

(ii) Identify one environmental problem, other than acid rain, that may result from the presence of oxides of nitrogen in the troposphere.

(1 mark)

(b) The concentration of carbon dioxide in the troposphere is critical to life on Earth.

(i) Describe how carbon dioxide acts to maintain a steady temperature in the troposphere.

(3 marks)

(ii) Plants require carbon dioxide for photosynthesis.

Write an equation for photosynthesis.

(2 marks)

(c) (i) The concentration of ozone in the stratosphere was measured by *Aura* and compared with the concentration measured by another satellite. The results are shown in the table below:

concentration of ozone measured by *Aura*	253.9 units
concentration of ozone measured by other satellite	253 units

State how the measurement from *Aura* displays a greater resolution than the measurement from the other satellite.

_____

_____ (1 mark)

(ii) Increased concentrations of chemical species such as Cl and NO have led to a greatly decreased concentration of ozone in the stratosphere above the Antarctic over the past 40 years.

(1) Identify one source of NO in the stratosphere that is the result of human activity.

_____ (1 mark)

(2) Describe how increased concentrations of chemical species such as Cl and NO have led to a greatly decreased concentration of ozone in the stratosphere above the Antarctic.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) Explain one disadvantage that a decreased concentration of ozone in the stratosphere has for life on Earth.

_____

_____

_____

_____ (2 marks)

TOTAL: 17 marks

QUESTION 3

Polymers can be synthetic or naturally occurring.

(a) Polypropene is one example of a synthetic polymer. Polypropene is manufactured from propene gas. The structural formula of propene gas is shown below:

$$CH_2 = CHCH_3$$

(i) Draw the structural formula of a section of polypropene that shows at least two repeating units.

(2 marks)

(ii) Identify the type of polymerisation reaction by which polypropene is manufactured.

_____ (1 mark)

(iii) Polypropene softens when heated.

(1) State a term used to describe a polymer that has this property.

_____ (1 mark)

(2) State one advantage of this property.

_____ (1 mark)

(b) Polyethene is another example of a synthetic polymer. The industrial process used to manufacture polyethene requires various reaction conditions, including high pressure and the use of a catalyst.

(i) One advantage of using high pressure in the process is that it leads to an increase in the rate of the reaction.

Explain why high pressure leads to an increase in the rate of the reaction.

_____

_____

_____

_____ (2 marks)

(ii) State one disadvantage of using high pressure in the process. Give a reason for your answer.

_____

_____

_____

_____ (2 marks)

(iii) State one advantage to the manufacturer of using a catalyst in the process. Give a reason for your answer.

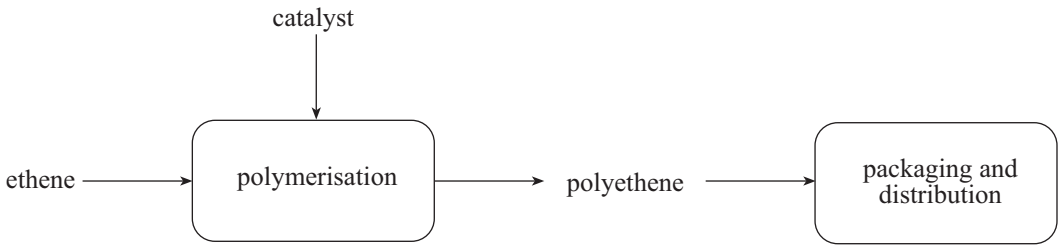
_____

_____

_____

_____ (2 marks)

(iv) The main steps in the manufacture of polyethene are shown in the flow chart below:



Using the information in the flow chart above, state one factor that should be considered when selecting a suitable site for a polyethene plant. Give a reason for your answer.

_____

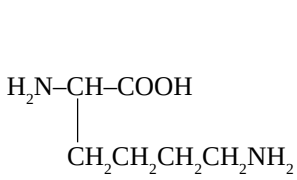
_____

_____

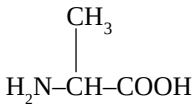
_____ (2 marks)

(c) Proteins are naturally occurring polymers. Elastin is a protein found in the walls of blood vessels.

(i) Elastin contains the amino acid units lysine and alanine. The structural formulae of lysine and alanine are shown below:



lysine



alanine

Draw the structural formula of a section of a protein chain that includes one unit of lysine and one unit of alanine.

(2 marks)

(ii) After stretching, elastin returns to its original size and shape.

Suggest how covalent cross links between the protein chains cause elastin to behave in this way.

_____

_____

_____

_____ (2 marks)

TOTAL: 17 marks

QUESTION 4

Potassium is an important plant nutrient that may be supplied to plants in different forms.

(a) Potassium may be supplied to plants as potassium nitrate, KNO_3, or as a zeolite charged with potassium ions.

(i) One advantage of using KNO_3 as a source of potassium is its solubility in water.

(1) State why plant nutrients must be supplied to plants in soluble form.

_____

_____ (1 mark)

(2) State one other advantage to the plant of supplying potassium as KNO_3.

_____

_____ (1 mark)

(ii) The formula of one zeolite is $K_2Al_2Si_3O_{10}.2H_2O$.

(1) State the charge on the aluminosilicate ion in this zeolite.

_____ (1 mark)

(2) Explain why, in regions of high rainfall, it is an advantage to use zeolites charged with potassium ions, rather than KNO_3, to supply potassium to plants.

_____

_____

_____

_____

_____

_____ (3 marks)

(b) Atomic absorption spectroscopy can be used to determine the concentration of potassium ions in soil water. Several solutions of known concentration of potassium ions were tested so that a calibration graph could be prepared. Three samples at each concentration were tested and their average absorbance was calculated. The results are shown in the table below:

Solution	**Concentration of $K^+_{(aq)}$ (mg L^{-1})**	**Absorbance**			**Average absorbance**
		Sample 1	**Sample 2**	**Sample 3**	
blank	0.00	0.008	0.006	0.008	0.007
Standard 1	0.55	0.200	0.199	0.206	0.202
Standard 2	1.10	0.399	0.399	0.390	0.396
Standard 3	2.20	0.768	0.771	0.756	0.765
Standard 4	4.40	1.595	1.651	1.551	1.599

(i) State one advantage of using average absorbances to plot the calibration graph.

_____

_____ (1 mark)

(ii) State one possible reason why the average absorbance of the blank samples is not zero.

_____

_____ (1 mark)

(iii) Compare the set of sample absorbances for Standard 2 with that for Standard 3.

(1) Identify the set of results that is more precise.

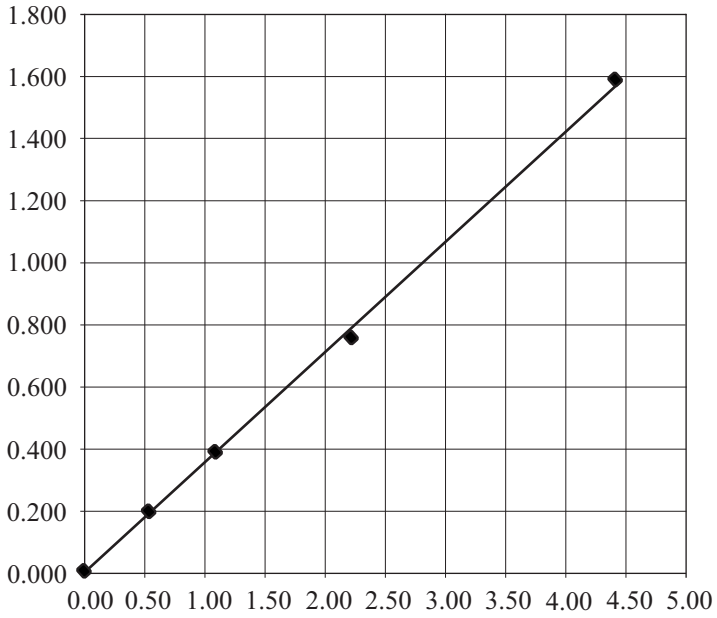
_____ (1 mark)

(2) State one reason for your answer.

_____

_____ (1 mark)

(iv) The calibration graph that was prepared is shown below:



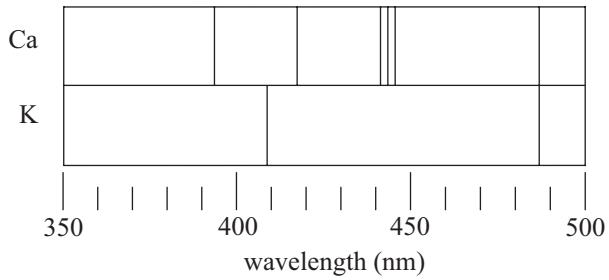
(1) Complete the calibration graph by labelling the axes. (2 marks)

(2) Use the calibration graph to determine the concentration of potassium ions, in mg L^{-1}, in soil water that has an absorbance of 0.550.

_____ (1 mark)

(v) The soil water that was tested also contained dissolved calcium ions.

Wavelengths of radiation emitted and absorbed by potassium and calcium over a limited range of the spectrum are shown in the diagram below:



Identify a wavelength of radiation in the spectrum above that would be suitable to use for the analysis of potassium in this soil water.

Explain your answer.

_____

_____

_____

_____

_____

_____ (3 marks)

TOTAL: 16 marks

You may write on this page if you need more space to finish your answers to Question Booklet 1. Make sure to label each answer carefully (e.g. 4(b)(i) continued).

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EXTERNAL EXAMINATION 2006

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FIGURES

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QUESTION BOOKLET

2

14 pages, 4 questions

Wednesday 15 November: 1.30 p.m.

Question Booklet 2

Write your answers to Questions 5 to 8 in this question booklet.

QUESTION 5

The production of zinc occurs in the steps listed below:

Step 1 Roasting of the mineral zinc sulfide in air.
Step 2 Production of sulfuric acid.
Step 3 Conversion of zinc oxide into zinc sulfate solution.
Step 4 Purification of zinc sulfate solution.
Step 5 Reduction of zinc sulfate solution.

(a) In Step 1 the roasting of the mineral zinc sulfide in air produces zinc oxide and sulfur dioxide gas, SO_2.

Write an equation for this reaction.

(2 marks)

(b) In Step 2 the SO_2 produced is used to make sulfuric acid. The first stage in the production of sulfuric acid is shown by the equation below:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad \Delta H = -198 \text{ kJ}$$

(i) Write a K_c expression for this reaction.

(2 marks)

(ii) State whether the reaction is exothermic or endothermic.

_____ (1 mark)

(iii) State and explain the effect on the value of K_c of increasing the temperature.

_____

_____

_____

_____

_____

_____ (3 marks)

(c) In Step 3 zinc oxide reacts with sulfuric acid to produce zinc sulfate solution.

Write an equation for this reaction.

(2 marks)

(d) In Step 4 metal ions that contaminate the zinc sulfate solution are removed by the addition of zinc powder.

Circle one ion, of those shown below, that will be removed by the addition of zinc powder.

Hg^{+} Pb^{2+} Mg^{2+} (1 mark)

(e) In Step 5 zinc sulfate solution is reduced to zinc using electrolysis. Electricity for this electrolysis is produced by the combustion of fossil fuels.

(i) State how the use of electrolysis suggests that the production of zinc from zinc sulfate is a non-spontaneous reaction.

_____ (1 mark)

(ii) State one reason why the manufacturer uses zinc sulfate solution, rather than molten zinc oxide, as the electrolyte for the electrolysis.

_____ (1 mark)

(iii) An alternative method of converting zinc oxide into zinc uses the reaction shown in the equation below:

$$ZnO + C \longrightarrow Zn + CO$$

Solar energy can be used to heat the reactants to the high temperatures required for the reaction.

Explain two advantages of using solar energy, rather than electricity produced by the combustion of fossil fuels, to produce zinc.

Advantage 1: _____

_____

_____

Advantage 2: _____

_____

_____ (4 marks)

TOTAL: 17 marks

QUESTION 6

Exhaust gases from motor vehicles may contain oxides of carbon and oxides of nitrogen.

(a) CO and CO_2 are two oxides of carbon present in the exhaust gases of motor vehicles that burn hydrocarbon fuels.

(i) State why both CO and CO_2 are present.

_____

_____

_____

_____ (2 marks)

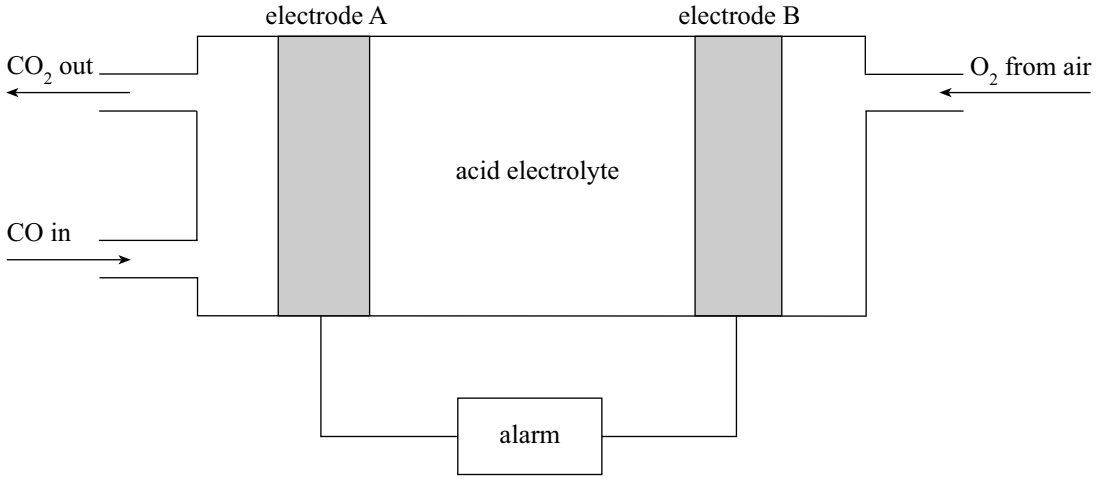
(ii) One reaction that leads to the formation of CO during the burning of hydrocarbon fuels is represented by the unbalanced equation below:

$$C_3H_8 + O_2 \longrightarrow CO + H_2O$$

Balance this equation. (1 mark)

(iii) Electrochemical devices are often used to detect harmful levels of CO in rooms. CO is used as a fuel in the device. High concentrations of CO cause an alarm to sound.

One detection cell is shown in the diagram below:



(1) The half-equation for the reaction at electrode B is shown below:

$$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$$

State whether electrode B is the anode or the cathode. Use the half-equation above to explain your answer.

(3 marks)

(2) Write a half-equation for the conversion of CO into CO_2 at electrode A.

(2 marks)

(3) On the diagram opposite, show the direction of the electron flow through the alarm.

(1 mark)

(b) NO and NO_2 are two oxides of nitrogen present in the exhaust gases of motor vehicles that burn hydrocarbon fuels.

Explain, with the aid of equations, why both NO and NO_2 are present.

(4 marks)

(c) When pure hydrogen is burnt as a fuel in motor vehicles, NO is still present in the exhaust gases but CO is not present.

(i) State why CO is not present.

_____

_____ (1 mark)

(ii) (1) Identify one method of energy production in which pure hydrogen is used as a fuel, and in which NO is not formed.

_____

_____ (1 mark)

(2) State one reason why NO is not formed.

_____

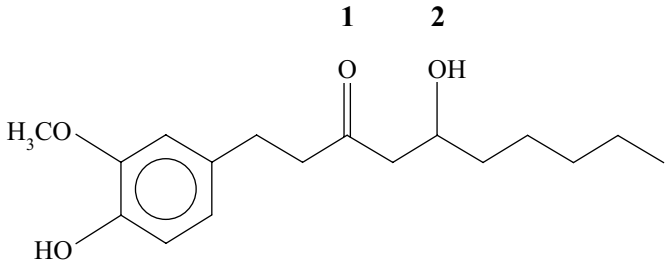
_____ (1 mark)

TOTAL: 16 marks

QUESTION 7

Many organic compounds are used to reduce inflammation and to relieve pain.

(a) Gingerol, a component of ginger, can be used to reduce inflammation. The structural formula of gingerol, with two of its functional groups numbered, is shown below:



(i) Name functional group **1**.

_____ (1 mark)

(ii) A sample of gingerol was mixed with acidified potassium dichromate solution and warmed. A colour change occurred.

(1) State the colour of the mixture after warming.

_____ (1 mark)

(2) The colour change was due to a reaction of one of the two numbered functional groups.

Identify the functional group that reacted, and state why only this functional group reacted.

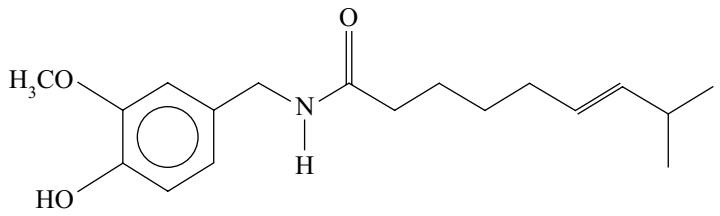
_____

_____

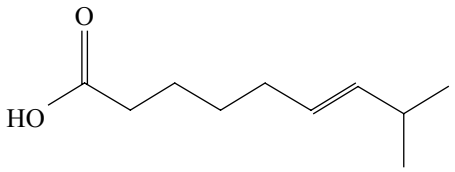
_____

_____ (2 marks)

(b) Capsaicin, a component of capsicum, can be used to relieve pain. The structural formula of capsaicin is shown below:



When capsaicin enters the stomach it is hydrolysed by the acidic solution in the stomach. The structural formula of one organic product of the hydrolysis reaction is shown below:



Draw the structural formula of the other organic product of the hydrolysis reaction.

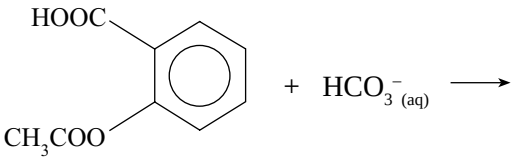
(2 marks)

(c) Aspirin is a drug commonly used to reduce inflammation and to relieve pain.

(i) Aspirin is often taken in ionic form. The ionic form is more soluble in water than the molecular form.

(1) The molecular form of aspirin reacts with $HCO_{3\ (aq)}^{-}$ to produce the ionic form of aspirin.

Complete the following equation for this reaction.



(2 marks)

(2) Explain why the ionic form of aspirin is more soluble in water than the molecular form.

_____

_____

_____

_____

_____

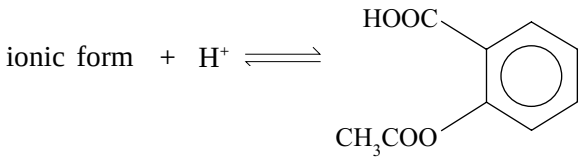
_____ (3 marks)

(ii) The solution in the stomach has pH = 2.1.

(1) Calculate the concentration of H^+ in the solution in the stomach.

(2 marks)

(2) In the stomach the ionic form of aspirin is in equilibrium with the molecular form, as shown in the diagram below:



molecular form

State and explain, in terms of the equilibrium shown above, which form of aspirin will be present in higher concentration in the stomach.

(3 marks)

TOTAL: 16 marks

QUESTION 8

The molar enthalpy of combustion of ethanol may be determined using calorimetry.

(a) The energy released by combustion of a sample of ethanol was determined in an experiment using a simple calorimeter.

The results obtained are shown below:

Mass of ethanol burnt	= 0.125 g
Mass of water in calorimeter	= 250 g
Initial temperature of water	= 17.0°C
Final temperature of water	= 19.0°C

4.18 J of energy is needed to raise the temperature of 1.0 g of water by 1.0°C.

(i) Calculate the energy, in kilojoules, absorbed by the water.

(2 marks)

(ii) Hence calculate the molar enthalpy of combustion of ethanol.

(3 marks)

(b) The molar enthalpy of combustion of ethanol was then determined in an experiment using a bomb calorimeter, as shown in the diagram below.

(i) The molar enthalpy of combustion of ethanol was found to be 1364 kJ mol^{-1}.

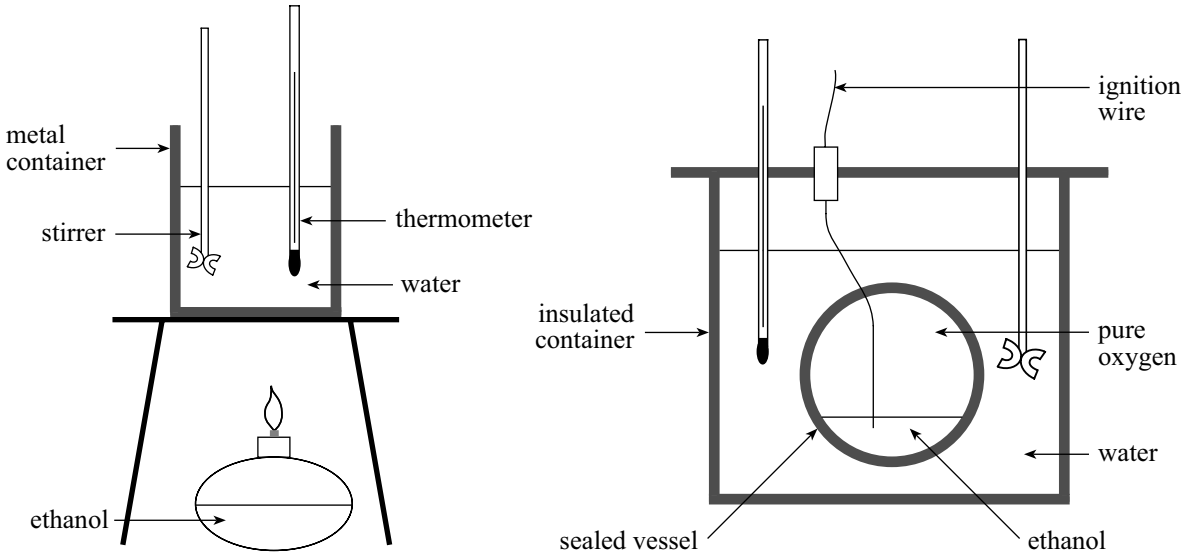
Write a thermochemical equation for the combustion of ethanol as determined using the bomb calorimeter.

(4 marks)

Credit will be given for answers to part (ii) which show clearly written, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer should be confined to the space provided and should take approximately 10 minutes.

(ii) The two calorimeters used in these experiments are shown in the diagrams below:



simple calorimeter **bomb calorimeter**

In the bomb calorimeter a sample of ethanol is placed in a sealed vessel containing pure oxygen gas and surrounded by a known mass of water. The ethanol ignites when an electric current heats the ignition wire.

Explain, by comparing three features of the calorimeters, why the values obtained for the molar enthalpy of combustion using the bomb calorimeter are greater than those obtained using the simple calorimeter.

(8 marks)

TOTAL: 17 marks

You may write on this page if you need more space to finish your answers to Question Booklet 2. Make sure to label each answer carefully (e.g. 7(c)(i)(2) continued).

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SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA

EXTERNAL EXAMINATION 2006

2006 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

3

14 pages, 4 questions

Wednesday 15 November: 1.30 p.m.

Question Booklet 3

Write your answers to Questions 9 to 12 in this question booklet.

QUESTION 9

Ethanal is a compound formed when ethanol enters the liver. Ethanal causes symptoms such as headache and nausea, and reacts with other substances in cells.

(a) Write the structural formula of ethanal.

(2 marks)

(b) A person drank a beverage containing ethanol. The concentration of ethanal in the blood leaving this person's liver 30 minutes later was 10.53 μmol L^{-1}.

Convert this concentration of ethanal into ppm. The molar mass of ethanal is 44 g mol^{-1}.

(3 marks)

(c) Disulfiram is a drug used to help people who are trying to stop drinking beverages that contain ethanol.

Disulfiram prevents the operation of the enzyme that oxidises ethanal.

(i) State the systematic name of the organic compound formed when ethanal is oxidised.

_____ (1 mark)

(ii) (1) Predict the effect of ethanol consumption on a person who has taken disulfiram.

_____

_____ (1 mark)

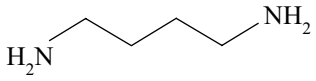
(2) State a reason for this effect.

_____

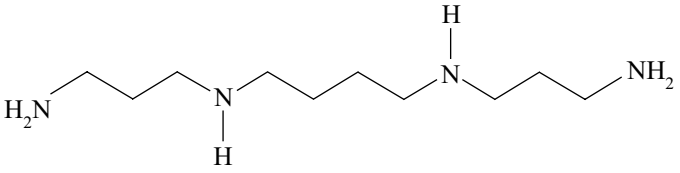
_____ (1 mark)

(d) Ethanal in the body reacts with polyamines in cells.

The structural formulae of two polyamines, putrescine and spermine, are shown below:



putrescine



spermine

(i) State the systematic name of putrescine.

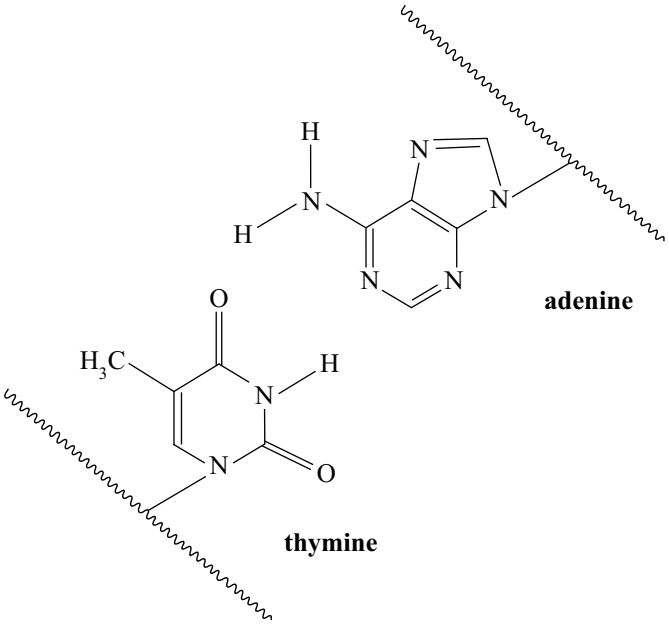
_____ (2 marks)

(ii) On the structural formula of spermine above, circle a secondary amino group. (1 mark)

(e) Ethanal in the body interferes with the normal action of the nucleic acids.

(i) The action of DNA and RNA depends on the polarity and shape of their base components.

(1) In DNA two strands are held together by hydrogen bonds between pairs of bases. An adenine–thymine base pair is shown in the diagram below:

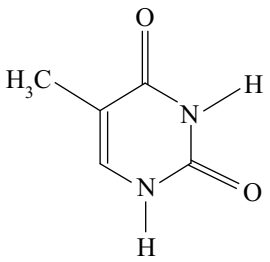


adenine

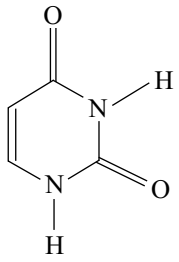
thymine

On the diagram above, draw one hydrogen bond. (1 mark)

(2) In RNA the base uracil is present in place of thymine. The structural formulae of thymine and uracil are shown below:



thymine



uracil

Use these structural formulae to explain why thymine is less polar than uracil.

_____

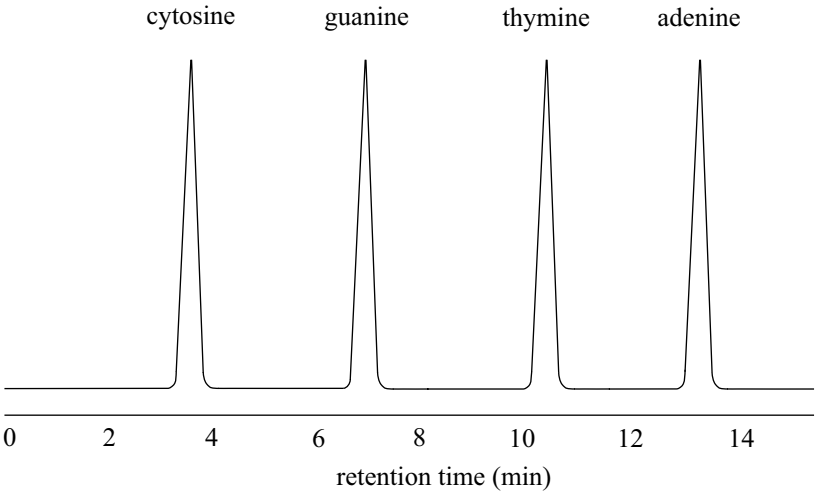
_____

_____

_____ (2 marks)

(ii) Ethanal in the body leads to the production of an altered form of the base guanine. The presence of the altered base can be detected by chromatography.

A mixture of the four normal DNA bases may be separated by liquid chromatography, using a polar solvent on a non-polar stationary phase. One chromatogram is shown in the diagram below:



(1) Explain how the chromatogram indicates that cytosine is the most polar base.

_____

_____

_____

_____

_____

_____ (3 marks)

(2) State how the presence of an altered form of the base guanine in a mixture of DNA bases would change the appearance of this chromatogram.

_____

_____ (1 mark)

TOTAL: 18 marks

QUESTION 10

Aspirin is a common pain-relieving drug. The following procedure was used to determine the percentage, by mass, of aspirin in aspirin tablets:

Step 1 Four aspirin tablets, each of mass 300.0 mg, were crushed and added to 30.0 mL of 1.0 mol L^{-1} NaOH solution. Excess NaOH remained after the reaction was complete.

Step 2 The excess NaOH was titrated with 0.50 mol L^{-1} H_2SO_4 solution from a burette.

(a) Suggest a reason why the aspirin tablets were crushed in Step 1.

_____ (1 mark)

(b) The burette used in this titration was prepared carefully, to ensure that the results were accurate.

State two steps that would have been followed in the preparation of the burette, and state why each step was necessary to ensure accuracy.

_____

_____

_____

_____

_____

_____

_____

_____ (4 marks)

(c) Bromothymol blue was used as an indicator for the titration. Bromothymol blue is yellow in acidic solution and blue in basic solution.

State the colour that would indicate the end-point of the titration.

_____ (1 mark)

Credit will be given for the correct use of significant figures in answers to part (d). (1 mark)

(d) (i) Calculate the number of moles of NaOH solution added to the aspirin tablets in Step 1.

(2 marks)

(ii) The equation for the titration reaction in Step 2 is shown below:

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$

In one titration 23.7 mL of H_2SO_4 was required to react completely with the excess NaOH.

(1) Calculate the number of moles of H_2SO_4 needed to neutralise the excess NaOH.

(2 marks)

(2) Hence calculate the number of moles of excess NaOH.

(1 mark)

(3) Hence calculate the number of moles of NaOH that reacted with the aspirin tablets in Step 1.

(1 mark)

(iii) Aspirin reacts with NaOH in a 1:1 mole ratio.

Use this information to calculate the total mass of aspirin in the tablets and hence the percentage, by mass, of aspirin in the tablets. The molar mass of aspirin is 180.17 g mol^{-1}.

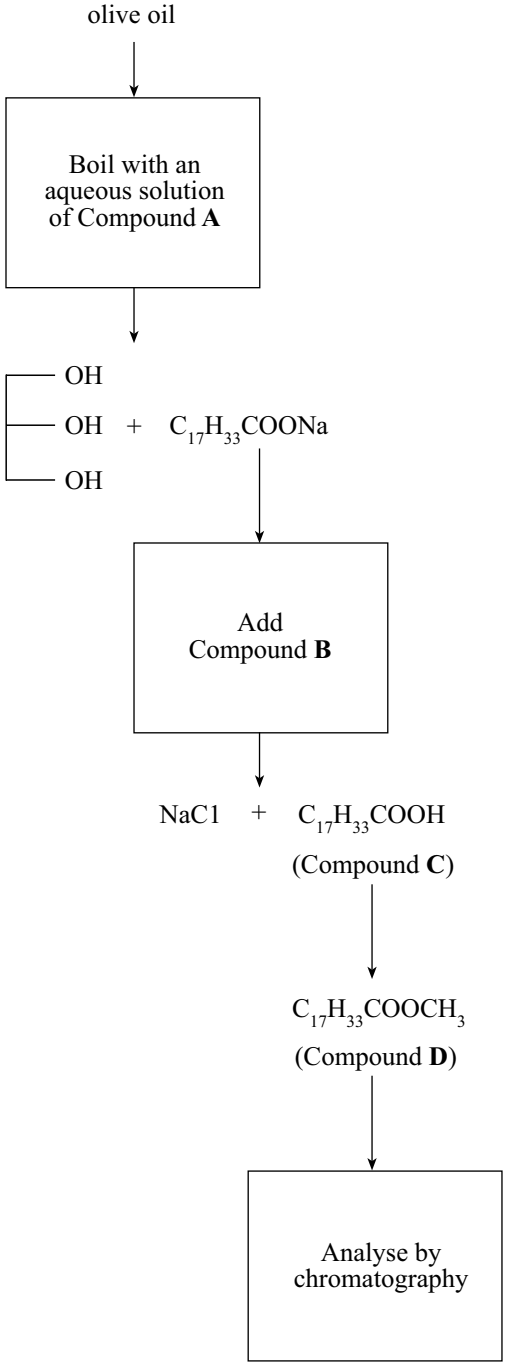
(3 marks)

TOTAL: 16 marks

QUESTION 11

Olive oils are commonly used in the preparation of salad dressings.

(a) The triglycerides in olive oils contain different proportions of several fatty acid components. A sample of one olive oil is prepared for analysis by chromatography. The steps in this preparation, and the organic products formed as a result of each step, are shown in the diagram below:



(i) Identify Compound **A** in the diagram on the page opposite.

_____ (1 mark)

(ii) Identify Compound **B**.

_____ (1 mark)

(iii) Explain why Compound **D** has a lower boiling-point than Compound **C**.

_____

_____

_____

_____

_____

_____ (3 marks)

(iv) State one condition that must be held constant in an analysis by chromatography if the composition of different oils is to be compared.

_____

_____ (1 mark)

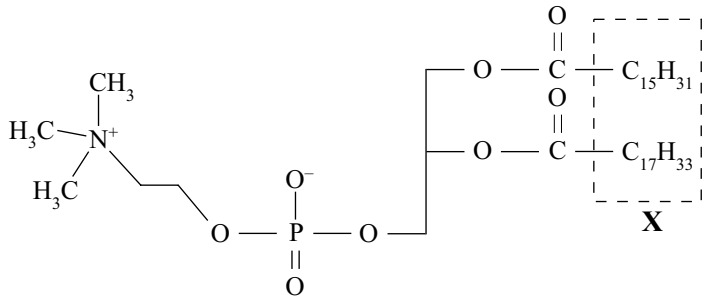
(b) A salad dressing is prepared by mixing an olive oil into an aqueous solution. The oil separates into small droplets in the solution. If allowed to stand, the droplets will combine to form a separate layer.

(i) Explain why the oil will not remain as separate droplets but will combine to form a separate layer.

(3 marks)

(ii) Lecithin is added during the preparation of some salad dressings. Lecithin prevents the droplets of oil from combining to form a separate layer.

The structural formula of lecithin is shown below:



(1) State whether the section of lecithin labelled **X** is hydrophobic or hydrophilic.

(1 mark)

(2) Use the structural formula of lecithin to explain why lecithin prevents the droplets of oil from combining in salad dressing.

(3 marks)

(3) Lecithin may be hydrolysed to form fatty acid molecules. One of the fatty acids formed reacts with iodine solution.

(A) Identify the functional group that is responsible for the reaction with iodine solution.

_____ (1 mark)

(B) State the observation that indicates that this reaction has taken place.

_____ (1 mark)

(C) Identify the fatty acid that reacts with the iodine solution.

_____ (2 marks)

TOTAL: 17 marks

QUESTION 12

Many different compounds are used to improve the quality of water.

(a) Compounds of phosphorus can be used to soften water.

(i) Write the electron configuration of phosphorus, using subshell notation.

_____ (2 marks)

(ii) Phosphorus commonly displays an oxidation state of +5 in its compounds.

(1) Explain why an oxidation state of +5 is possible for phosphorus. Refer to the electron configuration of phosphorus in your answer.

_____

_____

_____

_____ (2 marks)

(2) Identify the other positive oxidation state that phosphorus commonly displays in its compounds.

_____ (1 mark)

(iii) Sodium tripolyphosphate, $Na_3P_3O_9$, is commonly used to soften water.

(1) Draw the structural formula of the tripolyphosphate ion in $Na_3P_3O_9$.

(2 marks)

(2) State the arrangement of oxygen atoms around each phosphorus atom in the tripolyphosphate ion.

_____ (1 mark)

Credit will be given for answers to part (b) which show clearly written, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer, which must include at least one equation, should be confined to the space provided and should take approximately 10 minutes.

(b) Other compounds used to improve the quality of water are aluminium sulfate, $Al_2(SO_4)_3$, and sodium hypochlorite, NaClO.

Explain the action of each of these compounds in improving the quality of water.

(8 marks)

TOTAL: 16 marks

You may write on this page if you need more space to finish your answers to Question Booklet 3. Make sure to label each answer carefully (e.g. 9(e)(i)(2) continued).

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