Government of South Australia

SACE Board of SA

External Examination 2011

2011 CHEMISTRY

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

16 pages, 4 questions

Wednesday 9 November: 1.30 p.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (16 pages)
Question Booklet 2 (14 pages)
Question Booklet 3 (15 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 16 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 15 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
- have my results for the examination cancelled or amended
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as the SACE Board of South Australia 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 Caesium 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 183.8	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)	89[2] Ac Actinium (227)	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)							

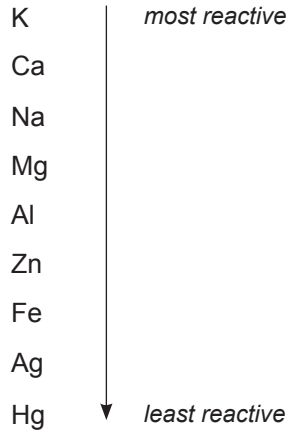
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 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)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

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

Ingeo™ is a trademark for a synthetic fibre made from 100% renewable resources such as corn. The starting material for producing the polymer is glucose.

(a) Glucose is produced in all green plants.

(i) Write an equation for the production of glucose in green plants.

(2 marks)

(ii) Some energy sources, such as coal, are described as 'non-renewable'. Corn, however, is described as a 'renewable resource'.

(1) State why coal is described as a non-renewable energy source whereas corn is described as a renewable resource.

_____

_____

_____

_____ (2 marks)

(2) Explain one benefit of producing fibres from renewable resources.

_____

_____

_____

_____ (2 marks)

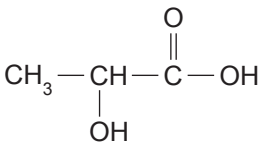
(b) Ingeo™ is biodegradable.

State one benefit of a biodegradable polymer.

_____

_____ (1 mark)

(c) In the production of Ingeo™ glucose is converted into lactic acid. The structural formula of lactic acid is shown below:



State whether lactic acid is or is not a carbohydrate, and give a reason for your answer.

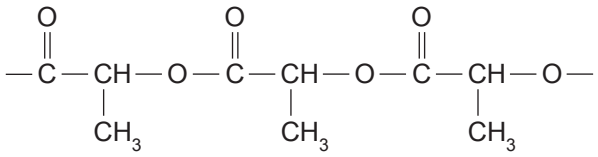
_____

_____

_____

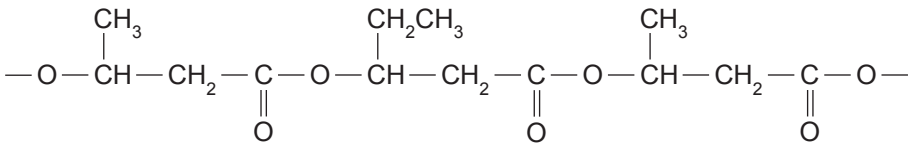
_____ (2 marks)

(d) The chains of the polymer Ingeo™ have the structural formula shown below:



On the structural formula above, mark one repeating unit. (1 mark)

(e) Another polymer is PHBV, which has chains with the structural formula shown below:



(i) Name the functional group common to Ingeo™ and PHBV.

_____ (1 mark)

(ii) State which feature of the structural formula of PHBV indicates that it is formed from two different monomers.

_____

_____ (1 mark)

(iii) Draw the structural formula of one of the monomers from which PHBV is formed.

(2 marks)

(iv) One advantage claimed for Ingeo™ over PHBV is that it is more hydrophilic. Explain why Ingeo™ is more hydrophilic than PHBV.

_____

_____

_____

_____

_____

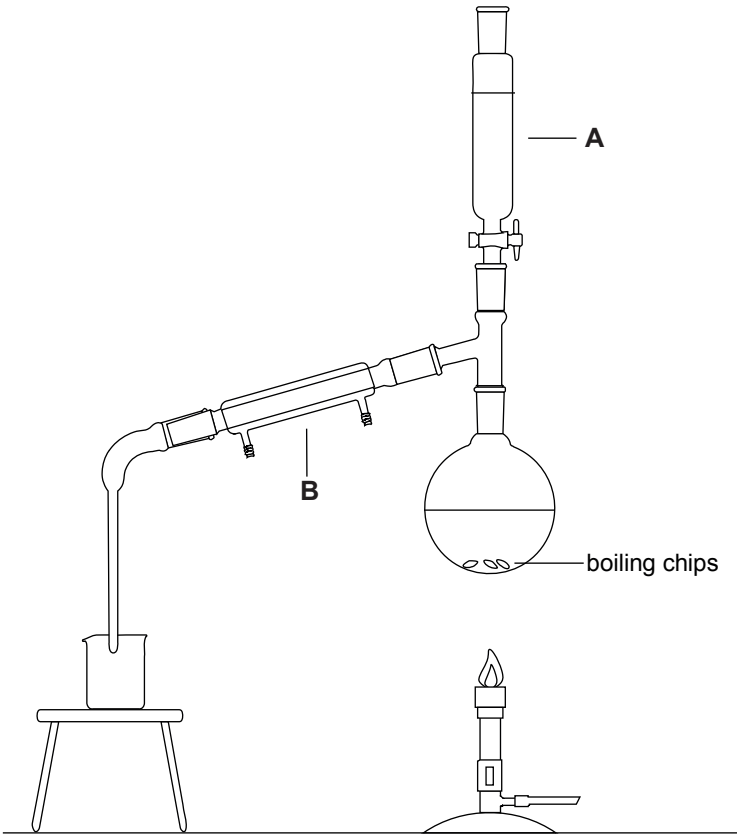
_____ (2 marks)

TOTAL: 16 marks

QUESTION 2

Aldehydes are used in many ways. Some aldehydes are found in natural materials, others are made synthetically.

(a) An aldehyde can be prepared from an alcohol, using the apparatus shown below:



(i) Name the pieces of glassware labelled **A** and **B**.

A is _____

B is _____ (2 marks)

(ii) State the purpose of the glassware labelled **B**.

_____ (1 mark)

(iii) On the diagram above, show the direction of the water flow through the glassware labelled **B**.

(1 mark)

(iv) State the function of the boiling chips in the flask.

_____

_____ (1 mark)

(v) The glassware labelled **A** contained a mixture of an alcohol and $Na_2Cr_2O_7$. The flask contained H_2SO_4.

(1) During the reaction the $Cr_2O_7^{2-}$ ions were converted into Cr^{3+}.

Write the half-equation for this conversion.

(2 marks)

(2) State why the alcohol and the $Na_2Cr_2O_7$ in the glassware labelled **A** did not react before being added to the flask.

_____

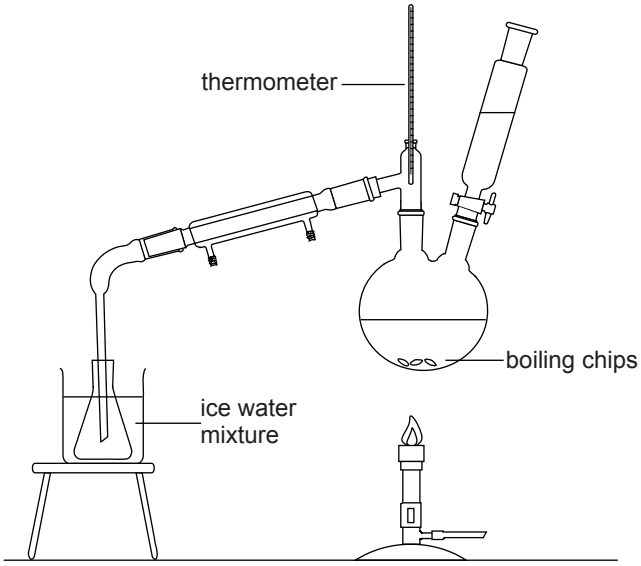
_____ (1 mark)

(vi) Identify a reagent that could be used and the observation that would demonstrate that the product was an aldehyde.

Reagent: _____

Observation: _____ (2 marks)

(vii) The diagram below shows a modified apparatus for the preparation of the aldehyde:



State one advantage of this apparatus compared with that shown on the page opposite.

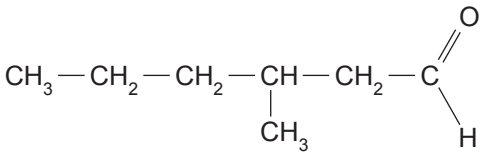
_____

_____ (1 mark)

(viii) Name the functional group that would be formed if the alcohol, $Na_2Cr_2O_7$, and H_2SO_4 were refluxed together rather than reacted in the apparatus shown.

_____ (1 mark)

(b) The structural formula of one aldehyde is shown below:



(i) Give the systematic name of the aldehyde shown above.

_____ (2 marks)

(ii) Draw the structural formula of a ketone that is an isomer of the aldehyde shown above.

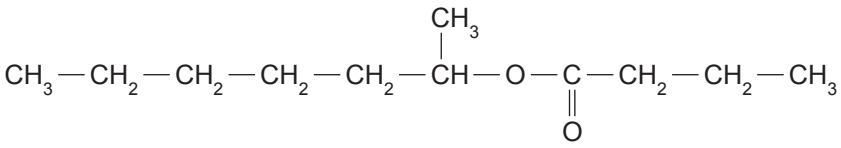
(2 marks)

TOTAL: 16 marks

QUESTION 3

Some cough mixtures contain camphor, whereas others contain flavouring agents to give the mixture a more pleasant taste.

(a) One flavouring agent has the structural formula shown below:



This compound can be synthesised in the laboratory by heating a carboxylic acid and an alcohol in the presence of a suitable catalyst.

(i) Give the systematic names of the carboxylic acid and the alcohol from which this compound can be synthesised.

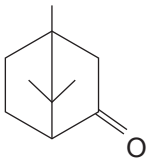
Carboxylic acid:_____

Alcohol:_____ (4 marks)

(ii) Identify the catalyst that would be used.

_____ (1 mark)

(b) The structural formula of camphor is shown below:



(i) Show that the relative molar mass of camphor is 152.2 (to four significant figures).

(3 marks)

(ii) Each 10 mL dose of one cough mixture contains 3 mg of camphor.

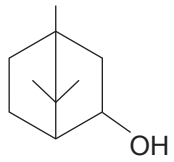
(1) Express the concentration of the camphor in the mixture as %w/v.

(2 marks)

(2) Express the concentration of the camphor in the mixture as mol L^{-1}.

(2 marks)

(iii) Borneol, which has the structural formula shown below, can be readily converted into camphor:



(1) State whether the functional group in borneol is a primary, secondary, or tertiary hydroxyl group.

_____ (1 mark)

(2) Explain why the atoms attached to the oxygen atom are arranged in a V-shape.

_____

_____

_____

_____

_____

_____ (3 marks)

TOTAL: 16 marks

QUESTION 4

Soaps and detergents are both used as cleaning agents. Soaps are made from naturally occurring materials whereas detergents are synthetic.

(a) Soap is made by the alkaline hydrolysis of triglycerides, commonly referred to as 'fats' and 'oils'.

(i) State the difference in physical property between fats and oils.

_____

_____

_____

_____ (2 marks)

(ii) The structural formulae of two carboxylic acids, present in fats and oils, are shown below:

$CH_3 (CH_2)_{16} COOH$ **stearic acid**

$CH_3 (CH_2)_7 CH = CH (CH_2)_7 COOH$ **oleic acid**

Identify a reagent that would enable you to discriminate between stearic acid and oleic acid, and describe what you would observe with each substance.

Reagent: _____

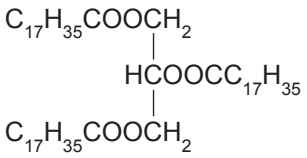
Observation with stearic acid: _____

_____

Observation with oleic acid: _____

_____ (4 marks)

(iii) The triglyceride that has the structural formula shown below can be hydrolysed using sodium hydroxide:



Draw the structural formula of the soap that would be formed.

(2 marks)

(iv) Describe the structural features common to soaps and detergents that enable them to remove grease from materials.

_____

_____

_____

_____ (2 marks)

(b) The following ingredients are listed on packets of a laundry detergent formulation:

- anionic and non-ionic surfactants
- sodium tripolyphosphate
- sodium silicate
- sodium carbonate
- sodium percarbonate (14.8%, available oxygen 2% w/w, 1% at expiry date).

(i) State which one of the ingredients listed above acts as a bleach.

_____ (1 mark)

(ii) Sodium tripolyphosphate is used to soften water.

(1) State how, when water is softened, its composition changes.

_____

_____ (1 mark)

(2) One sodium tripolyphosphate that is used is $Na_3P_3O_9$.

(A) Draw the structural formula of the cyclic tripolyphosphate anion in $Na_3P_3O_9$.

(2 marks)

(B) State the shape in which the oxygen atoms are arranged around the phosphorus in $Na_3P_3O_9$.

_____ (1 mark)

(3) $Na_3P_3O_9$ is made by heating NaH_2PO_4. Water is the only other product.

Write an equation for the reaction.

(2 marks)

TOTAL: 17 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. 1(a)(ii)(2) continued).

Government of South Australia

SACE Board of SA

External Examination 2011

2011 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET 2

14 pages, 4 questions

Wednesday 9 November: 1.30 p.m.

Question Booklet 2

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

QUESTION 5

Aluminium is produced by electrolysis of Al_2O_3 extracted from bauxite ore. Bauxite contains Al_2O_3, SiO_2, and Fe_2O_3 as well as small amounts of other metal compounds. SiO_2 and Fe_2O_3 are removed from the bauxite before electrolysis.

(a) Explain why Fe_2O_3 must be removed from the bauxite before electrolysis.

_____

_____

_____

_____ (2 marks)

(b) The bauxite is treated with hot, concentrated NaOH, which reacts with the Al_2O_3 and SiO_2 but does not react with the Fe_2O_3.

(i) Write an equation for the reaction of NaOH with Al_2O_3.

(2 marks)

(ii) Explain why NaOH reacts with Al_2O_3 and SiO_2 but does not react with Fe_2O_3.

_____

_____

_____

_____

_____

_____

_____

_____ (4 marks)

(iii) After the reaction, a red sludge of unreacted Fe_2O_3 and NaOH is allowed to settle in a reservoir.

(1) In one reservoir the pH of the sludge was measured as 12.8.

Calculate the concentration, in mol L^{-1}, of OH^- in the sludge.

(3 marks)

(2) The sludge also contained toxic metals such as mercury.

(A) Calculate the mass, in kilograms, of mercury in 400 000 tonnes of sludge if its concentration is 1.3 ppm (1 tonne = 1000 kg).

(3 marks)

(B) In one environmental accident, the reservoir leaked and the sludge contaminated the surrounding land and river. The surrounding clay-rich soil was contaminated with significant amounts of mercury ions.

Explain why the clay-rich soil retained mercury ions.

_____

_____

_____

_____ (2 marks)

(c) The final step in the production of aluminium metal involves electrolysis of molten Al_2O_3.

State why solid Al_2O_3 cannot conduct an electric current.

_____

_____ (1 mark)

TOTAL: 17 marks

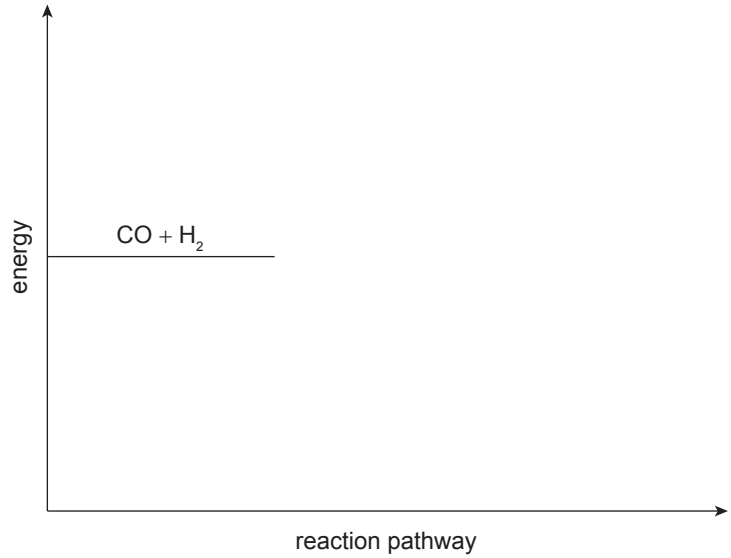
QUESTION 6

In New Zealand, liquid hydrocarbon fuel is produced from methane in a two-stage process.

(a) In the first stage of the process methane is converted into CO, which is then reacted under the conditions shown in the table below:

equation	$CO + 2\,H_2 \rightleftharpoons CH_3OH$
temperature (ºC)	250
pressure (atmospheres)	100
catalyst	copper–zinc
ΔH reaction (kJ mol^{-1})	–128

(i) Using the information in the table, complete the energy profile diagram below to show how the catalyst affects this reaction.



(3 marks)

(ii) There are commercial implications for the manufacturer if the conditions differ from those shown in the table on the page opposite.

(1) If the temperature falls below 250ºC the reaction rate decreases.

Explain why a fall in temperature has this effect.

_____

_____

_____

_____

_____

_____

_____ (3 marks)

(2) Explain the disadvantage to the manufacturer if the temperature rises above 250ºC.

_____

_____

_____

_____

_____

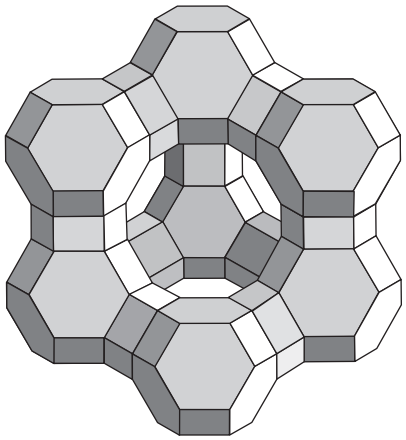
_____ (3 marks)

(iii) The methanol produced may be used as a fuel. The complete combustion of 1 mole of methanol releases 725 kJ of energy.

Write a thermochemical equation for this reaction.

(4 marks)

(b) In the second stage of the process methanol is converted into a mixture of hydrocarbons in the presence of a zeolite catalyst. A typical structure of a zeolite is shown below:



(i) Suggest which structural feature of the zeolite shown above contributes to its effectiveness as a catalyst.

_____ (1 mark)

(ii) One zeolite catalyst commonly used in the petroleum industry is faujasite, an aluminosilicate with the formula $Na_{56}Al_{56}Si_{136}O_{384}$.

(1) State the value of *x* that represents the charge on the aluminosilicate ion ($Al_{56}Si_{136}O_{384}^{x-}$) in faujasite.

_____ (1 mark)

(2) Faujasite can also be used as a water softener. When faujasite is used in this way calcium ions in the water replace the sodium ions in the faujasite.

Explain why the aluminium in the faujasite is not readily replaced by calcium ions.

_____

_____

_____

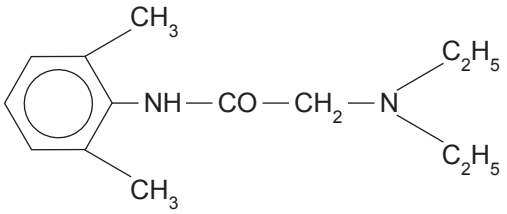
_____ (2 marks)

TOTAL: 17 marks

QUESTION 7

Many different chemicals are used in dentistry.

(a) Lignocaine is used as a local anaesthetic. Its structural formula is shown below:



(i) State whether lignocaine contains a primary, secondary, or tertiary amino group.

_____ (1 mark)

(ii) Explain why treating lignocaine with hydrochloric acid makes it more soluble in water.

_____

_____

_____

_____

_____

_____ (3 marks)

(b) Caps for teeth are made of zirconium dioxide (ZrO_2). One form of ZrO_2 can react with acids and bases.

(i) State the word used to describe oxides that can react with acids and bases.

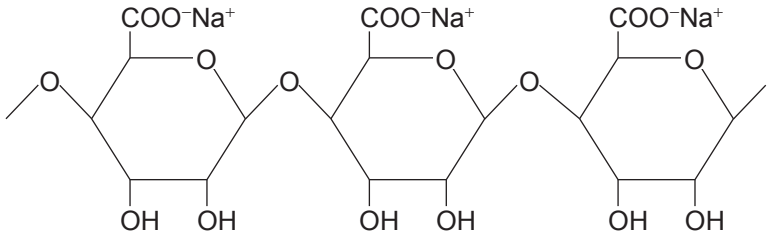
_____ (1 mark)

(ii) The hydrated form, $Zr(OH)_4$, can react with acids and bases.

Write an equation for the reaction of $Zr(OH)_4$ with sulfuric acid.

(2 marks)

(c) Alginates are used for taking impressions of teeth. The structural formula of one alginate is shown below:



(i) Explain why this alginate readily absorbs water.

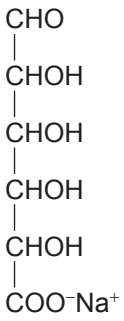
_____

_____

_____

_____ (2 marks)

(ii) The monomer of this alginate can take the form of a chain as well as a cyclic structure. The structural formula of the chain form is shown below:



The carbon atoms in the chain form are numbered from the —COO^-Na^+ functional group.

(1) Name the —COO^- functional group.

_____ (1 mark)

(2) Give the numbers of the two carbon atoms on which the hydroxyl groups link to other cyclic monomers in the polymer.

_____ (2 marks)

(d) Amalgams, used for dental fillings, are alloys of mercury with other metals such as zinc. Zinc is obtained from ores that contain the sulfide ZnS.

(i) Name the process used to obtain concentrated zinc sulfide from the crushed ore.

_____ (1 mark)

(ii) After concentration the zinc sulfide is roasted in air, forming sulfur dioxide.

(1) Write an equation for the reaction that occurs when zinc sulfide is roasted in air.

(2 marks)

(2) State one environmental consequence of allowing the gaseous product of the roasting to escape into the atmosphere.

_____

_____ (1 mark)

(iii) The zinc product of roasting is dissolved in acid to generate a solution containing Zn^{2+} ions. Electricity is then used to reduce the Zn^{2+} ions to zinc metal.

Name the type of electrochemical cell used in this process.

_____ (1 mark)

TOTAL: 17 marks

QUESTION 8

Proteins are polyamides formed from amino acids.

(a) To synthesise amino acids, plants need nitrogen.

Explain why the N_2 in the atmosphere is not readily available to plants as a source of nitrogen.

_____

_____

_____

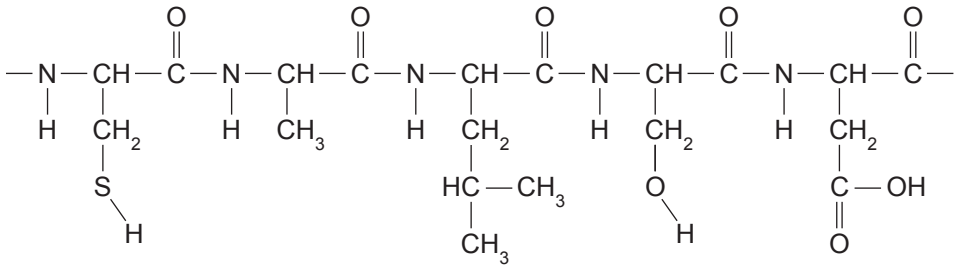
_____ (2 marks)

(b) Under certain conditions, proteins decompose to form methane.

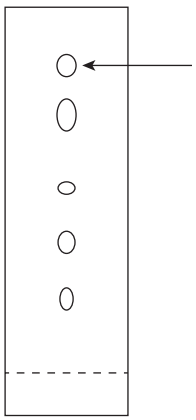
Identify one other product of the decomposition of a protein under these conditions.

_____ (1 mark)

(c) The structural formula of a section of one protein chain is shown below:



(i) This section of the protein chain was hydrolysed and the amino acids were separated by thin-layer chromatography, using a polar solvent on a non-polar stationary phase. The chromatogram obtained is shown below:



(1) State whether the amino acid indicated by the arrow in the chromatogram on the page opposite is the most polar or the least polar amino acid and explain your reasoning.

_____

_____

_____

_____

_____

_____ (3 marks)

(2) With reference to the structural formula of the section of protein chain on the page opposite, draw the structural formula of the amino acid that would be present at the position indicated by the arrow in the chromatogram.

(2 marks)

(ii) The side chains of a protein play an important role in determining the shape adopted by the protein.

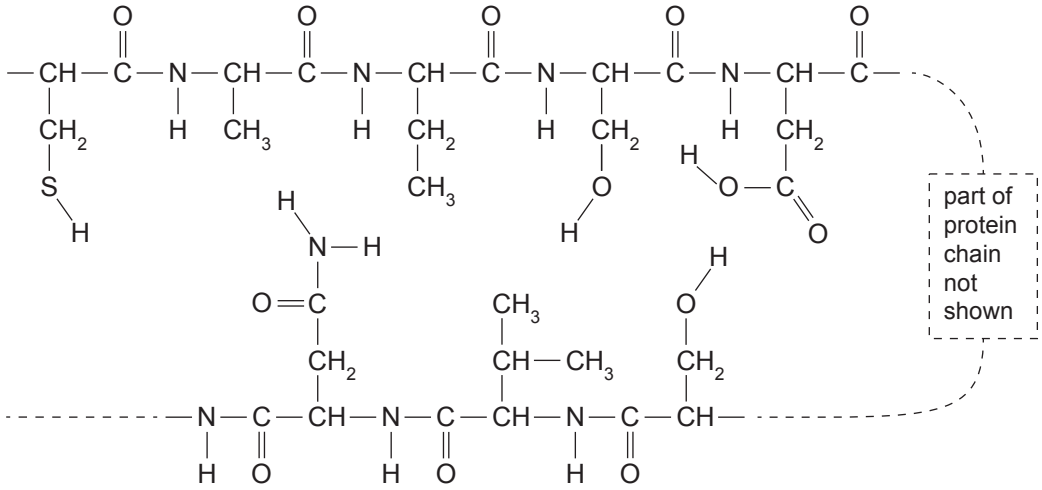
On the structural formula of the section of protein chain on the page opposite, circle a side chain that is hydrophobic. (1 mark)

Credit will be given for answers to part (d) which correctly use appropriate chemical terms and effectively communicate knowledge and understanding of chemistry.

In your answer you may refer to annotations you make on the diagram below.

Your answer should be confined to the space provided.

(d) Hydrogen bonds form between some side chains on a section of protein when they are close to each other. The diagram below shows the structural formula of sections of a protein chain:



With reference to the sections of protein chain shown in the diagram above, explain:

- how a hydrogen bond forms between two groups
- the effect that increasing pH has on the hydrogen bonding in the protein, and hence on its function.

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_____ (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. 5(b)(iii)(2)(A) continued).

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External Examination 2011

2011 CHEMISTRY

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QUESTION BOOKLET

3

15 pages, 4 questions

Wednesday 9 November: 1.30 p.m.

Question Booklet 3

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

QUESTION 9

The combustion of carbon-based fuels may release CO into the atmosphere.

(a) State why significant amounts of CO may be released into the atmosphere during the combustion of carbon-based fuels.

_____ (1 mark)

(b) Black coal, when burnt, releases a mixture of CO and CO_2. For each mole of CO that is produced instead of CO_2, 282 kJ less energy is released.

Calculate the amount of energy lost if a coal-burning power station generates 6000 kg of CO in a day.

(3 marks)

(c) One type of galvanic cell sounds an alarm when the atmospheric concentration of CO increases. CO is converted into CO_2 at one of the electrodes in this cell.

(i) Write a half-equation for the conversion of CO into CO_2 in acidic conditions.

(2 marks)

(ii) State whether this reaction occurs at the positive electrode or the negative electrode.

_____ (1 mark)

(d) CO is toxic because it displaces O_2 from oxyhaemoglobin (HbO_2) in the blood and forms carboxyhaemoglobin (HbCO). This reduces the amount of O_2 available for respiration in cells. A simplified equation for this process is shown below:

$$HbO_2 + CO \rightleftharpoons HbCO + O_2 \qquad K_c = 210$$

(i) Using the information given above, deduce whether haemoglobin (Hb) binds more strongly to CO or to O_2.

_____

_____

_____

_____

_____ (3 marks)

(ii) A person suffering from CO poisoning may be treated with air containing a high concentration of O_2.

Explain why a high concentration of O_2 will reduce the concentration of HbCO in the blood.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) (1) Write an expression for K_c for the reaction

$$HbO_2 + CO \rightleftharpoons HbCO + O_2 \qquad K_c = 210$$

(1 mark)

(2) CO can be fatal if the ratio $\frac{[HbCO]}{[HbO_2]} \geq 0.2$.

A sample of polluted air has the composition shown below:

$[O_2] = 0.0065$ mol L^{-1} and $[CO] = 5.3 \times 10^{-6}$ mol L^{-1}.

Using the expression for K_c, determine whether or not breathing this air could be fatal.

(3 marks)

TOTAL: 17 marks

QUESTION 10

Ammonia, NH_3, is a toxic gas, commonly available as aqueous solutions that are used as household cleaning agents.

The label on one bottle of household ammonia solution contained the following information:

> **Ammonia Solution**
>
> Harmful by inhalation.
>
> Irritating to eyes, respiratory system and skin.
>
> Ingestion may produce health damage.

The concentration of ammonia in this solution can be determined by titration.

(a) In addition to the use of protective clothing and glasses, other precautions must be taken to ensure safety when a titration is performed with this solution.

State one such precaution.

_____

_____ (1 mark)

(b) In one titration, 20.0 mL samples of the household ammonia solution were titrated with a standard HCl solution.

(i) (1) Name the glassware used to deliver the HCl solution.

_____ (1 mark)

(2) Identify the solution used to rinse this glassware immediately before use.

_____ (1 mark)

(ii) A series of titrations were performed, and the results that were obtained are shown in the table below:

Titration Number	Titre Value (mL)
1	17.95
2	17.80
3	17.70
4	17.55
5	17.40

Using the information about ammonia given above, suggest an explanation for the continuing decrease in titre values.

_____

_____

_____

_____ (2 marks)

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

(c) A different procedure was then followed, as summarised below:

Step 1 A volume of 25.0 mL of the household ammonia solution was made up to 250.00 mL.

Step 2 A 20.00 mL aliquot was taken and immediately added to 50.00 mL of 0.1000 mol L^{-1} HCl solution. An equation for the reaction that occurred is shown below:

$$NH_3 + HCl \longrightarrow NH_4Cl$$

Step 3 Unreacted acid was titrated with sodium hydroxide solution. A volume of 7.70 mL of 0.1302 mol L^{-1} sodium hydroxide solution was required. An equation for the reaction that occurred is shown below.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

(i) Calculate the number of moles of HCl that were added to the diluted ammonia solution in Step 2.

(2 marks)

(ii) Calculate the number of moles of HCl that reacted with sodium hydroxide in Step 3.

(2 marks)

(iii) Calculate the number of moles of HCl that reacted with ammonia in Step 2.

(1 mark)

(iv) Calculate the number of moles of ammonia in the 20.00 mL aliquot that was titrated in Step 2.

(1 mark)

(v) Hence calculate the number of moles of ammonia in the 250.0 mL of diluted ammonia solution.

(2 marks)

(vi) Hence calculate the %w/v of ammonia in the household ammonia solution.

(3 marks)

TOTAL: 17 marks

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QUESTION 11

Arsenic, which is toxic, is found in drinking water in some places. Arsenic-rich groundwater can be treated by the SORAS method. In this process the arsenic is oxidised to form products that are adsorbed onto the surface of iron(III) oxides in the groundwater.

(a) Iron(III) oxides contain the Fe^{3+} ion.

Write the electronic configuration of the Fe^{3+} ion, using subshell notation.

(2 marks)

(b) Arsenic in the groundwater is in the +3 oxidation state in the form of uncharged arsenous acid, H_3AsO_3. In the SORAS method, it is oxidised to the +5 state and is in the form of ions, $H_2AsO_4^-$ and $HAsO_4^{2-}$.

(i) Arsenous acid is formed when arsenic(III) oxide reacts with water.

Write an equation for this reaction.

(2 marks)

(ii) Explain why the species that contain arsenic in the +5 oxidation state are more strongly attracted to the Fe^{3+} ions than the species that contain arsenic in the +3 oxidation state.

_____

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_____ (3 marks)

(c) Concentrations of arsenic may be determined using atomic absorption spectroscopy (AAS). The first step in this process involves calibrating the equipment. The table below shows the absorbance of a number of solutions with known concentrations of arsenic:

Concentrations of Arsenic ($\mu g\ L^{-1}$)	**Absorbance**
0	0.00
50	0.10
100	0.21
200	0.40

(i) Using the data in the table above, construct a calibration graph for measuring concentrations of arsenic.

(5 marks)

(ii) The World Health Organization recommends that the concentration of arsenic in drinking water should not exceed 10 µg L^{-1}.

Measurements were taken to determine the effectiveness of the SORAS method for the removal of arsenic from groundwater.

Two samples of groundwater from the same source were analysed to determine their concentrations of arsenic. The results are shown in the table below:

Sample	Absorbance
Before SORAS treatment	0.28
After SORAS treatment	0.13

Discuss the effectiveness of the SORAS method in making the water fit for drinking.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) The AAS equipment was also to be used for measuring the concentration of antimony in the groundwater.

State two steps that would need to be taken before equipment that had been used for arsenic determination could be used to measure the concentration of antimony in the groundwater.

_____

_____

_____

_____ (2 marks)

TOTAL: 17 marks

QUESTION 12

Increasing concentration of atmospheric CO_2 has been associated with global warming.

(a) Carbon and oxygen form CO_2 molecules. Although they contain polar covalent bonds, the molecules are nonpolar.

(i) Explain why the covalent bonds in CO_2 are polar.

_____

_____

_____

_____ (2 marks)

(ii) Explain why the CO_2 molecules are nonpolar.

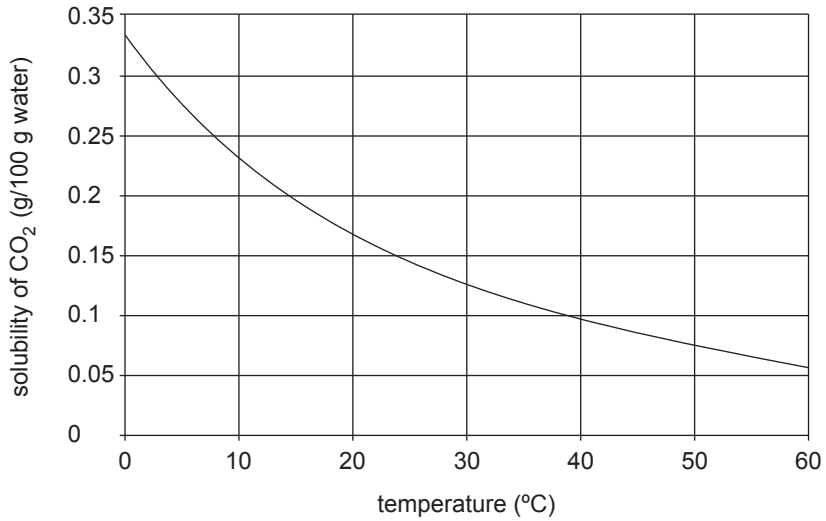
_____

_____

_____

_____ (2 marks)

(b) The solubility of carbon dioxide in water varies with temperature, as shown in the graph below:



(i) State the effect that increasing water temperature has on the solubility of CO_2.

_____ (1 mark)

(ii) Using the graph above, construct a table for recording the solubility of CO_2 in water at different temperatures.

There is no need to add data to the table.

(2 marks)

Credit will be given for answers to part (c) which correctly use appropriate chemical terms and effectively communicate knowledge and understanding of chemistry.

You may include one or two equations in your answer.

(c) It has been suggested that the oceans have absorbed more than half of the carbon dioxide generated by human activity in the last two centuries. Carbon dioxide dissolves in water and is used by marine organisms for photosynthesis. However, the capacity of the oceans to absorb carbon dioxide is limited. Furthermore, absorption of carbon dioxide by the oceans may have negative environmental consequences in the long term.

Discuss the present-day benefit of the oceans' absorption of carbon dioxide and the possible long-term environmental consequences for the oceans.

(9 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. 11(c)(ii) continued).