Government of South Australia

SACE Board of SA

External Examination 2012

2012 CHEMISTRY

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

16 pages, 4 questions

Wednesday 7 November: 9 a.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (16 pages)
Question Booklet 2 (13 pages)
Question Booklet 3 (11 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 13 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 11 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 180. 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)	112 Cn Copernicium (285)						

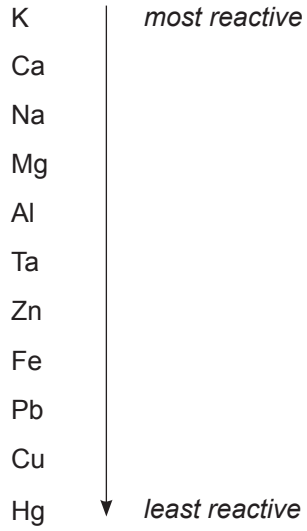
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 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
tera	T	10^{12}
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

There are nitrogen compounds in the Earth's atmosphere and in all living organisms.

(a) Nitrogen compounds produced in motor vehicles are pollutants that can lead to the formation of photochemical smog.

The concentrations of a number of pollutants, measured at the same time at two locations, are shown in the table below:

Pollutant	Location A (ppm)	Location B (ppm)
ozone	0.029	0.028
nitrogen dioxide	0.042	0.068
sulfur dioxide	0.0048	0.0051
carbon monoxide	0.36	0.34

(i) From the pollutants listed in the table above, identify a primary pollutant that is generated by the incomplete combustion of fuels.

_____ (1 mark)

(ii) Determine the concentration of ozone at Location A in ppb.

_____ (1 mark)

(iii) Using the information in the table, identify which location is more likely to experience photochemical smog.

_____

_____

_____

_____ (2 marks)

(iv) Ozone, a pollutant in photochemical smog, is formed from NO_2.

(1) Describe how ozone is formed from NO_2 in the atmosphere.

_____

_____

_____

_____

_____

_____ (3 marks)

(2) Identify one harmful effect of ozone pollution in the troposphere.

_____ (1 mark)

(b) Describe the process by which NO_2 in the atmosphere can contribute to an increase in the level of nitrogen in the soil.

_____

_____

_____

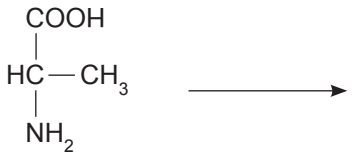
_____

_____

_____ (3 marks)

(c) (i) Plants use nitrogen compounds in the soil to synthesise amino acids.

One such amino acid is alanine, the structural formula of which is shown below:



alanine **self-ionised form**

In the space above, draw the structural formula of the self-ionised form of the amino acid alanine.

(2 marks)

(ii) State the name given to the functional group that forms when amino acid monomers link, forming proteins.

_____ (1 mark)

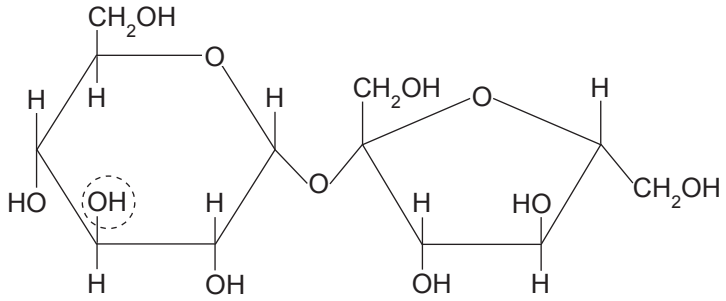
(iii) Identify the nitrogen compound that is produced when amino acids in living organisms undergo anaerobic decomposition.

_____ (1 mark)

TOTAL: 15 marks

QUESTION 2

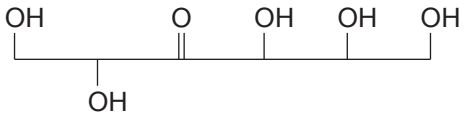
Honey bees use an invertase enzyme to convert sucrose into a mixture of glucose and fructose.
The structural formula of sucrose is shown below:



(a) (i) State whether the functional group circled in the diagram above is a primary, a secondary, or a tertiary hydroxyl group.

_____ (1 mark)

(ii) The structural formula of fructose is shown below:



(1) State why fructose is classified as a carbohydrate.

_____

_____

_____

_____ (2 marks)

(2) Tollens reagent is added to a solution of fructose in a test tube, which is then shaken.

State, giving a reason, what would be observed.

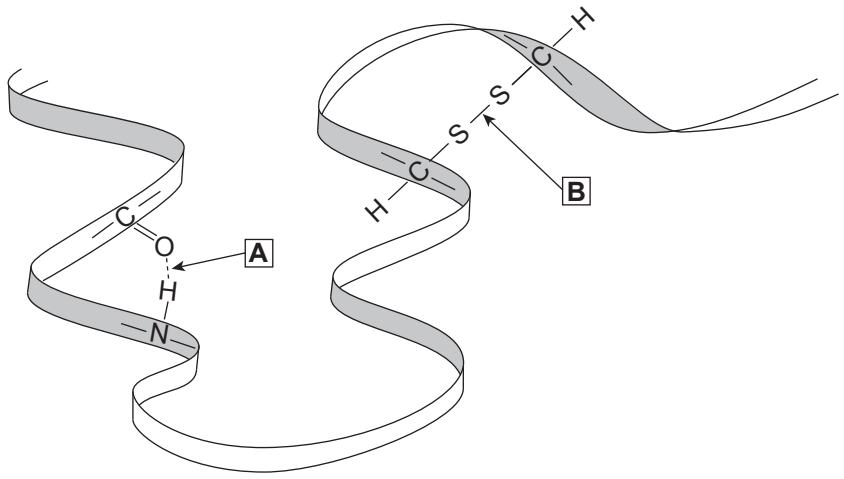
_____

_____

_____

_____ (2 marks)

(b) Some of the interactions between atoms in an invertase molecule are shown in the diagram below:



(i) Name the types of interactions labelled **A** and **B**.

A is _____

B is _____ (2 marks)

(ii) State which interaction is stronger, **A** or **B**.

_____ (1 mark)

(iii) Explain why a change of pH may affect the action of the invertase enzyme.

_____

_____

_____

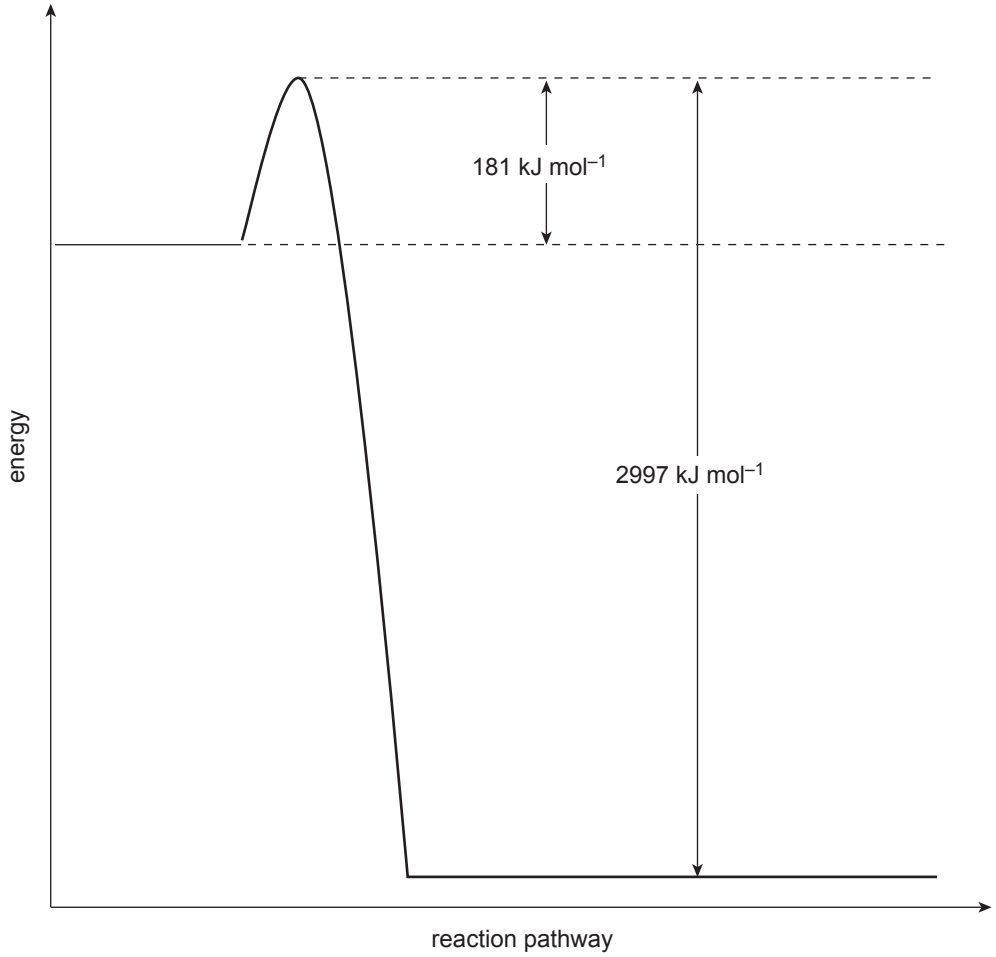
_____ (2 marks)

(c) Honey bees obtain energy from the aerobic respiration of glucose.

(i) Write an equation for the aerobic respiration of glucose.

(2 marks)

(ii) The energy changes associated with the aerobic respiration of glucose are shown in the energy diagram below:



Using the energy diagram above, determine the enthalpy change for the aerobic respiration of glucose.

ΔH = _____ kJ mol^{-1} (2 marks)

TOTAL: 14 marks

QUESTION 3

Sodium chloride is commonly found in food. The concentration of the sodium and chloride ions can be determined in a number of ways.

(a) Atomic absorption spectroscopy (AAS) was used to determine the sodium content of a sample of tomato sauce.

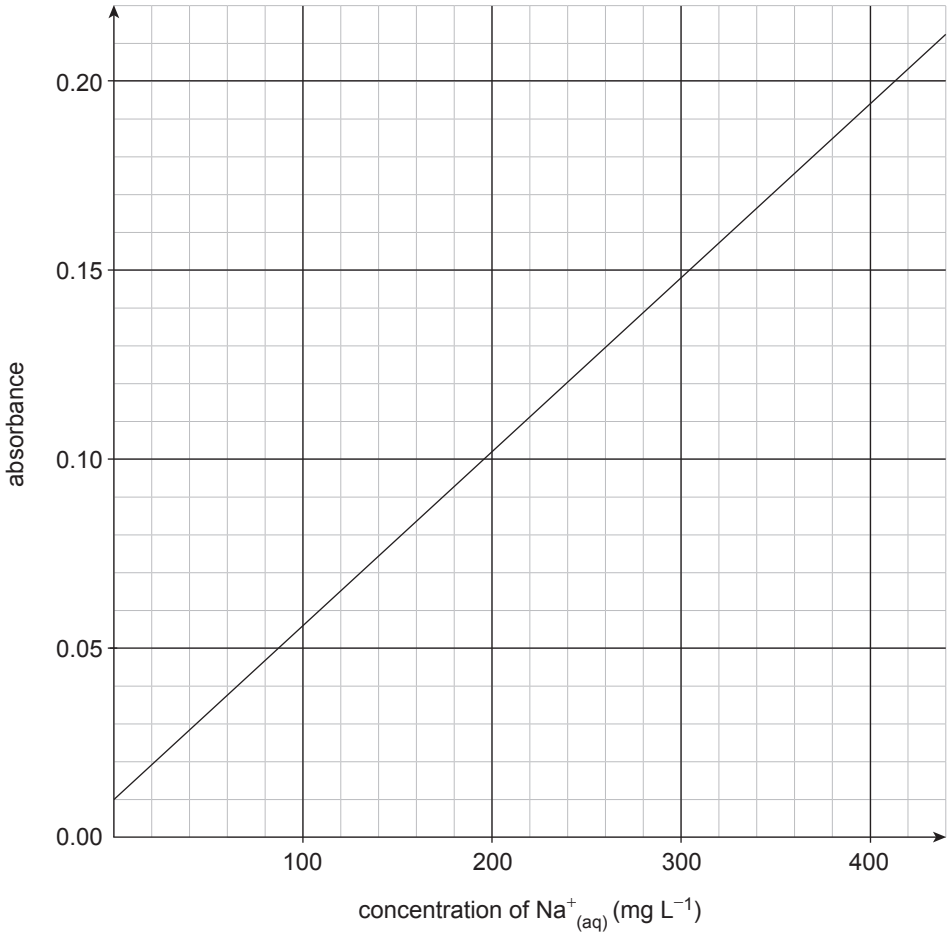
Solutions with known concentrations of sodium ions were prepared for use in this determination.

(i) Identify one possible random error in the preparation of the solutions.

_____

_____ (1 mark)

(ii) The solutions of known concentration were used in constructing the calibration graph shown below:



Identify the dependent variable with reference to the graph above.

_____ (1 mark)

(iii) Suggest why the calibration line does not pass through the origin.

_____

_____

_____

_____ (2 marks)

(iv) Explain why the presence of calcium ions in the sauce would not affect the measurement of the concentration of sodium ions by AAS.

_____

_____

_____

_____

_____

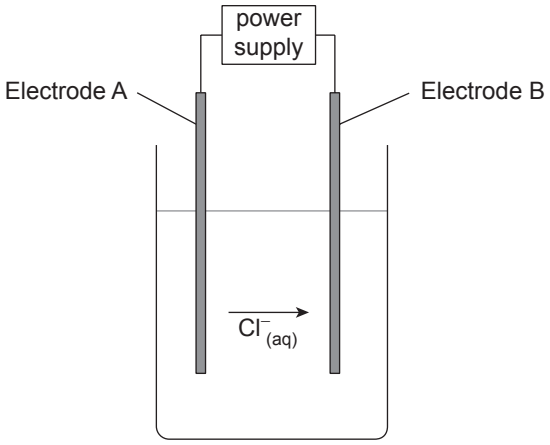
_____ (3 marks)

(v) A 25.00 mL sample of the sauce was diluted to 500.0 mL with distilled water. The diluted sample was found to have an absorbance of 0.165.

Using the calibration graph on the page opposite, determine the concentration (in mg L^{-1}) of sodium ions in the undiluted sauce.

(2 marks)

(b) The concentration of chloride ions in a solution can be determined by using the electrical conductivity of the solution. The cell used is shown in the diagram below:



(i) State whether the chemical reaction occurring in this cell is spontaneous or non-spontaneous.

_____ (1 mark)

(ii) State which electrode, A or B, is the anode in this cell.

_____ (1 mark)

(iii) During the operation of the cell, chemical reactions occur at the electrodes.

(1) Write a half-equation for the production of oxygen from water at the positive electrode.

(2 marks)

(2) Explain why sodium is not produced from sodium ions in this cell.

_____

_____

_____

_____ (2 marks)

TOTAL: 15 marks

QUESTION 4

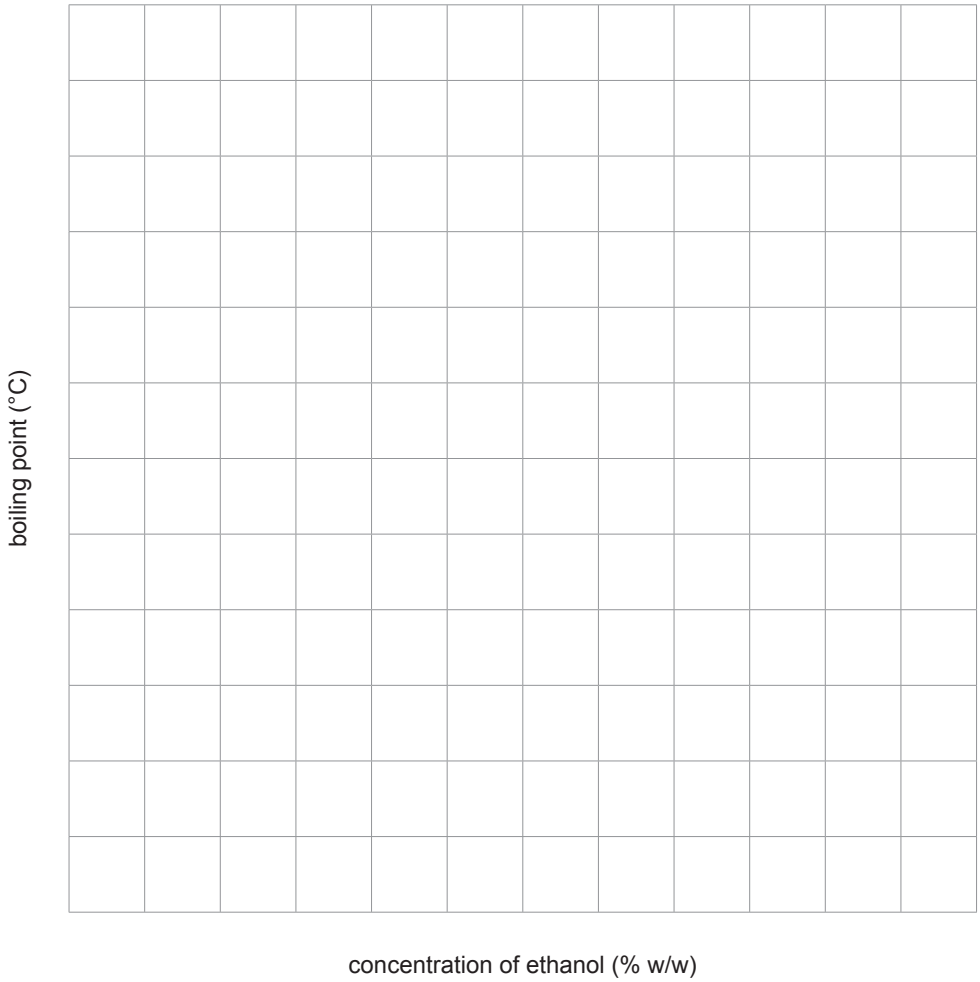
Ethanol is an alcohol found in alcoholic beverages and in some fuels.

(a) The ethanol content of wine can be determined from its boiling point.

A student recorded the boiling points of various ethanol–water mixtures of different concentrations. The results are shown in the table below:

concentration of ethanol (% w/w)	0	25	50	70	85	100
boiling point (°C)	100	85	81	80	78	78

On the grid below, draw a line graph, using the data from the table above.



(3 marks)

(b) When ethanol is used as a fuel complete combustion of each mole releases 1367 kJ of heat.

1.25 g of ethanol was burnt completely to heat 170 g of water.

Calculate the increase in temperature of the water (in °C), assuming that half of the heat was transferred to the surroundings.

Assume that the specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

(4 marks)

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

Your answer, which may include an equation, should be confined to the space provided.

(c) Ethanol can be produced by the fermentation of glucose.

Describe the fermentation process, explaining two of the reaction conditions necessary.

(8 marks)

TOTAL: 15 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. 2(a)(ii)(1) continued).

Government of South Australia

SACE Board of SA

External Examination 2012

2012 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET 2

13 pages, 4 questions

Wednesday 7 November: 9 a.m.

Question Booklet 2

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

QUESTION 5

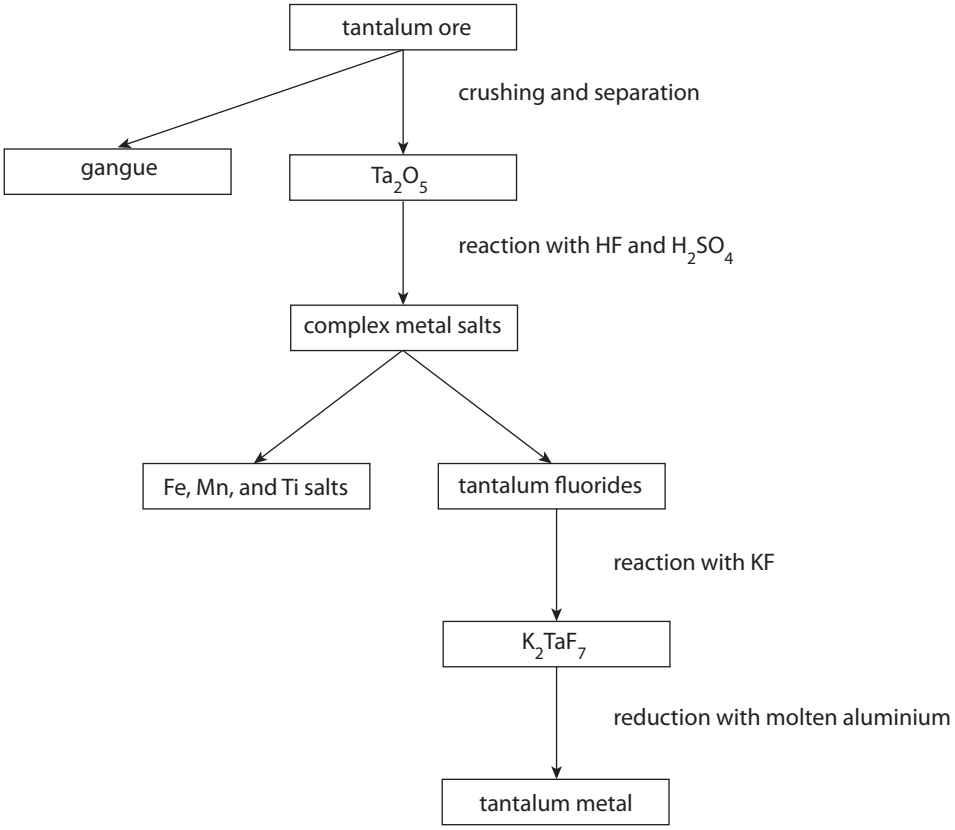
Tantalum (Ta) is a metal that occurs, in combination with other elements, in small quantities in the Earth's crust.

(a) State why tantalum is not naturally found in its pure metallic state.

_____

_____ (1 mark)

(b) The production of tantalum from its ore involves a number of steps, as shown in the flow chart below:



(i) Explain why the crushing of the ore is an important step in the extraction process.

_____

_____

_____

_____ (2 marks)

(ii) Write the formula of one compound that may be obtained as a by-product of the process shown in the flow chart on the page opposite.

_____ (1 mark)

(iii) One reaction that occurs in the extraction process is shown below:

$$Ta_2O_5 + \quad HF \longrightarrow \quad H_2TaF_7 + \quad H_2O$$

(1) Balance the equation above. (1 mark)

(2) The HF used in this reaction is in the form of an aqueous solution. HF is very soluble in water because of the hydrogen bonds formed between HF and H_2O molecules.

Explain, with the aid of a diagram, why hydrogen bonding occurs between HF and H_2O molecules.

_____

_____

_____

_____

_____

_____

_____

_____ (4 marks)

(iv) Identify the reagent used to prepare the tantalum salt that undergoes reduction.

_____ (1 mark)

(v) Molten aluminium is able to reduce tantalum ions to tantalum metal.

(1) Using subshell notation, write the electron configuration of aluminium.

_____ (2 marks)

(2) Explain why molten aluminium is able to reduce tantalum ions to tantalum metal.

_____

_____

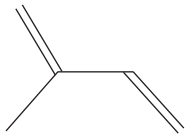
_____

_____ (2 marks)

TOTAL: 14 marks

QUESTION 6

Rubber was originally derived from latex, a milky substance produced by some plants. Latex is an addition polymer of isoprene (C_5H_8), which has the structural formula shown below:



isoprene

(a) State the systematic name of isoprene.

_____ (2 marks)

(b) The polymer in latex has an average relative molar mass of 750 000.

(i) Determine the average number of isoprene units in the polymer in latex.

(2 marks)

(ii) State the number of significant figures to which the answer to part (b)(i) should be given.

_____ (1 mark)

(c) Natural rubber is made from the latex produced by some plants. Synthetic rubber can be made from monomers that are manufactured from petroleum.

(i) Describe one advantage of natural rubber over synthetic rubber.

_____

_____

_____

_____ (2 marks)

(ii) Describe one advantage of synthetic rubber over natural rubber.

_____

_____

_____

_____ (2 marks)

(d) Natural rubber deforms easily when heated.

State the term used to describe a polymer that softens when heated.

_____ (1 mark)

(e) Rubber that is to be used in tyres is treated with sulfur in a process known as 'vulcanisation'. This process creates extensive cross links between individual polymer chains.

(i) Explain how the vulcanisation process changes the properties of the rubber.

_____

_____

_____

_____

_____

_____ (3 marks)

(ii) Explain why vulcanised rubber is more difficult than unvulcanised rubber to recycle.

_____

_____

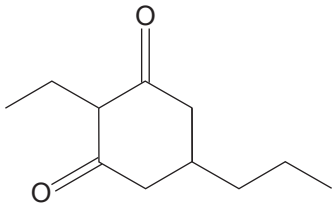
_____

_____ (2 marks)

TOTAL: 15 marks

QUESTION 7

The *Chiloglottis* orchid produces the compound chiloglottone-1, which attracts male wasps that transfer pollen to other flowers. The structural formula of chiloglottone-1 is shown below:



chiloglottone-1

(a) State the molecular formula of chiloglottone-1.

_____ (2 marks)

(b) State the colour that would be observed after chiloglottone-1 is shaken with bromine solution.

_____ (1 mark)

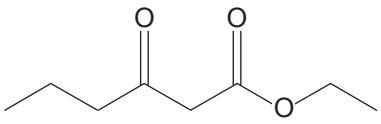
(c) (i) Draw the structural formula of the diol that could be oxidised to produce chiloglottone-1.

(2 marks)

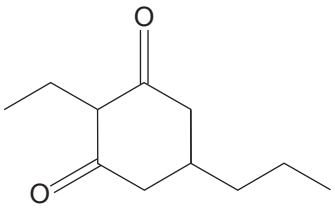
(ii) Name a laboratory reagent that is commonly used to oxidise alcohols.

_____ (2 marks)

(d) Compound C is one of the starting materials for the synthesis of chiloglottone-1. The structural formula of Compound C is shown below:



Compound C



chiloglottone-1

Chromatography is used to separate the chiloglottone-1 from unreacted Compound C.

(i) State, giving a reason, whether Compound C is more polar or less polar than chiloglottone-1.

_____

_____

_____

_____ (2 marks)

(ii) A polar stationary phase and a non-polar mobile phase are used in the chromatography.

Explain whether the retention time of Compound C would be shorter or longer than that of chiloglottone-1.

_____

_____

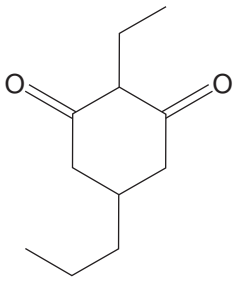
_____

_____

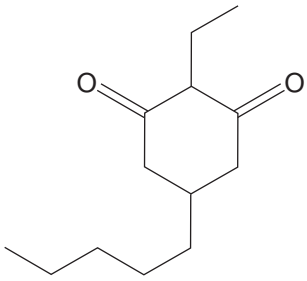
_____

_____ (3 marks)

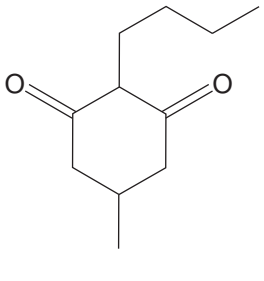
(e) The structural formulae of several compounds from the same family as chiloglottone-1 are shown below:



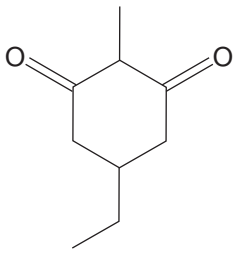
chiloglottone-1



chiloglottone-2



chiloglottone-3



Compound D

(i) Two of the compounds shown above have the same molecular formula.

(1) State the word used to describe molecules that have the same molecular formula but different structural formulae.

_____ (1 mark)

(2) Identify the compound that has the same molecular formula as chiloglottone-1.

_____ (1 mark)

(ii) Chiloglottone-1 is 2-ethyl-5-propylcyclohexan-1,3-dione.

Chiloglottone-2 is 2-ethyl-5-pentylcyclohexan-1,3-dione.

Using this information and the structural formulae above, deduce the systematic name of Compound D.

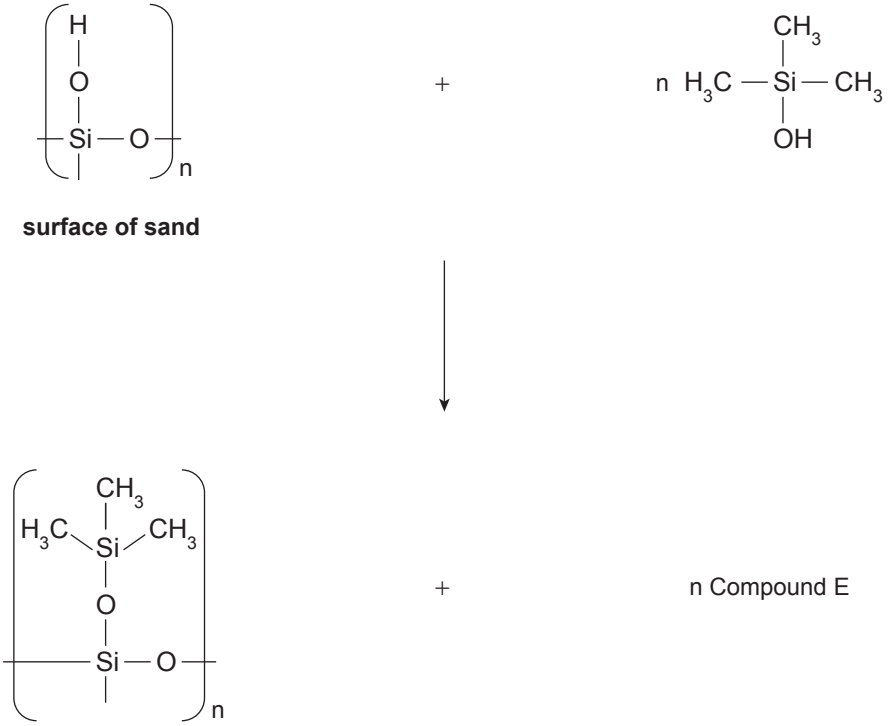
_____ (2 marks)

TOTAL: 16 marks

QUESTION 8

The surface chemistry of a solid determines many of its properties.

(a) 'Magic sand' is a material made by reacting sand with $(CH_3)_3SiOH$. A representation of the reaction is shown below:



(i) Identify Compound E.

_____ (1 mark)

(ii) Name the type of reaction that has occurred.

_____ (1 mark)

(iii) Magic sand can be used in the cleaning-up process after an oil spill as its surface is able to adsorb oil.

Explain why the surface of magic sand is able to adsorb oil.

_____

_____

_____

_____ (2 marks)

(iv) Explain how the addition of a detergent enables magic sand to attract water.

_____

_____

_____

_____

_____

_____ (3 marks)

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

Your answer, which may include an equation, should be confined to the space provided.

(b) Zeolites are aluminosilicates, which may be used to soften water. One advantage of using a zeolite as a water softener is that the same zeolite can be recharged and reused many times.

Explain how sodium zeolites soften water and how they can be recharged with a solution of sodium chloride.

(8 marks)

TOTAL: 15 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) continued).

Government of South Australia

SACE Board of SA

External Examination 2012

2012 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

3

11 pages, 4 questions

Wednesday 7 November: 9 a.m.

Question Booklet 3

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

QUESTION 9

A number of chemicals are used as bleaches.

(a) Oxygen bleaches release hydrogen peroxide, which decomposes, releasing oxygen.

(i) Write an equation for the decomposition of hydrogen peroxide.

(2 marks)

(ii) Explain why oxygen is released more rapidly at higher temperatures.

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_____

_____ (3 marks)

(b) Chlorine bleaches are commonly solutions of sodium hypochlorite (NaOCl).

(i) A typical solution of chlorine bleach contains 6.0% NaOCl by weight.
Convert this concentration into mol L^{-1}.

(3 marks)

(ii) The hypochlorite ion removes stains because of its oxidising ability.
Write a half-equation for the conversion of hypochlorite ions into chloride ions.

(2 marks)

(c) Solutions made by bubbling chlorine gas (Cl_2) through water can also be used as bleach. The reversible reaction between Cl_2 and water is shown in the equation below:

$$Cl_2 + H_2O \rightleftharpoons HClO + HCl$$

(i) At room temperature the equilibrium constant for this reaction is 4.5×10^{-4}.

State whether, at equilibrium, most of the chlorine is present as Cl_2 or as HClO and HCl.

_____ (1 mark)

(ii) Explain why the smell of Cl_2 is not evident if the solution has a pH of 12.4.

_____

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_____ (3 marks)

(iii) Calculate the concentration, in mol L^{-1}, of hydroxide ions in a solution that has a pH of 12.4.

(2 marks)

TOTAL: 16 marks

QUESTION 10

Sulfur dioxide (SO_2) is an important industrial gas that is also found in small quantities in the Earth's atmosphere.

(a) SO_2 also occurs in the upper atmosphere of Venus where it is converted into SO_3 by reaction with atomic oxygen. The atomic oxygen is produced when ultraviolet light dissociates carbon dioxide into carbon monoxide and atomic oxygen.

(i) State the name given to a chemical reaction that is initiated by the absorption of light energy.

_____ (1 mark)

(ii) Write an equation showing the effect of ultraviolet light on carbon dioxide.

(2 marks)

(b) In industry, sulfur dioxide is commonly produced by roasting metal sulfides in air.

Write an equation for the roasting of FeS_2 in air, given that the other product is Fe_3O_4.

(2 marks)

(c) The major use of SO_2 is in the manufacture of sulfuric acid by the contact process. In this process, SO_2 is reacted with oxygen to produce sulfur trioxide (SO_3) at 450°C, at a pressure slightly above atmospheric pressure, in the presence of a catalyst. Under these conditions the yield is approximately 96%. The equation for this reaction is shown below:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad \Delta H = -196 \text{ kJ}$$

(i) Explain why a higher pressure would improve the yield of sulfur trioxide.

_____

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_____ (3 marks)

(ii) Suggest why a higher pressure is not used.

_____

_____ (1 mark)

(iii) Explain how the operating temperature of 450°C represents a compromise between yield and rate.

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_____ (4 marks)

(iv) V_2O_5 in the reaction vessel lowers the overall activation energy. The V_2O_5 catalyses the reaction in the following two steps:

Step 1 $SO_2 + V_2O_5 \longrightarrow SO_3 + 2VO_2$

Step 2 $4VO_2 + O_2 \longrightarrow 2V_2O_5$

Using the information above, explain why the V_2O_5 is described as a catalyst in this reaction.

_____

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_____ (2 marks)

TOTAL: 15 marks

QUESTION 11

One potential application of nanochemistry is the delivery of drugs by means of carbon nanotubes.

(a) State the block of the periodic table to which carbon belongs.

_____ (1 mark)

(b) The carbon nanotube is a cylinder of covalently bonded carbon atoms.

Explain why the bonds in the carbon nanotube are non-polar.

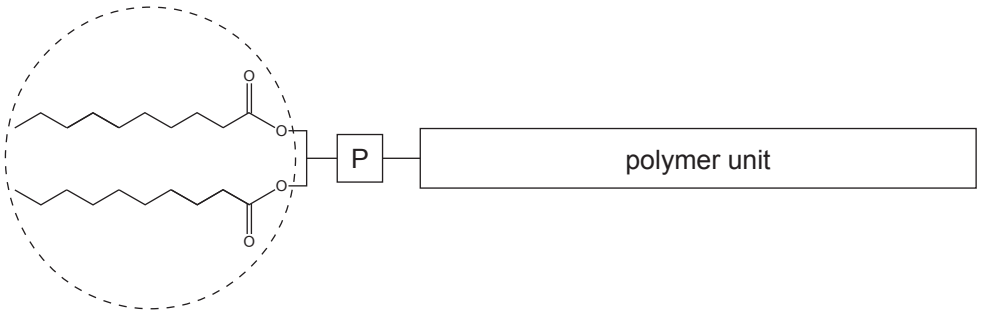
_____

_____

_____

_____ (2 marks)

(c) To improve the solubility of the carbon nanotube in an aqueous environment, large molecules are adsorbed onto the carbon nanotubes. One of these large molecules is shown in the diagram below:



(i) Phosphate ions (PO_4^{3-}) are used to make the phosphate group shown as P in the diagram on the page opposite.

(1) Draw the structural formula of the phosphate ion, clearly showing its shape.

(2 marks)

(2) State the oxidation number of phosphorus in the phosphate ion.

_____ (1 mark)

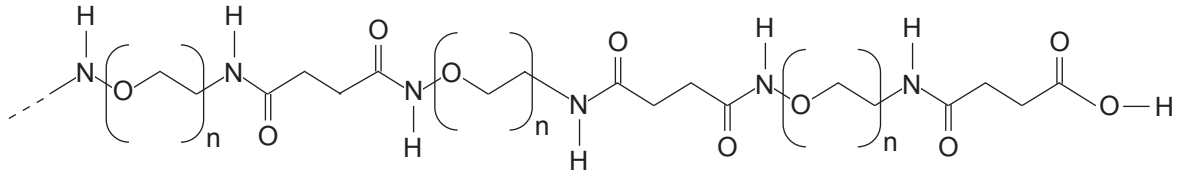
(ii) The large molecule can be hydrolysed if exposed to an alkaline environment.

When the large molecule undergoes alkaline hydrolysis a product is formed from the circled section in the diagram on the page opposite.

Draw the structural formula of the product formed.

(2 marks)

(d) The structural formula of the polymer unit of the large molecule is shown below:



(i) On the structural formula above, show the polarity of one polar bond in the polymer unit. (1 mark)

(ii) Explain how the polymer unit improves the solubility of the carbon nanotube in an aqueous environment.

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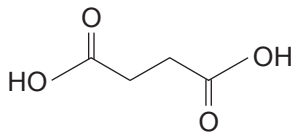
_____ (2 marks)

(iii) The structural formula of one of the monomers used to make the polymer unit is shown below:



State the systematic name of this monomer.

_____ (2 marks)

(iv) Draw the structural formula of the other monomer, a diamine, used to make the polymer unit.

(2 marks)

TOTAL: 15 marks

QUESTION 12

Consumers are gradually adopting biodiesel as a fuel in motor vehicles, replacing diesel and petrol.

(a) Diesel fuel consists of hydrocarbons with between 8 and 21 carbon atoms per molecule, whereas petrol consists of hydrocarbons with between 4 and 12 carbon atoms per molecule.

State, giving a reason, whether diesel or petrol has the higher boiling point.

_____

_____

_____

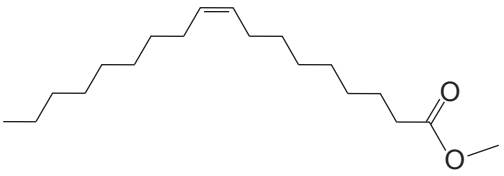
_____

_____

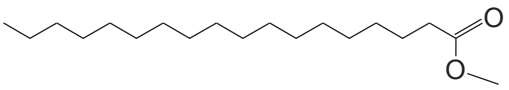
_____ (3 marks)

(b) Biodiesel is a mixture of methyl or ethyl esters of long-chain carboxylic acids and can be made from soybean oil and palm oil.

(i) The esters in biodiesel have structures of the types shown below:



unsaturated molecule



saturated molecule

Biodiesel made from soybean oil has a higher proportion of unsaturated molecules than biodiesel made from palm oil.

Explain why biodiesel made from soybean oil has a lower melting point than biodiesel made from palm oil.

_____

_____

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_____ (3 marks)

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

(ii) Biodiesel contains small amounts of free monoprotic acids. The total concentration of acid in a sample of biodiesel was measured by titration with potassium hydroxide (KOH) solution.

(1) A KOH solution was prepared and shown to have a concentration of 0.01017 mol L^{-1}.

Calculate the mass of KOH in 250.0 mL of this solution.

(3 marks)

(2) A volume of 1.000 L of biodiesel solution was prepared by diluting 20.00 mL of biodiesel.

20.00 mL samples of the biodiesel solution were titrated with the 0.01017 mol L^{-1} KOH solution.

(A) Name the apparatus that would have been used to accurately transfer the samples of biodiesel solution to the titration flasks.

_____ (1 mark)

(B) It was found that an average of 4.2 mL of KOH solution was required in the titration.

Calculate the total concentration of monoprotic acids in the original biodiesel.

(4 marks)

TOTAL: 15 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. 10(c)(iii) continued).