1

Government of South Australia

SACE Board of SA | South Australian Certificate of Education

Chemistry
2017

Question Booklet 1

- (Questions 1 to 4) 61 marks
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 17 if you need more space
- Allow approximately 60 minutes

Examination information

Materials

- Question Booklet 1 (Questions 1 to 4)
- Question Booklet 2 (Questions 5 to 8)
- Question Booklet 3 (Questions 9 to 12)
- SACE registration number label

Reading time

- 10 minutes
- You may make notes on scribbling paper

Writing time

- 3 hours
- Clear, well-expressed answers are required
- Use black or blue pen
- Approved calculators may be used

Total marks 180

Attach your SACE registration number label here

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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)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

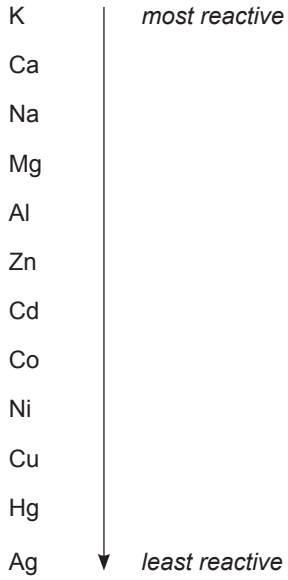
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71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

PLEASE TURN OVER

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

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}

The examination questions begin on page 6.

Question 1 (15 marks)

CO is one pollutant that may be found in the exhaust gases produced by petrol-burning vehicles.

(a) (i) Explain why there may be CO in the exhaust gases produced by a petrol-burning vehicle.

_____

_____

_____

_____ (2 marks)

(ii) State why CO is considered to be a pollutant.

_____

_____ (1 mark)

(iii) State and explain whether CO is a primary or secondary pollutant.

_____

_____

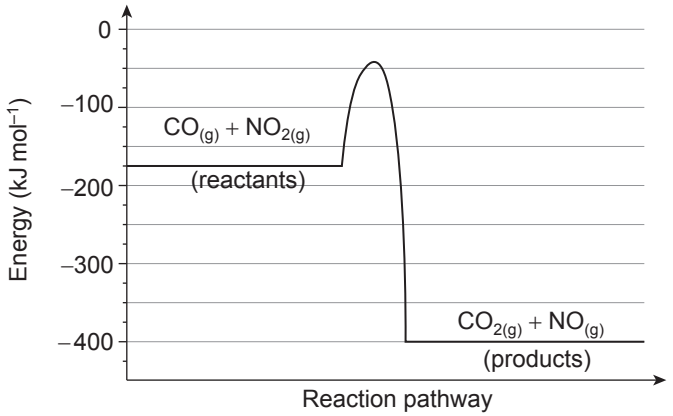
_____

_____ (2 marks)

(iv) One reaction that can occur between two exhaust gases is:

$$CO_{(g)} + NO_{2(g)} \longrightarrow CO_{2(g)} + NO_{(g)}$$

The energy profile diagram for this reaction is shown below.



Determine the magnitude and sign of ΔH for the forward reaction, in kJ mol^{-1}.

_____ (2 marks)

(b) All modern petrol-burning vehicles are fitted with catalytic converters that convert CO into CO_2.

(i) Explain the effect of the catalyst on the activation energy of this reaction.

_____

_____

_____

_____ (2 marks)

(ii) Explain the effect of the catalyst on the magnitude of ΔH for this reaction.

_____

_____

_____

_____ (2 marks)

(iii) The honeycomb structure inside a catalytic converter provides a very large surface, which is coated with the catalyst.

Explain, in terms of collisions between reactant particles, why an increase in surface area produces an increase in the rate of reaction.

_____

_____

_____

_____ (2 marks)

(iv) An incomplete thermochemical equation for the conversion of CO into CO_2 in a catalytic converter is:

$$CO + O_2 \longrightarrow CO_2 \qquad \Delta H = -283 \text{ kJ mol}^{-1}.$$

Complete this thermochemical equation. (2 marks)

Question 2 (10 marks)

'Cold and flu' medications contain a variety of chemicals.

(a) Ethanol can be used as a solvent in these medications.

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

(1) Write an equation for the fermentation of glucose.

(2 marks)

(2) State *one* observation that would indicate that fermentation is occurring.

_____ (1 mark)

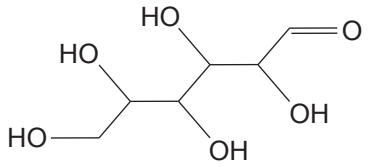
(ii) The ethanol present in these medications can produce positive results in alcohol breath tests that use dichromate ions as the oxidising agent.

State the colour change observed when dichromate ions react with ethanol.

_____ (2 marks)

(b) Fexofenadine and pseudoephedrine are active ingredients in some cold and flu medications.

(i) Glucose is used as a raw material in the production of pseudoephedrine. The structural formula of glucose is shown below.



State why glucose is classified as a carbohydrate.

_____

_____ (1 mark)

(ii) The production of pseudoephedrine involves a reaction between glucose and benzaldehyde, an aldehyde.

Explain why Tollens' reagent cannot be used to conclude that excess benzaldehyde remained at the end of this reaction.

_____

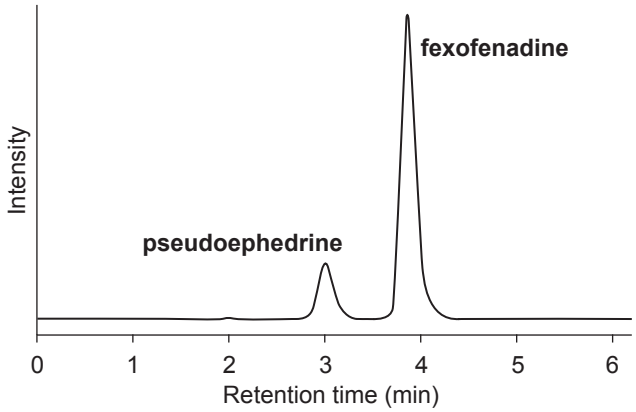
_____

_____

_____ (2 marks)

(iii) A mixture of fexofenadine and pseudoephedrine was separated, using high-performance liquid chromatography. The stationary phase was less polar than the mobile phase.

The resultant chromatogram is shown below.



Explain how the chromatogram above shows that pseudoephedrine is more polar than fexofenadine.

_____

_____

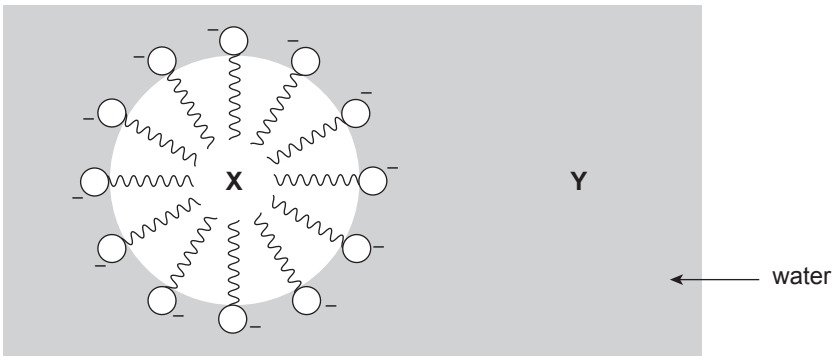
_____

_____ (2 marks)

Question 3 (18 marks)

Soaps are commonly used cleaning agents.

(a) Soap anions remove grease by forming micelles in water. A diagram of a micelle in water is shown below.



Identify the region (**X** or **Y**) that is more polar.

_____ (1 mark)

(b) The effectiveness of a soap can be measured by its ability to froth in water.

Trials were conducted, using one piece of glassware, to compare the effectiveness of one soap in samples of water taken from three different sources.

In each trial, 1.0 mL of soap solution was added to 80.0 mL samples of water. The glassware was sealed and then shaken vigorously for 10 seconds. The total volume, including the froth formed, was recorded.

Three trials were conducted for each water source. The results obtained from this experiment are shown in the table below.

	Total volume (mL)			
Water source	*Trial 1*	*Trial 2*	*Trial 3*	*Average*
1	91.0	93.0	92.0	92.0
2	89.0	86.0	86.0	87.0
3	82.0	82.0	84.0	82.7

(i) State the independent variable for this experiment.

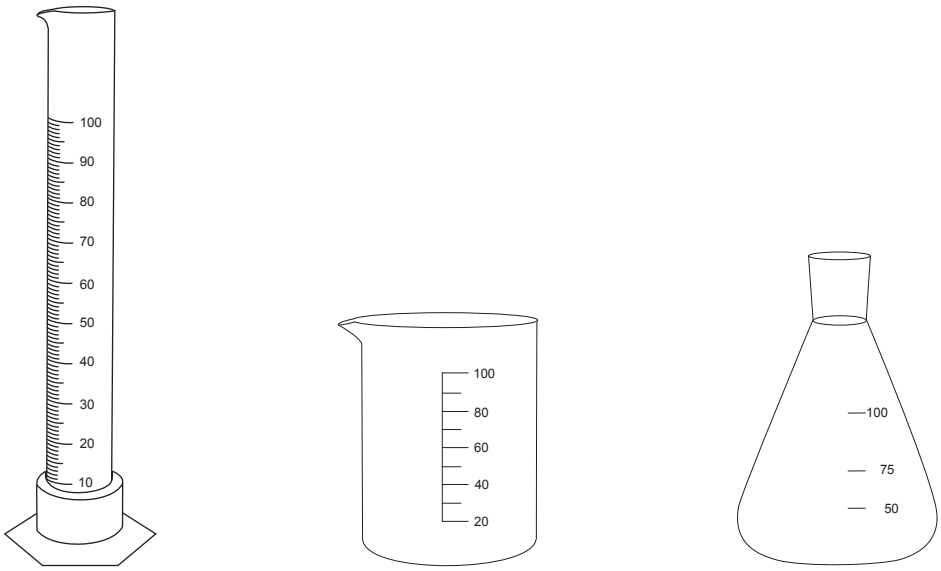
_____ (1 mark)

(ii) State the benefit of obtaining an average volume from three trials for each water source.

_____

_____ (1 mark)

(iii) Three pieces of glassware that could have been used to conduct the trials are shown below.



Identify the piece of glassware that would provide the most appropriate resolution for measuring the volume in these trials.

_____ (1 mark)

(iv) (1) Identify the water source in which the soap is least able to froth.

_____ (1 mark)

(2) Explain the likely reason why the soap is least able to froth in the water from this source.

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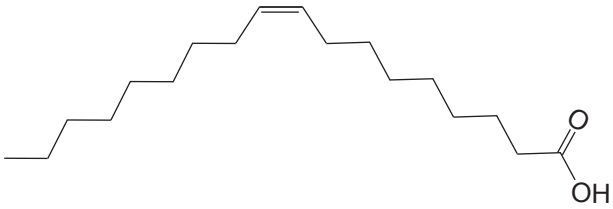
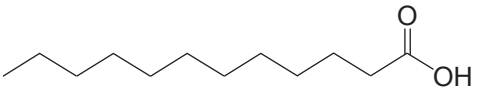
_____(3 marks)

(c) Soaps can be made from a variety of oils, including almond oil and coconut oil. Triglycerides made from oleic acid make up the major component of almond oil. Triglycerides made from lauric acid make up the major component of coconut oil.

The structural formulae of these two acids are shown below.



oleic acid



lauric acid

(i) Draw the structural formula of a triglyceride made from lauric acid.

(2 marks)

(ii) Explain why soap made from almond oil has a lower melting point than soap made from coconut oil.

_____

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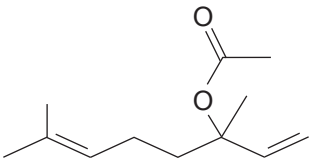
_____

_____ (3 marks)

(d) Oils from plants such as lavender may be added to soaps to provide fragrance.

The structural formula of an ester found in lavender oil is shown below.



(i) Each carbon atom in this ester is bonded to either three or four other atoms.

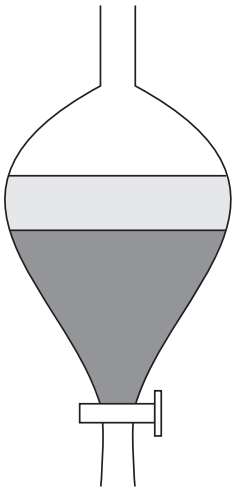
State the number of carbon atoms in this molecule that are bonded to *four* other atoms.

_____ (1 mark)

(ii) State the systematic name of the acid produced during hydrolysis of this ester.

_____ (2 marks)

(iii) One step in the production of lavender oil involves the separation of oil from water using a separating funnel. Two layers form in the funnel, as shown below:



Suggest *one* method of determining which of these two layers is the water layer.

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_____ (2 marks)

PLEASE TURN OVER

Question 4 (18 marks)

Research indicates that as increasing amounts of CO_2 from the atmosphere are dissolving in sea water, the pH of sea water is decreasing. Some seawater species that have shells composed primarily of $CaCO_3$ may be affected.

(a) Explain, with the aid of an equation, how CO_2 dissolved in sea water decreases the pH of the sea water.

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_____ (3 marks)

(b) The pH of sea water from a particular location was found to be 7.5.

Calculate the concentration of $H^+_{(aq)}$, in $mol\,L^{-1}$, in this sea water.

(2 marks)

(c) Explain how the decreased pH levels of sea water could affect the mass of shells that contain $CaCO_3$.

_____

_____

_____

_____ (2 marks)

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

(d) The following procedure was used to investigate the effect of the decreasing pH levels of sea water on the mass of the shells of one seawater species:

Step 1 A crushed shell with a mass of 0.145 g was placed in a conical flask.

Step 2 50.0 mL of standardised 0.200 mol L^{-1} HCl solution was added to the conical flask.

Step 3 At the completion of the reaction, the unreacted HCl in the conical flask was titrated with 0.250 mol L^{-1} NaOH solution. The equation for this reaction is shown below.

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

The titre recorded was 0.02870 L.

(i) Calculate the number of moles of NaOH in the titre.

(1 mark)

(ii) Determine the number of moles of HCl that reacted in the titration.

(1 mark)

(iii) Calculate the number of moles of HCl that reacted with the $CaCO_3$ in the shell.

(2 marks)

(iv) $CaCO_3$ reacts with HCl as shown in the equation below.

$$2HCl + CaCO_3 \longrightarrow H_2O + CO_2 + CaCl_2$$

Calculate the mass of $CaCO_3$ ($M = 100.09\ g\,mol^{-1}$) in the shell.

(2 marks)

(v) Determine the percentage, by mass, of $CaCO_3$ in the shell.

(1 mark)

(vi) After the investigation was completed, the concentration of the HCl solution was determined to have been less than $0.200\ mol\,L^{-1}$.

Explain the effect that this had on the calculated mass of $CaCO_3$.

_____

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_____ (3 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(b)(ii) continued).

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Chemistry
2017

Question Booklet 2

2

- (Questions 5 to 8) 60 marks
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 12 if you need more space
- Allow approximately 60 minutes

Copy the information from your SACE label here

SEQ	FIGURES	CHECK LETTER	BIN

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Question 5 (15 marks)

HOCl and OCl^- (together commonly referred to as 'free chlorine') are used as antibacterial agents in the treatment of water.

(a) State the action of HOCl and OCl^- in this process.

_____ (1 mark)

(b) OCl^- undergoes the following reaction with water:

$$OCl^- + H_2O \rightleftharpoons HOCl + OH^-$$

HOCl is a more effective antibacterial agent than OCl^-.

Explain why water needs to be mildly acidic in order to maximise the antibacterial effectiveness of free chlorine.

_____

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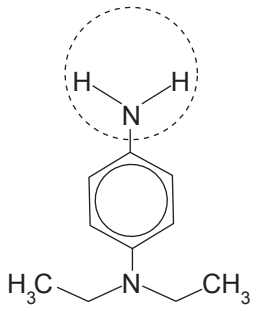
_____ (3 marks)

(c) *N,N*-Diethyl-*p*-phenylenediamine (DPD) can be used to measure free chlorine concentration in water. The structural formula of DPD is shown below.



(i) State whether the amine group circled on the structural formula above is a primary, secondary, or tertiary amine.

_____ (1 mark)

(ii) Explain why DPD is only slightly soluble in water.

_____

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_____ (3 marks)

(iii) DPD reacts with acid to form a new product.

(1) This reaction is exothermic.

State whether energy is absorbed or released during this reaction.

_____ (1 mark)

(2) (A) Draw the structural formula of the product formed when DPD reacts with excess acid.

(2 marks)

(B) Explain whether this product is more soluble or less soluble in water than DPD.

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_____ (4 marks)

Question 6 (16 marks)

The production of cement contributes significantly to total global CO_2 emissions.

(a) The first step in cement production is the thermal decomposition of $CaCO_3$, as shown in the following equation:

$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

One particular cement factory produces approximately 225 000 tonnes of CaO each year.

1 tonne = 1 x 10^6 grams.

(i) (1) Calculate the number of moles of CaO produced annually.

(2 marks)

(2) Hence calculate, in tonnes, the mass of CO_2 ($M = 44.01\ g\,mol^{-1}$) emissions produced annually.

(2 marks)

(ii) The thermal decomposition of $CaCO_3$ accounts for 55% of the total annual CO_2 emissions from this cement factory.

Calculate the total annual mass of CO_2 emissions from this cement factory.

(1 mark)

(iii) A very large area of forest (the size of a small city) would need to be planted in order to offset the annual CO_2 emissions from this cement factory.

Write a balanced equation for the process in which plants remove CO_2 from the atmosphere.

(2 marks)

(b) During cement production, CaO reacts with SiO_2 to form a mixture of silicates.

(i) Using this information, explain whether SiO_2 has an acidic or a basic character.

_____

_____

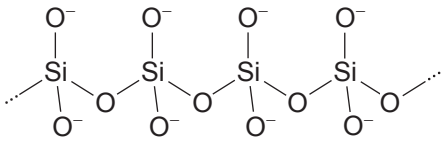
_____

_____ (2 marks)

(ii) One possible reaction of CaO with SiO_2 is:

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

The structure of a section of the silicate anion formed in this reaction is shown below.



Explain why the spatial arrangement of oxygen atoms about each silicon atom is tetrahedral.

_____

_____

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_____ (3 marks)

(c) Scientists agree that the increasing global emissions of CO_2 are disrupting the thermal balance of the atmosphere.

(i) Explain how increased CO_2 emissions contribute to an increased average global temperature.

_____

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_____ (3 marks)

(ii) State *one* environmental consequence that may arise from disrupting the thermal balance of the atmosphere.

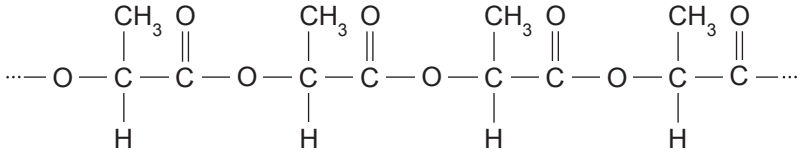
_____

_____ (1 mark)

Question 7 (14 marks)

Polylactic acid (PLA) is a biodegradable plastic made from renewable resources.

A section of a PLA polymer chain is shown below.



(a) State the name given to the type of polymerisation reaction that produces PLA.

_____ (1 mark)

(b) PLA is formed from lactic acid monomers.

(i) Draw the structural formula of the lactic acid monomer.

(2 marks)

(ii) Name the new functional group that is formed when lactic acid monomers react to produce PLA.

_____ (1 mark)

(c) Explain, in terms of its structure, why PLA is classified as a thermoplastic polymer.

_____

_____

_____

_____ (2 marks)

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

(d) Plasticisers are added to PLA to increase the flexibility of the final product.

Caprolactone, derived from crude oil, is commonly used as a plasticiser. Recently, pinene (an oil found in pine trees, and a waste product of the paper manufacturing industry) has been used as an alternative to caprolactone.

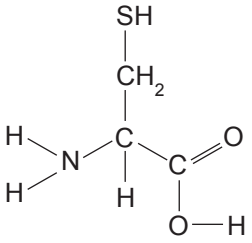
Explain *three* benefits of producing PLA with pinene rather than with caprolactone.

(8 marks)

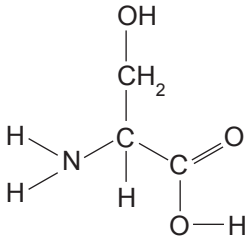
Question 8 (15 marks)

Enzymes are made from small molecules such as cysteine and serine.

The structural formulae of cysteine and serine are shown below.



cysteine



serine

(a) Identify the group of organic compounds to which cysteine and serine belong.

_____ (1 mark)

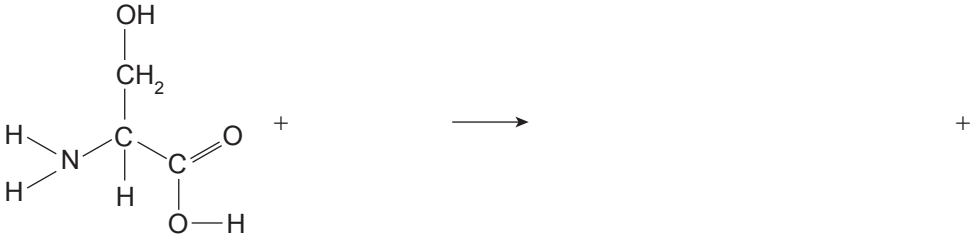
(b) (i) Serine is able to self-ionise.

Draw the self-ionised form of serine.

(2 marks)

(ii) Serine reacts with hydrogencarbonate ions.

Complete the equation for this reaction.



serine **organic product**

(2 marks)

(c) When one molecule of cysteine and one molecule of serine react together, two possible products can be formed.

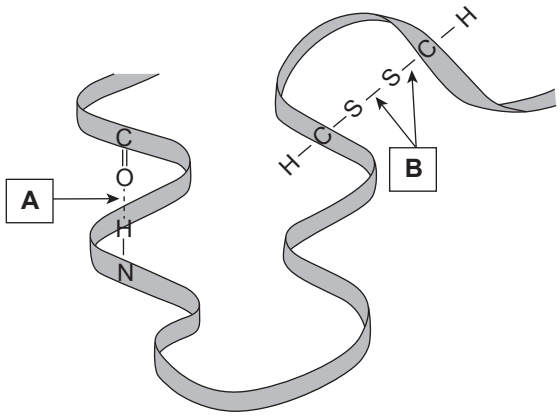
(i) Draw the structural formula of *one* of these products.

(2 marks)

(ii) Name the functional group formed in this reaction.

_____ (1 mark)

(d) A section of an enzyme is represented in the diagram below.



(i) (1) Name the type of secondary interaction indicated by **A**.

_____ (1 mark)

(2) Name the type of primary bond indicated by **B**.

_____ (1 mark)

(ii) If the pH of the enzyme's environment decreased, state whether the secondary interaction indicated at **A** or the primary bonds indicated at **B** would be more likely to be affected.

_____ (1 mark)

(iii) Explain how a decrease in pH affects the biological function of the enzyme.

_____

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_____

_____ (4 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(c)(iii)(2)(B) continued).

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Question Booklet 3

- (Questions 9 to 12) 59 marks
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 12 if you need more space
- Allow approximately 60 minutes

3

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SEQ	FIGURES	CHECK LETTER	BIN

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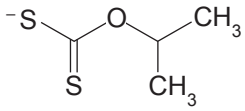
Question 9 (13 marks)

A number of processes are used to extract pure nickel from its ore.

(a) Froth flotation is used to concentrate nickel sulfide from its crushed ore.

The structural formula of one frothing agent, the isopropyl xanthate anion, is shown below.



Explain, with reference to its structure, how the isopropyl xanthate anion acts as a frothing agent.

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_____ (4 marks)

(b) During the roasting of nickel sulfide, oxides of sulfur are released to the atmosphere. These oxides may react with rainwater to form acid rain.

(i) Write an equation for the reaction of sulfur trioxide with rainwater.

(2 marks)

(ii) State *one* environmental effect of acid rain.

_____

_____ (1 mark)

(c) Ni^{2+} may be reduced to nickel metal using carbon.

(i) Using subshell notation, write the electron configuration of Ni^{2+}.

_____ (2 marks)

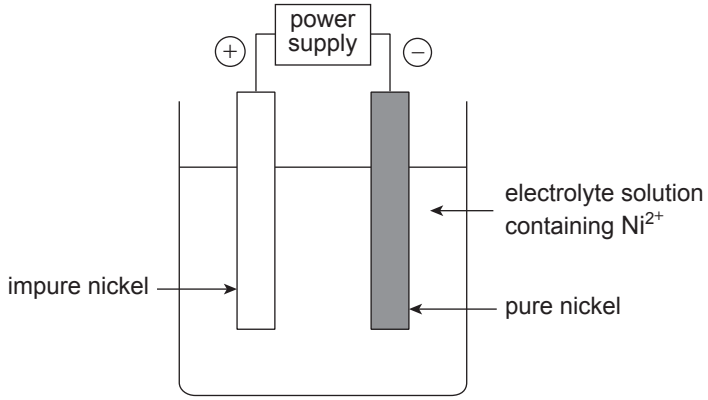
(ii) State why carbon is a suitable reducing agent for Ni^{2+}.

_____

_____ (1 mark)

(d) The nickel metal produced requires refining.

The diagram below shows an electrochemical cell used to refine nickel metal.



(i) State whether nickel is produced at the anode or at the cathode of this cell.

_____ (1 mark)

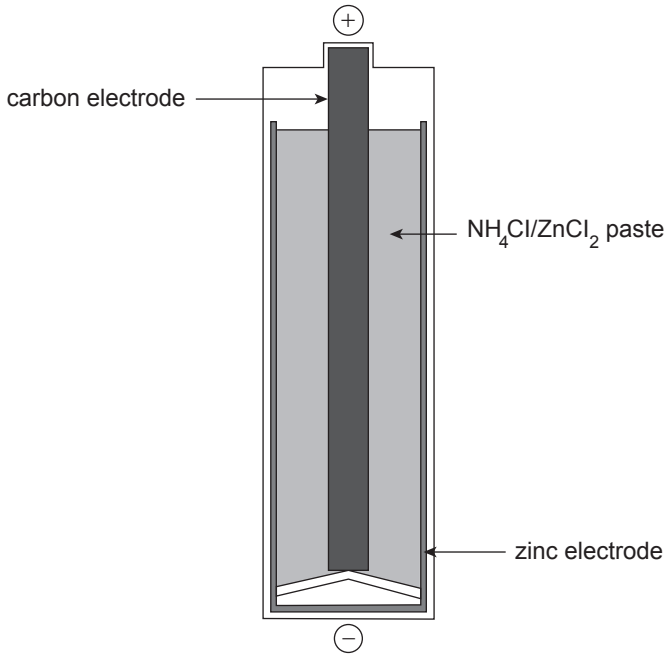
(ii) Write the half-equation for the reduction of Ni^{2+}.

(2 marks)

Question 10 (18 marks)

The first rechargeable battery was invented in 1859. Prior to this, batteries were non-rechargeable.

(a) A cross-section of one type of non-rechargeable battery that is used in a remote control is shown below.



(i) Identify the anode in this battery.

_____ (1 mark)

(ii) State the energy transformation that occurs as this battery supplies electrical energy to the remote control.

_____ (1 mark)

(b) One example of a rechargeable battery is a nickel–metal hydride (NiMH) battery.

(i) The charging and discharging process in a NiMH battery is represented by the following equation, in which M represents a metal other than nickel:

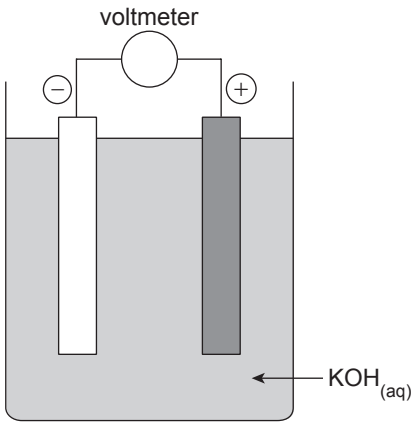
$$M + Ni(OH)_2 \underset{\text{discharging}}{\overset{\text{charging}}{\rightleftharpoons}} MH + NiO(OH)$$

(1) On the equation above, assign oxidation states to nickel in $Ni(OH)_2$ and $NiO(OH)$. (2 marks)

(2) Hence state whether nickel is being oxidised or reduced during the charging process.

_____ (1 mark)

(ii) The diagram below represents one NiMH battery.



(1) State whether this battery is operating as a galvanic or an electrolytic cell.

_____ (1 mark)

(2) Hence state whether this battery is undergoing the process of charging or discharging.

_____ (1 mark)

(3) Explain the function of $KOH_{(aq)}$ in this battery.

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_____

_____

_____ (2 marks)

(c) Hydrogen fuel cells provide electrical energy in spacecraft. Only heat and water are produced as the cells discharge.

(i) At the positive electrode, a gas other than hydrogen reacts.

Identify this gas.

_____ (1 mark)

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

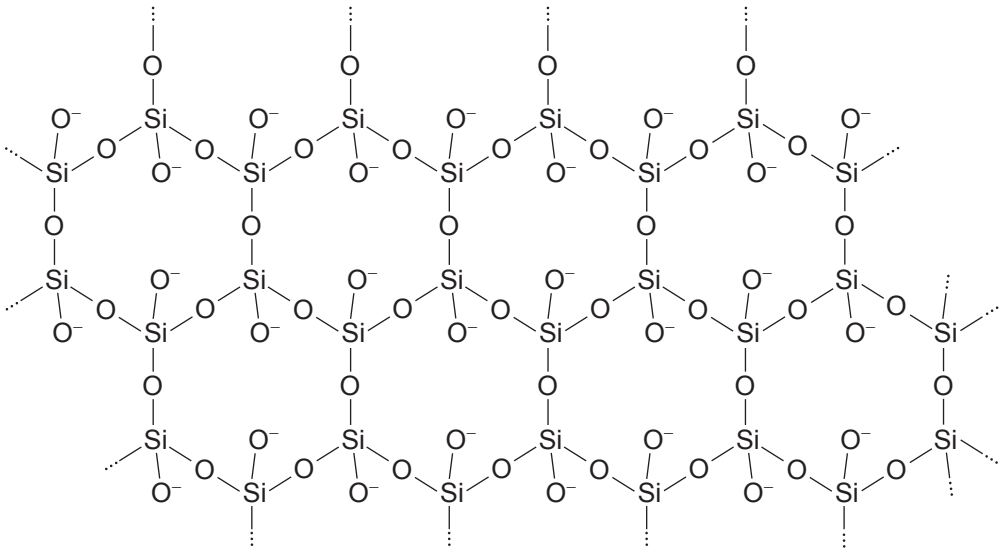
(ii) Explain the advantages and disadvantages of using hydrogen fuel cells to provide electrical energy in spacecraft.

(8 marks)

Question 11 (14 marks)

Ca^{2+} is a cation commonly present in soil.

(a) One clay that contains Ca^{2+} is montmorillonite. The structure of the silicate anion, $(Si_2O_5^{2-})_n$, in montmorillonite is shown below.



On the structure above, draw a rectangle around *one* repeating unit. (1 mark)

(b) Clintonite is an aluminosilicate found in some soils.

The formula of the clintonite anion is $Al_2Si_2O_{10}^{6-}$. The lattice structure of clintonite contains Ca^{2+} and Mg^{2+}, in a 1:3 ratio, and OH^- to balance the overall charge.

Write the formula of clintonite.

_____ (2 marks)

(c) Some fertilisers contain NH_4^+. When these fertilisers are added to soil, the concentration of $NH_{4\,(aq)}^+$ in the soil water increases and then the acidity of the soil water increases.

(i) Explain how an increase in $NH_{4\,(aq)}^+$ concentration causes $Ca^{2+}_{(clay)}$ to be released from clay.

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_____ (3 marks)

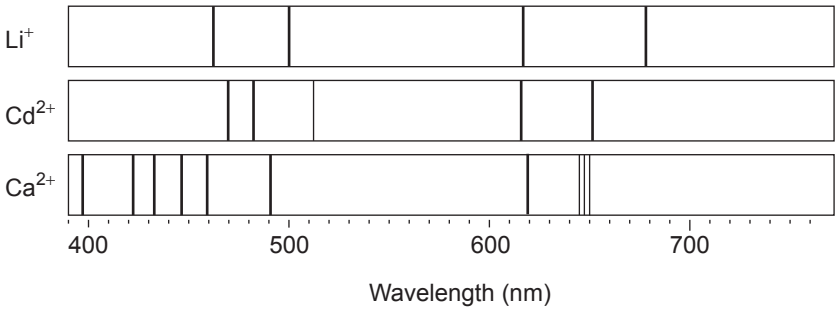
(ii) CaO can be added to decrease the acidity of soil water.

Write an equation that shows how CaO reacts to decrease the acidity of soil water.

(2 marks)

(d) Ca^{2+} concentration in soil water can be measured using atomic absorption spectroscopy (AAS).

(i) The emission spectra of some cations that are found in soil are shown below.

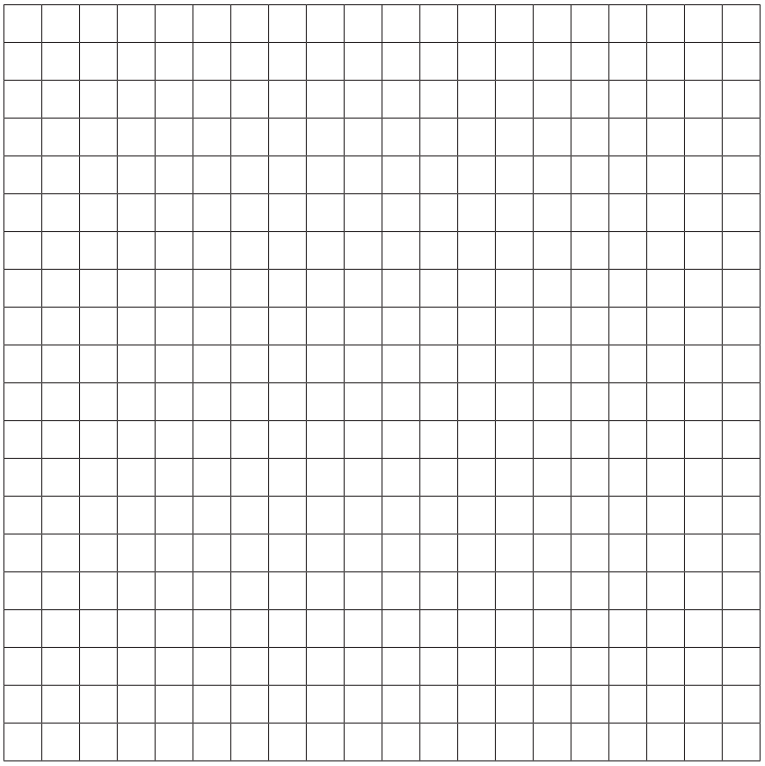


On the diagram above, circle the wavelength on the emission spectrum for Ca^{2+} that would ***not*** be suitable to use for measuring the concentration of Ca^{2+} in a soil-water sample if both Li^{+} and Cd^{2+} were also present. (1 mark)

(ii) Standard solutions of Ca^{2+} were used to calibrate the spectrometer, and the following data were recorded:

Ca^{2+} concentration ($mg\,L^{-1}$)	*Absorbance*
0.0	0.010
1.0	0.045
2.0	0.080
2.5	0.095
3.0	0.115
4.0	0.150

On the grid below, plot the data and draw the calibration line.



(4 marks)

(iii) The absorbance of a soil-water sample containing Ca^{2+} was found to be 0.070.

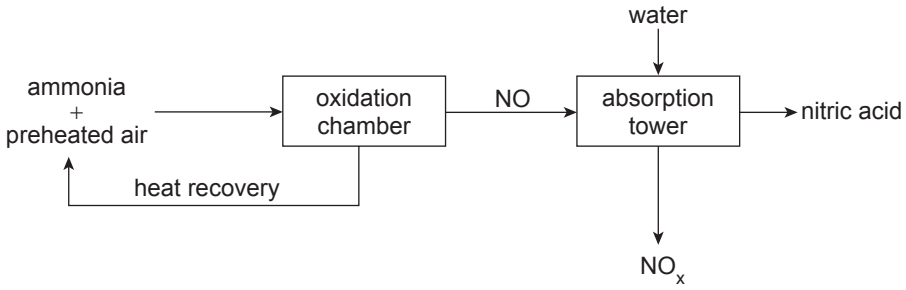
Using your calibration line, determine the concentration, in $mg\,L^{-1}$, of Ca^{2+} in the sample.

_____ (1 mark)

Question 12 (14 marks)

Nitrogen oxides have several industrial applications, including the production of nitric acid and fuel.

(a) The simplified diagram below represents the process of nitric acid production.



(i) Identify *two* raw materials shown on this diagram.

_____

_____ (2 marks)

(ii) Describe *one* method of reducing emissions of nitrogen oxides from the absorption tower.

_____

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_____

_____ (2 marks)

(b) Dinitrogen tetroxide, N_2O_4, is used as a fuel in spacecraft. One reaction in the production of N_2O_4, as shown in the equation below, was investigated in a laboratory.

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

(i) Write the K_c expression for this reaction.

(1 mark)

(ii) In this investigation, 1.3 mol of $NO_{2(g)}$ was placed in an empty 1.00 L flask, which was then sealed and heated to 127°C. When the system reached equilibrium, 0.24 mol of $N_2O_{4(g)}$ was present in the flask.

Show that at 127°C, $K_c = 0.36$.

(3 marks)

(iii) At 25°C, $K_c = 8.3$.

State and explain whether the forward reaction is exothermic or endothermic.

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_____ (3 marks)

(iv) (1) State *one* change to reaction conditions, other than temperature, that would increase the yield of $N_2O_{4(g)}$.

_____

_____ (1 mark)

(2) Explain how this change would increase the yield of $N_2O_{4(g)}$.

_____

_____

_____

_____ (2 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(b)(ii)(3) continued).