Government of South Australia

SACE Board of SA

External Examination 2013

2013 CHEMISTRY

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ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

14 pages, 4 questions

Thursday 14 November: 9 a.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (14 pages)
Question Booklet 2 (11 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 14 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 11 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)		114 Fl Flerovium (289)		116 Lv Livermorium (293)		

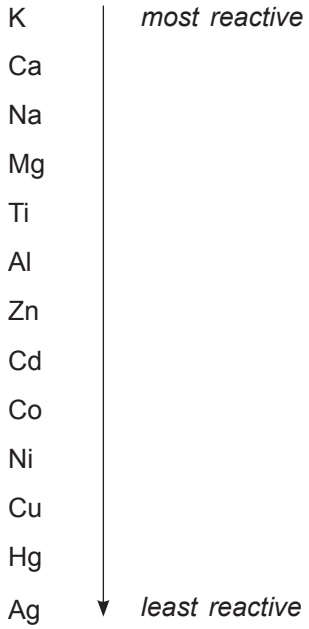
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71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



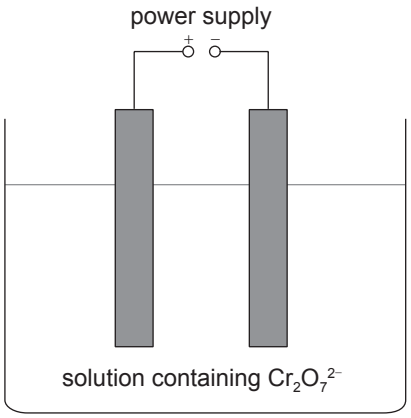
You may refer to the following table, which shows SI prefixes, their symbols, and their values, when answering questions that involve the conversion of units:

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

Waste water from a chromium-plating factory has been identified as the source of contamination of groundwater nearby.

(a) The diagram below shows the apparatus used for one method of chromium-plating a piece of metal:



(i) State whether this is a galvanic cell or an electrolytic cell.

_____ (1 mark)

(ii) Show the direction of electron flow on the diagram. (1 mark)

(iii) Label the anode on the diagram. (1 mark)

(b) Chromium forms several compounds, in which it shows a range of oxidation states.

(i) State the block of the periodic table in which chromium occurs.

_____ (1 mark)

(ii) In the plating process $Cr_2O_7^{2-}$ is converted into Cr.

(1) Determine the oxidation state of Cr in $Cr_2O_7^{2-}$ and Cr.

$Cr_2O_7^{2-}$ _____ Cr _____ (2 marks)

(2) State whether the conversion of $Cr_2O_7^{2-}$ into Cr represents oxidation or reduction.

_____ (1 mark)

(iii) The compound Cr_2O_3 reacts with HCl solution.
Write an equation for this reaction.

(2 marks)

(c) Before contaminated groundwater is fit for drinking, several steps are required to remove contaminants and heavy metals.

(i) In one step fine clay particles are removed by adding aluminium sulfate to the water.

Explain how aluminium sulfate is used to remove fine clay particles from water.

(3 marks)

(ii) In another step the concentration of Cr^{3+} ions in the water can be reduced by cation exchange, using a zeolite column.

(1) State two characteristics of the zeolite's structure that make it effective in removing Cr^{3+} ions from large volumes of water.

(2 marks)

(2) The maximum acceptable concentration of Cr in drinking water is 50 ppb.

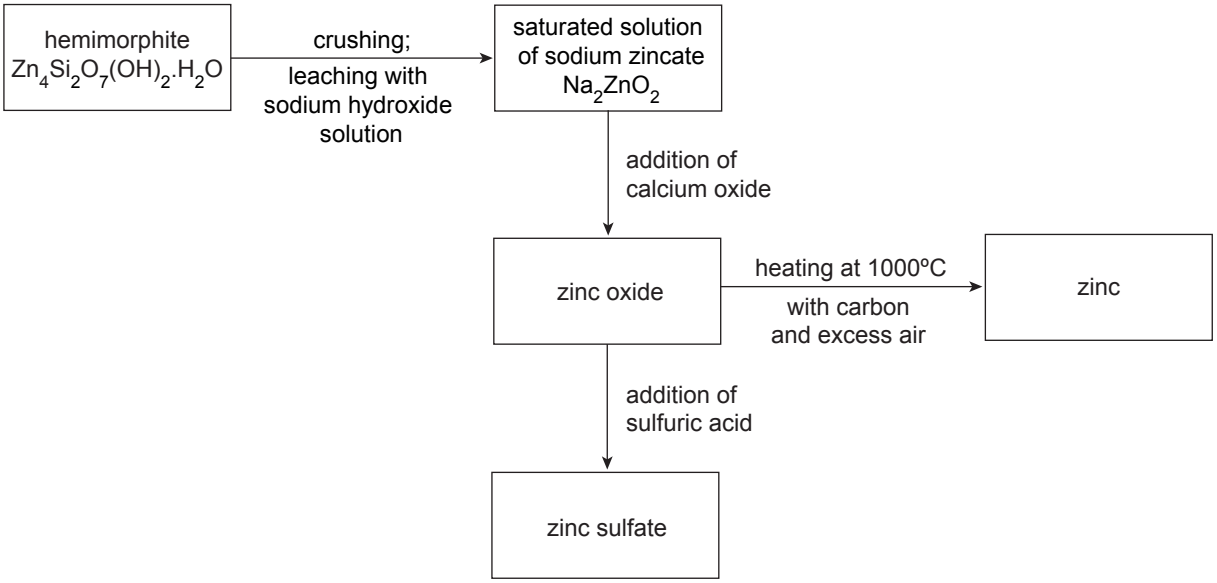
Calculate the number of milligrams of Cr in 250 mL of water in which the concentration of Cr is 50 ppb.

(2 marks)

TOTAL: 16 marks

QUESTION 2

Zinc and zinc sulfate are obtained from the mineral hemimorphite, as shown in the flow chart below:



(a) Use the information in the flow chart above to answer the following questions.

(i) Name the process used to increase the rate of reaction of hemimorphite with sodium hydroxide solution.

_____ (1 mark)

(ii) Identify evidence in the flow chart that shows that zinc is a metalloid.

_____

_____

_____

_____ (2 marks)

(iii) State the function of carbon in the conversion of zinc oxide into zinc.

_____ (1 mark)

(b) A saturated aqueous solution of sodium zincate establishes an equilibrium in which the products are zinc oxide and sodium hydroxide.

Write an equation for this equilibrium.

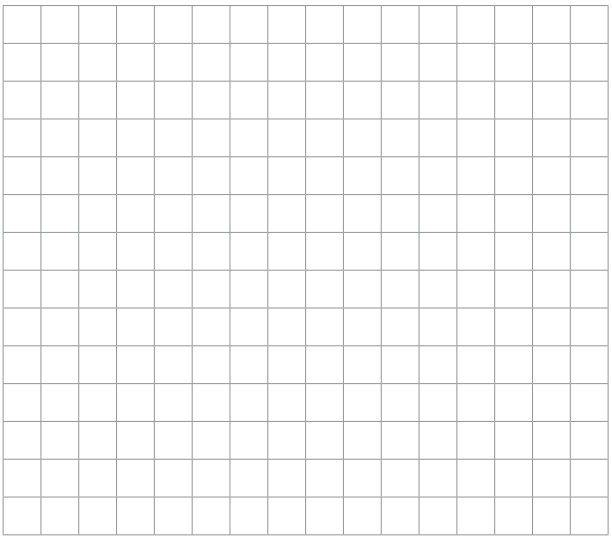
(2 marks)

(c) Zinc oxide is used in sunscreen. To investigate the possibility of Zn^{2+} from zinc oxide moving through the skin, sunscreen was applied to the outer surface of a skin-like material. The level of Zn^{2+} present on the inner surface was determined 2 hours later, using atomic absorption spectroscopy (AAS) on a sample.

Calibration of the AAS was completed using four standards containing known concentrations of Zn^{2+} in solution. The following results were obtained:

Solution	Concentration of Zn^{2+} in solution (mg L^{-1})	Absorbance
Standard 1	0.005	0.12
Standard 2	0.015	0.33
Standard 3	0.020	0.49
Standard 4	0.025	0.60

(i) Using the data in the table above, construct a calibration graph for measuring concentrations of Zn^{2+} in solution.



(5 marks)

(ii) State the evidence in the graph that indicates the presence of random errors.

_____ (1 mark)

(iii) After the 2 hours the inner surface of the skin-like material gave an absorbance reading of 0.52.

Use the graph to determine the concentration of Zn^{2+} for the sample.

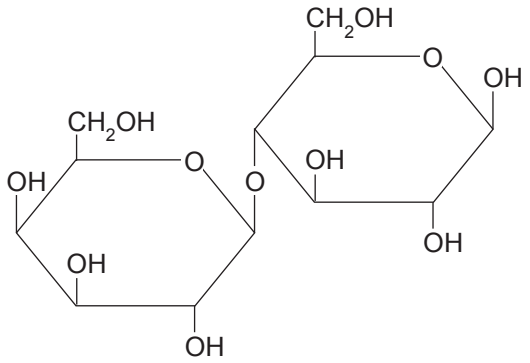
_____ (2 marks)

TOTAL: 14 marks

QUESTION 3

The enzyme lactase is able to convert the sugar lactose into glucose and galactose.

(a) Lactose, which has the structural formula shown below, consists of the two linked 6-carbon sugar molecules, glucose and galactose:



(i) State the name given to a carbohydrate that consists of two linked sugar molecules.

_____ (1 mark)

(ii) Name the type of reaction in which lactose is converted into glucose and galactose.

_____ (1 mark)

(iii) State the molecular formula of galactose.

_____ (1 mark)

(b) Genetic variations alter the amino acid sequence in lactase. One amino acid difference in an enzyme may affect its ability to perform its function.

(i) Explain how one amino acid difference in an enzyme may make it unable to act as a catalyst.

_____

_____

_____

_____

_____

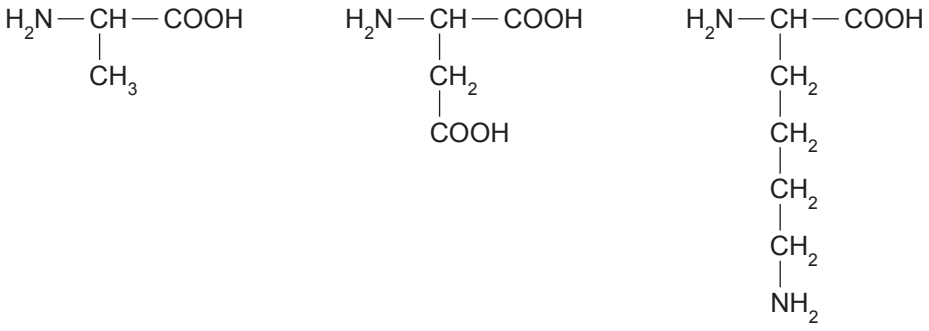
_____(3 marks)

(ii) State why one amino acid difference in an enzyme may not affect its ability to act as a catalyst.

_____

_____ (1 mark)

(c) The structural formulae of three of the amino acids from which lactase is formed are shown below:



alanine **aspartic acid** **lysine**

(i) Name the functional group that links the amino acid units in an enzyme.

_____ (1 mark)

(ii) Draw a section of the lactase chain that contains one alanine unit and one aspartic acid unit.

(2 marks)

(iii) Lysine undergoes a reaction and forms the compound whose structural formula is shown below:

$$H_2N\,CH_2\,CH_2\,CH_2\,CH_2\,CH_2\,NH_2$$

State the systematic name of this compound.

_____ (2 marks)

(iv) Amino acids can undergo self-ionisation.

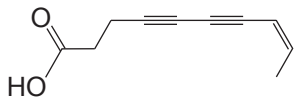
Draw the structural formula of alanine in its self-ionised form.

(2 marks)

TOTAL: 14 marks

QUESTION 4

Dihydromatricaria acid (DHMA), a colourless liquid excreted by soldier beetles, has several potential medical applications. The structural formula of DHMA is shown below:



(a) On the diagram above, circle the functional group that gives DHMA its acidic properties. (1 mark)

(b) DHMA reacts with sodium carbonate.

State one observation that would indicate a reaction was occurring.

_____

_____ (1 mark)

(c) DHMA can be synthesised from oleic acid, a colourless, 18-carbon chain carboxylic acid containing one carbon–carbon double bond.

(i) A catalyst is used in this synthesis to provide an alternative pathway with a lower activation energy.

Explain how a pathway with a lower activation energy speeds up the rate of a chemical reaction.

_____

_____

_____

_____ (2 marks)

(ii) Describe how a bromine solution could be used to determine which of two colourless liquids is DHMA and which is oleic acid.

_____

_____

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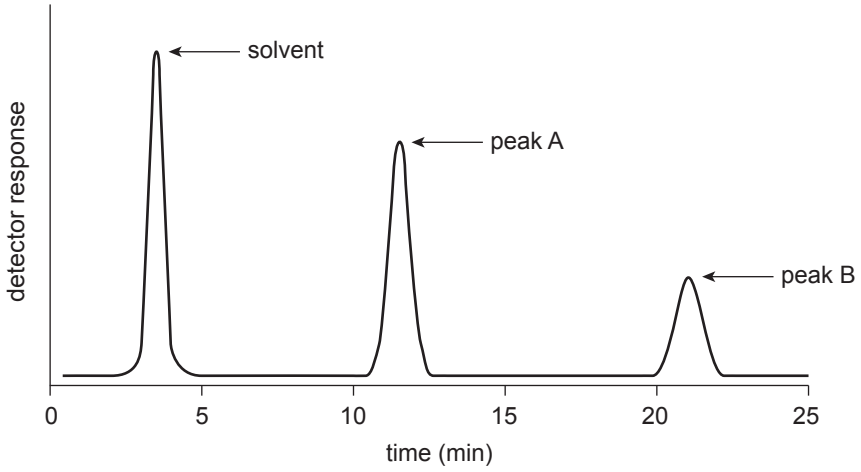
_____

_____ (4 marks)

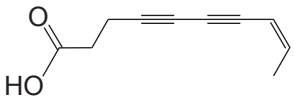
Credit will be given for answers to part (iii) which correctly use appropriate chemical terms and effectively communicate knowledge and understanding of chemistry.

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

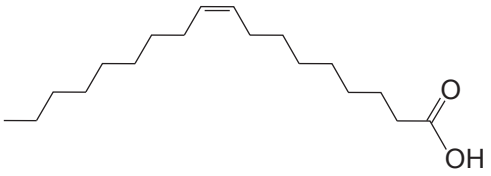
(iii) After the synthesis, pure DHMA is obtained by using chromatography to separate it from unreacted oleic acid. The mixture of DHMA and oleic acid is dissolved in a solvent and passed through a chromatography column containing a non-polar stationary phase. The resulting chromatogram is shown below:



The structural formulae of DHMA and oleic acid are shown below:



DHMA



oleic acid

Explain how chromatography using a non-polar stationary phase can be used to separate DHMA from oleic acid and identify, justifying your answer, whether peak A or peak B represents DHMA.

(8 marks)

TOTAL: 16 marks

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

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QUESTION BOOKLET

2

11 pages, 4 questions

Thursday 14 November: 9 a.m.

Question Booklet 2

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

QUESTION 5

The reaction of ethene (C_2H_4) with steam can produce ethanol, as shown in the equation below:

$$C_2H_{4(g)} + H_2O_{(g)} \rightleftharpoons C_2H_5OH_{(g)} \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

(a) Write an expression for the equilibrium constant, K_c.

(1 mark)

(b) An equilibrium mixture of the gases in a 2.00 L closed container was analysed and found to contain 1.0 mol of ethene, 1.2 mol of water, and 0.050 mol of ethanol.

(i) (1) Calculate the value of K_c.

(2 marks)

(2) State what the K_c value indicates about the equilibrium yield of ethanol.

_____

_____ (1 mark)

(ii) The equilibrium mixture was established by starting with ethene and water.
Calculate the number of moles of ethene and water present initially.

(3 marks)

(c) Identify one change in temperature or pressure that would increase the percentage yield of ethanol, and use Le Châtelier's principle to explain why the change would increase the percentage yield.

_____

_____

_____

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_____

_____ (4 marks)

(d) State two other conditions that would increase the percentage yield of ethanol.

_____

_____

_____

_____ (2 marks)

(e) The temperature for maximum yield for this reaction is less than 300°C yet manufacturers tend to carry out the reaction at 350°C.

State the advantage of using the higher operating temperature.

_____

_____ (1 mark)

(f) Describe one possible use for the heat produced in this reaction.

_____

_____ (1 mark)

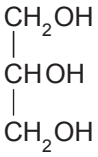
TOTAL: 15 marks

QUESTION 6

Detergent formulations frequently contain anionic or non-ionic surfactants.

(a) Triglycerides, found in fats and oils, undergo alkaline hydrolysis and produce long-chain carboxylate anions that are able to act as surfactants.

(i) When triglycerides are hydrolysed one of the products is glycerol, whose structural formula is shown below:



State the systematic name of glycerol.

_____ (2 marks)

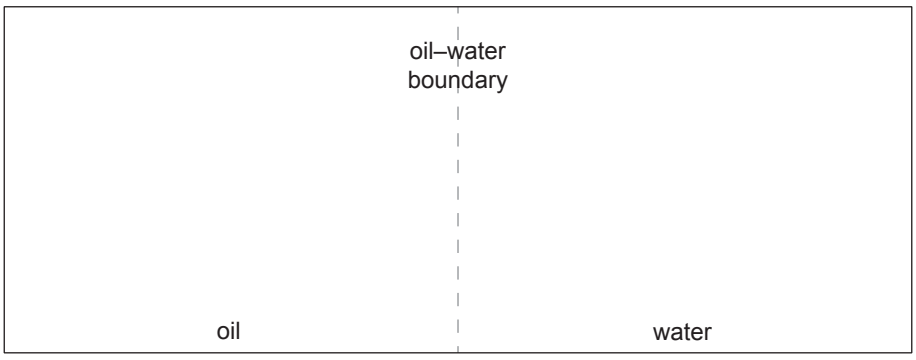
(ii) All the carboxylate anions produced in the alkaline hydrolysis of a particular triglyceride have the formula $CH_3(CH_2)_{16}COO^-$.

Draw the structural formula of the triglyceride.

(2 marks)

(iii) An oil droplet suspended in water interacts with these carboxylate anions.

(1) Show the orientation of one of these carboxylate anions at the oil–water boundary of an oil droplet suspended in water.



(2 marks)

(2) Explain how these carboxylate anions hold oil droplets in suspension in water.

_____

_____

_____

_____ (2 marks)

(b) In certain conditions non-ionic surfactants are more effective cleaning agents than carboxylate anionic surfactants. One non-ionic surfactant has the structural formula shown below:

$$CH_3(CH_2)_{11}OCH_2CH_2OH$$

(i) Circle the hydrophilic end of the structural formula above. (1 mark)

(ii) Compare the behaviour of the hydrophilic ends of anionic and non-ionic surfactants in solutions that have a high concentration of H^+ ions.

_____

_____

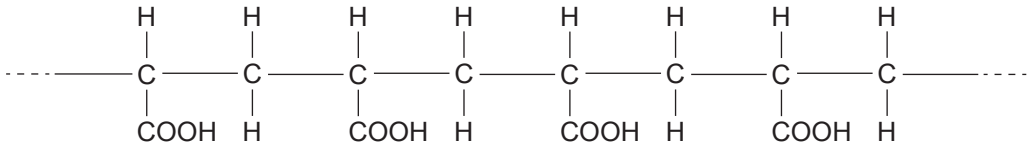
_____

_____

_____

_____ (3 marks)

(c) Polycarboxylates in detergent formulations are produced from polycarboxylic acid polymers. The structural formula of a section of one such polymer is shown below:



(i) Mark the repeating unit on the structural formula above. (1 mark)

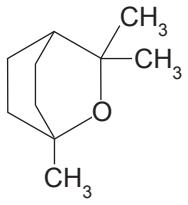
(ii) Draw the structural formula of the monomer used to make this polymer.

(2 marks)

TOTAL: 15 marks

QUESTION 7

Oils in eucalyptus trees contribute to the intensity of bushfires in Australia. The compound cineole is a liquid that acts as a fuel in eucalyptus oil. The structural formula of cineole is shown below:



(a) Determine the molecular formula of cineole.

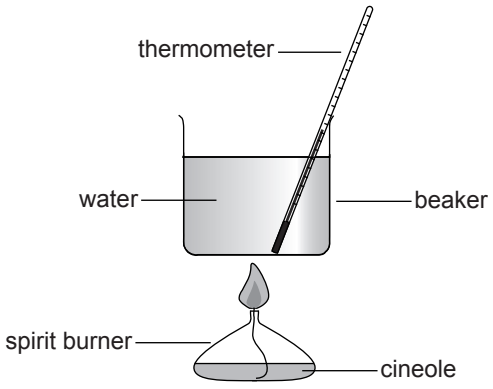
_____ (2 marks)

(b) Liquid cineole burns completely in excess oxygen and generates 6121 kilojoules per mole.

Write the thermochemical equation for the combustion of cineole.

(4 marks)

(c) A student carried out two experiments in which a spirit burner containing cineole was used to heat 100.0 g of water, as shown below:



The following results were recorded:

Experiment	Mass of the spirit burner and cineole (g)		Temperature of the water (°C)		Heat energy released (J)
	Initial	Final	Initial	Final	
1	120.5	119.6	16.0	58.5	
2	124.8	123.6	18.0	63.0	18 800

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

In the following calculations assume that the specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

(i) Calculate the heat energy released in Experiment 1.
There is no need to add data to the table.

(3 marks)

(ii) The molar mass of the cineole is 154.244 g mol^{-1}.
Determine the number of moles of cineole burnt in Experiment 2.

(2 marks)

(iii) Using the data from Experiment 2, determine the molar enthalpy of combustion of cineole.

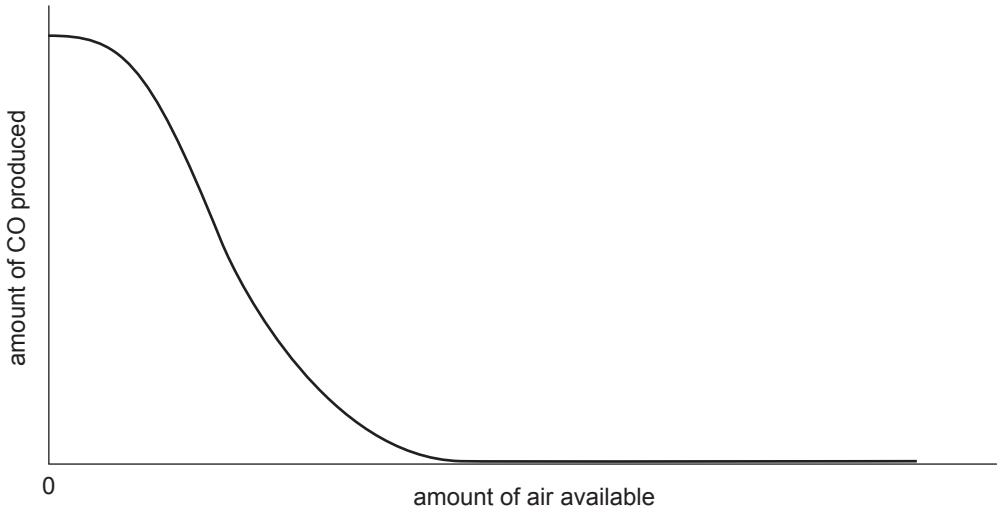
(3 marks)

TOTAL: 15 marks

QUESTION 8

The burning of carbon-based fuels is associated with a number of environmental problems.

(a) The amount of carbon monoxide (CO) produced in an engine when methane is burnt in air varies with the amount of air available, as shown in the graph below:



(i) State whether CO is a primary pollutant or a secondary pollutant.

_____ (1 mark)

(ii) Explain why the amount of CO produced decreases as the amount of air available increases.

_____

_____

_____

_____ (2 marks)

(iii) Identify one other pollutant that would show a similar decrease with an increase in the amount of air available.

_____ (1 mark)

(b) Nitrogen oxides (NO_x) are also produced when fuels are burnt in air.

(i) Describe how NO_x are produced when fuels are burnt in air.

_____

_____

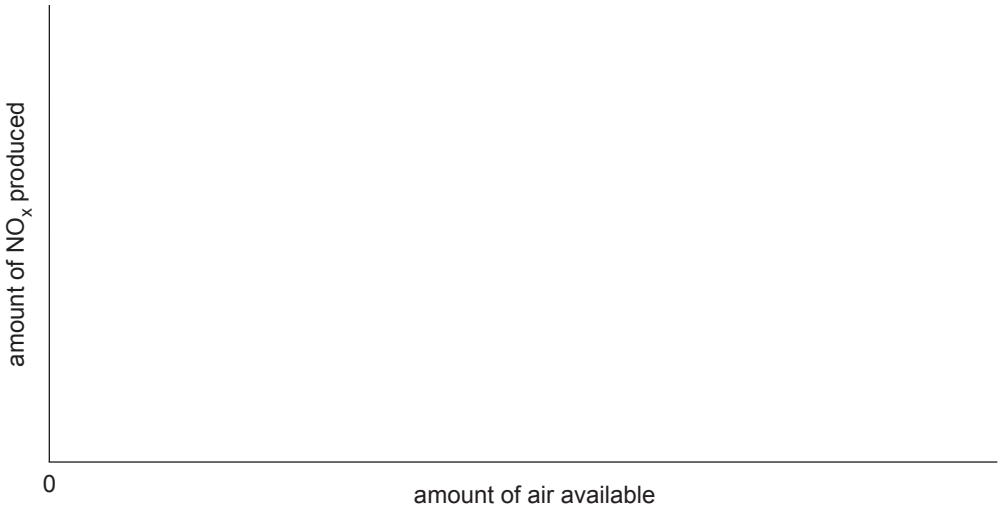
_____

_____

_____

_____ (3 marks)

(ii) On the axes below, draw a line to show how the amount of NO_x produced varies with the amount of air available.



(1 mark)

(iii) NO_x in the troposphere can lead to the formation of ozone.

State two conditions necessary for the formation of dangerous levels of ozone in the troposphere.

_____

_____

_____

_____ (2 marks)

(c) Explain two ways in which human activity can disrupt the thermal balance of the atmosphere.

_____

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_____

_____ (5 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. 8(b)(i) continued).

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CHEMISTRY

QUESTION BOOKLET

3

11 pages, 4 questions

Thursday 14 November: 9 a.m.

Question Booklet 3

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

QUESTION 9

Olive oil is a mixture of triglycerides. Small amounts of carboxylic acids, which affect the quality of the oil, are also present.

(a) Olive oil deteriorates when oxygen in the air reacts with unsaturated carboxylic acids in the oil. Each double bond breaks and smaller compounds are formed. The structural formula of one of these compounds is shown below:

$$CH_3(CH_2)_4CHO$$

State the systematic name of this compound.

_____ (2 marks)

(b) The grade of olive oil is defined by the amount of oleic acid ($C_{17}H_{33}COOH$) present. The amount of oleic acid in a sample was determined by titration with a potassium hydroxide solution.

(i) State the reacting mole ratio of potassium hydroxide and oleic acid.

_____ (1 mark)

(ii) Calculate the mass of potassium hydroxide required to prepare 250 mL of solution with a concentration of 0.10 mol L^{-1}.

(3 marks)

(iii) The olive oil sample was prepared for titration by adding propan-2-ol.

Explain why propan-2-ol, rather than water, was added to the olive oil.

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_____ (2 marks)

(iv) The potassium hydroxide solution was checked and found to have a concentration of 0.108 mol L^{-1}. A titre of 6.45 mL of this potassium hydroxide solution was required to neutralise the oleic acid in the olive oil sample.

(1) Calculate the mass of oleic acid in the olive oil sample, given that 1 mol has a mass of 282.46 g.

(3 marks)

(2) The mass of olive oil in the sample used was 9.543 g.

Calculate the concentration of oleic acid (as % w/w).

(2 marks)

(3) The grades of olive oil are shown in the table below:

Grade	Concentration of oleic acid (% w/w)
extra virgin	≤ 1
virgin	1–2
ordinary virgin	2–3.3
lampate virgin	> 3.3

Use your answer to part (2) to determine the grade of the olive oil.

_____ (1 mark)

(4) Phenolphthalein, the indicator used, has two forms; one has the formula $C_{20}H_{14}O_4$ and the other has the formula $C_{20}H_{12}O_4^{2-}$. The reaction solution was initially colourless and turned pink when the required amount of potassium hydroxide solution had been added.

Identify the coloured form of phenolphthalein.

_____ (1 mark)

TOTAL: 15 marks

QUESTION 10

Two oxides of copper are CuO and Cu_2O.

(a) Fehling's solution, containing Cu^{2+}, is used to test for sugars that are readily oxidised. When Fehling's solution reacts with a readily oxidised sugar, Cu_2O is formed.

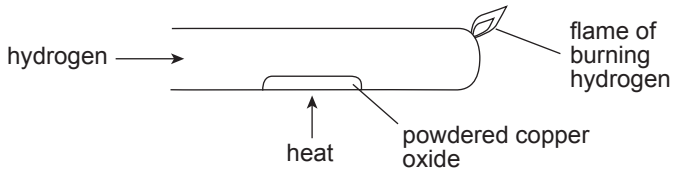
(i) Write the electron configuration of Cu^{2+}, using subshell notation.

_____ (2 marks)

(ii) Write a half-equation for the conversion of Cu^{2+} into Cu_2O.

(2 marks)

(b) A student used the equipment shown in the following diagram to reduce a copper oxide to copper metal:



(i) Identify another metal whose oxide is reduced by hydrogen.

_____ (1 mark)

(ii) Explain why the flame of the burning hydrogen is coloured blue–green when copper oxide is reduced, but not when a different metal oxide is reduced.

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_____ (4 marks)

(iii) The student recorded the following results:

mass of empty tube	4.625 g
mass of tube + copper oxide	4.996 g
mass of tube + copper	4.921 g

(1) Calculate the number of moles of copper present at the end of the reaction.

(2 marks)

(2) Determine the formula of the copper oxide.

(3 marks)

(iv) In this experiment systematic errors occur because of the equipment or the materials used.

Identify one systematic error in the experiment and explain the effect that this error could have on the calculated formula of the copper oxide.

(3 marks)

TOTAL: 17 marks

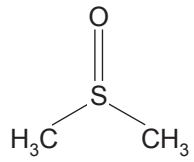
QUESTION 11

Dimethyl sulfoxide (DMSO) is used as a commercial solvent. Some safety information for DMSO is shown below:

SAFETY INFORMATION

Dimethyl sulfoxide (DMSO)

Structural formula:



Product name: Dimethyl sulfoxide
Synonym: Methyl sulfoxide; DMSO
Chemical name: Dimethyl sulfoxide
Chemical formula: $(CH_3)_2SO$
Molar mass: 78.13 g mol^{-1}
Melting point: 19°C
Boiling point: 189°C

Risk	Low	Medium	High
Health		X	
Flammability			X
Reactivity	X		

(a) Use the safety information above to identify a hazard that needs to be considered when working with DMSO in the laboratory, and describe how this hazard can be minimised.

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_____ (2 marks)

(b) Explain why the DMSO molecule has a trigonal pyramid shape.

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_____ (3 marks)

(c) Ethyl ethanoate (molar mass = 88.11 g mol^{-1}) is also used as a commercial solvent. Because of its higher boiling point, DMSO is favoured over ethyl ethanoate in some situations.

(i) Draw the structural formula of ethyl ethanoate.

(2 marks)

(ii) Explain why DMSO has a higher boiling point than ethyl ethanoate.

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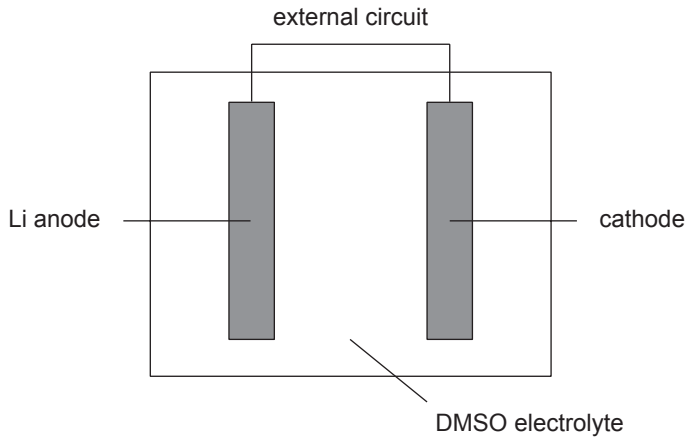
_____ (3 marks)

(d) DMSO is also used as an electrolyte in rechargeable lithium–air batteries. The diagram below shows one such cell when discharging:



(i) State the charge on the cathode when the cell is discharging.

_____ (1 mark)

(ii) When the cell is discharging, insoluble lithium peroxide (Li_2O_2) is produced on the surface of the cathode.

(1) Explain why the presence of Li_2O_2 would affect the operation of the cell.

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_____ (2 marks)

(2) State the oxidation number of oxygen in Li_2O_2.

_____ (1 mark)

TOTAL: 14 marks

QUESTION 12

Olivine, a silicate mineral rich in Mg^{2+} and Fe^{2+}, is found in the Earth's crust.

(a) In olivine the ratio of silicon to oxygen in the silicate anion is 1:4.

(i) State the charge on the silicate anion in olivine.

_____ (1 mark)

(ii) Mg^{2+} and Fe^{2+} are found in equal proportions in one sample of olivine.

Write the formula for this sample of olivine.

_____ (2 marks)

(b) Magnesium is an essential mineral for green plants.

Explain how rain with a pH of 6.0 releases Mg^{2+} cations held on the surface of olivine and makes them available to plants.

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_____ (3 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 must include an equation, should be confined to the space provided.

(c) The reaction of atmospheric carbon dioxide with water produces carbonic acid, which causes ocean acidification.

Explain how olivine might be used to decrease the acidity of the oceans and hence reduce atmospheric levels of carbon dioxide.

(8 marks)

TOTAL: 14 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) continued).