1

Government of South Australia

SACE Board of SA

External Examination 2016

2016 CHEMISTRY

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ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

14 pages, 4 questions

Wednesday 16 November: 9 am

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (14 pages)
Question Booklet 2 (12 pages)
Question Booklet 3 (12 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 12 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 12 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.

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)	113 Uut Ununtrium (284)	114 Fl Flerovium (289)	115 Uup Ununpentium (288)	116 Lv Livermorium (293)	117 Uus Ununseptium (294)	118 Uuo Ununoctium (294)

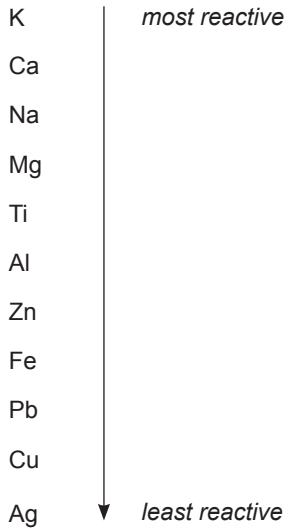
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71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

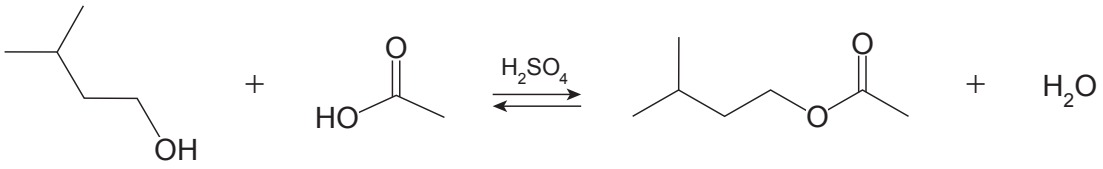
SI prefix	*Symbol*	*Value*
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

QUESTION 1 (15 marks)

Bananas contain a range of organic compounds.

(a) Esters contribute to the odour of ripe bananas.

One ester can be synthesised under reflux according to the equation below:



(i) State the systematic name of the alcohol used to prepare this ester.

_____ (2 marks)

(ii) State the purpose of adding a trace amount of concentrated sulfuric acid.

_____

_____ (1 mark)

(iii) (1) Explain, with reference to the equation above, why the yield of this ester does not reach 100%, even with extended heating under reflux.

_____

_____

_____

_____ (2 marks)

(2) If water could be removed during reflux, state and explain how this would affect the percentage yield of this ester.

_____

_____

_____

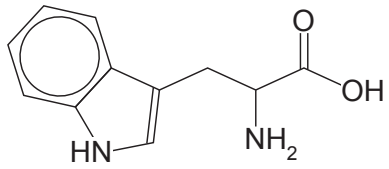
_____

_____

_____ (3 marks)

(b) Bananas contain the amino acid tryptophan.

The structural formula of tryptophan is shown below:



(i) Explain why tryptophan is classified as an amino acid.

_____

_____

_____

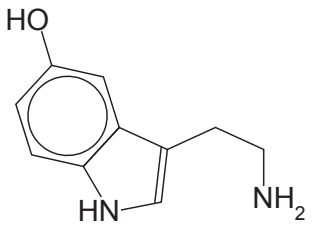
_____ (2 marks)

(ii) Draw the structural formula of the self-ionised form of tryptophan.

(2 marks)

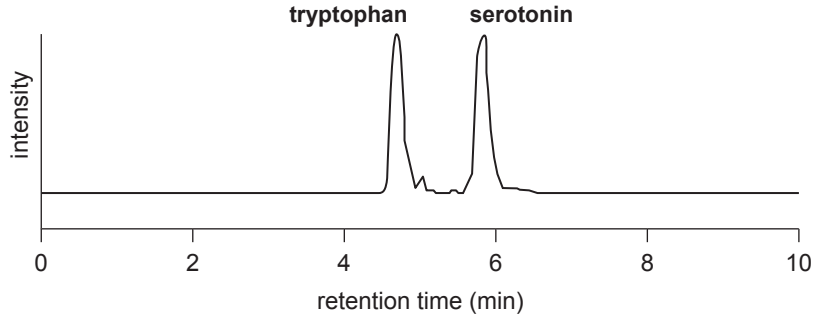
(iii) In the human body, tryptophan is converted into serotonin, which is known for its calming properties.

The structural formula of serotonin is shown below:



Circle the primary amine group on this structural formula. (1 mark)

(iv) A urine sample was analysed for the presence of tryptophan and serotonin, using chromatography. The chromatogram below shows the retention times for these molecules:



By referring to retention time, compare the extent of the interactions of these two molecules with the stationary phase.

_____

_____

_____

_____ (2 marks)

QUESTION 2 (16 marks)

Acetaldehyde (CH_3CHO), a colourless, flammable liquid, is an important industrial chemical.

(a) State the systematic name of acetaldehyde.

_____ (2 marks)

(b) Acetaldehyde can be prepared by oxidation of ethanol, using acidified dichromate solution.

(i) In this reaction, dichromate is converted into chromium ions as shown below:

$$Cr_2O_7^{2-} \longrightarrow Cr^{3+}$$

(1) Assign oxidation numbers to Cr in both species above, to help explain that $Cr_2O_7^{2-}$ is reduced.

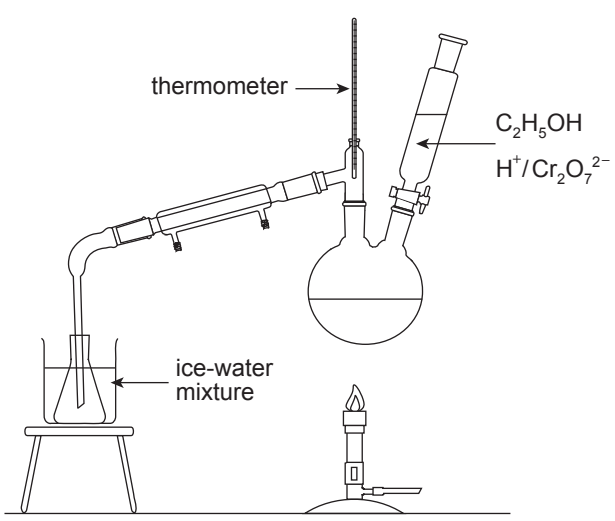
_____

_____ (3 marks)

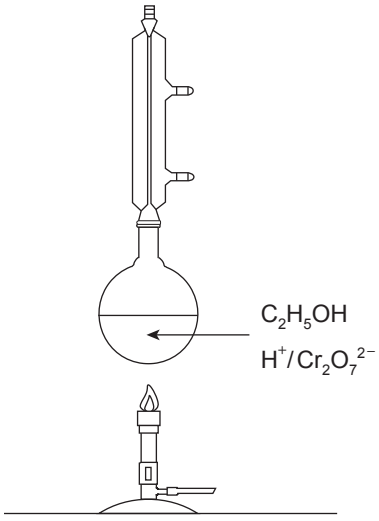
(2) State the colour of Cr^{3+}.

_____ (1 mark)

(ii) Two assemblies that can be used when preparing organic compounds in the laboratory are shown below:



Assembly A



Assembly B

(1) Explain why Assembly A, rather than Assembly B, is used when preparing acetaldehyde.

_____

_____

_____

_____ (2 marks)

(2) Suggest one safety precaution — apart from wearing personal protective equipment — that should be taken when using Assembly A.

_____

_____ (1 mark)

(iii) Explain why acetaldehyde has a significantly lower boiling point than ethanol.

_____

_____

_____

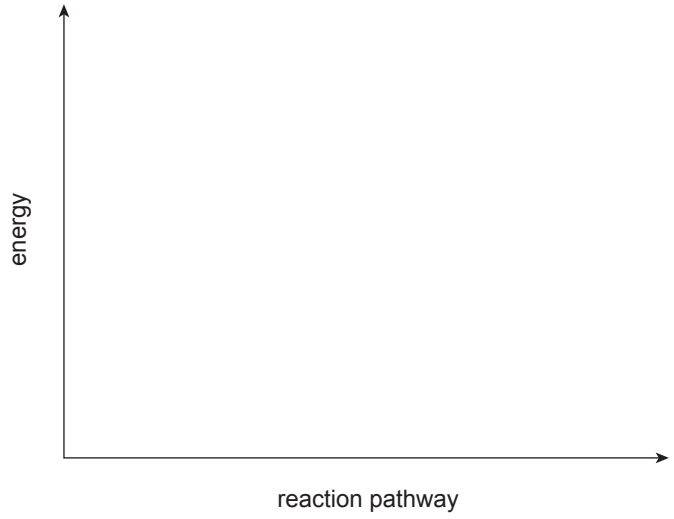
_____

_____

_____ (3 marks)

(c) Acetaldehyde can be prepared industrially by oxidation of ethanol, using a copper catalyst. ($\Delta H = +84$ kJ mol^{-1}.)

On the set of axes below, draw an energy profile diagram for this reaction, both with and without a catalyst, clearly labelling each activation energy and the enthalpy change.

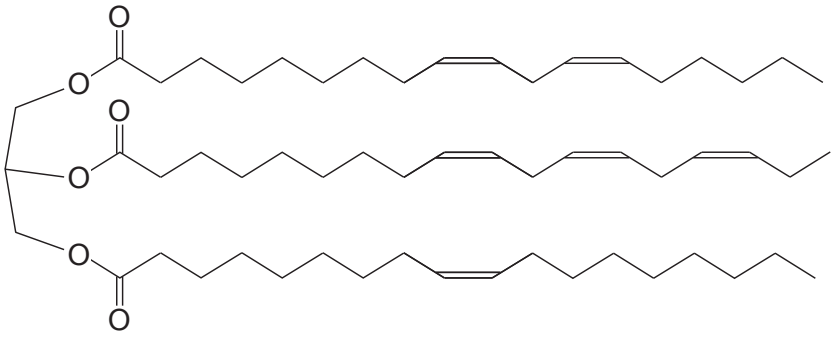


(4 marks)

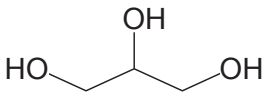
QUESTION 3 (14 marks)

A galvanised iron sheet consists of iron coated with a protective layer of zinc.

(a) To prepare the iron for coating, alkaline hydrolysis is used to remove triglycerides from its surface as water-soluble products. The structural formula of one such triglyceride is shown below:



(i) One product formed from this alkaline hydrolysis, propane-1,2,3-triol, is shown below:



Explain why propane-1,2,3-triol is soluble in water.

_____

_____

_____

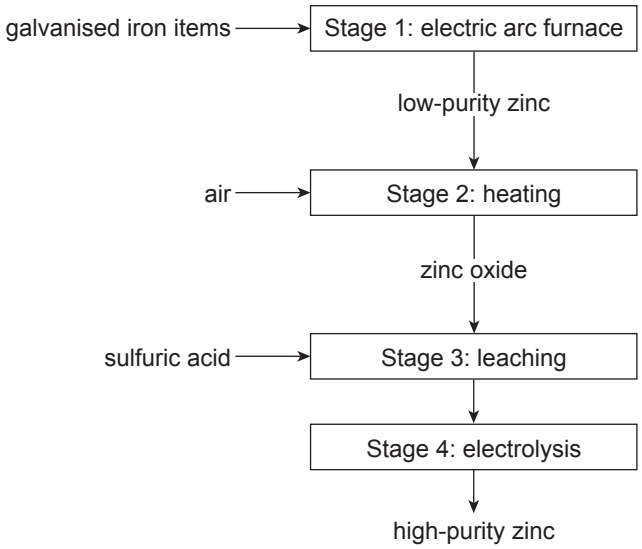
_____ (2 marks)

(ii) In the space below:

(1) draw the structural formula of one of the other products of this alkaline hydrolysis. (2 marks)

(2) draw a water molecule next to the product that you drew and indicate the strongest interaction between them, using appropriate symbols. (3 marks)

(b) Zinc can be recycled from galvanised iron sheets, as shown in the flow chart below:



(i) Write a balanced equation for the reaction of zinc oxide during leaching.

(2 marks)

(ii) State whether the zinc oxide is acting as an acidic oxide or as a basic oxide during leaching.

_____ (1 mark)

(iii) During electrolysis high-purity zinc is formed.

(1) State whether the reaction for the formation of zinc during electrolysis represents oxidation or reduction.

_____ (1 mark)

(2) State whether, during electrolysis, zinc is formed at the positive electrode or the negative electrode.

_____ (1 mark)

(iv) Explain one environmental advantage of recycling zinc rather than producing zinc from its ore.

_____

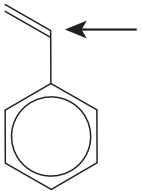
_____

_____

_____ (2 marks)

QUESTION 4 (15 marks)

Styrene is a monomer that is used to make a variety of polymers. The structural formula of styrene is shown below:



(a) Refer to the carbon atom that is indicated by the arrow.

(i) State the number of bonded electron pairs around this carbon atom.

_____ (1 mark)

(ii) Explain why the structural arrangement of atoms around this carbon atom is trigonal planar in shape.

_____

_____

_____

_____ (2 marks)

(b) Styrene undergoes an addition reaction with bromine.

(i) State the observation that would indicate that an addition reaction is occurring when bromine is added dropwise to styrene.

_____ (1 mark)

(ii) Draw the structural formula of the product of this reaction.

(2 marks)

(iii) The 'bromine number' of a compound is the mass of bromine, in grams, that reacts with 100 grams of the compound.

Calculate the bromine number of styrene ($M = 104.15\ g\,mol^{-1}$).

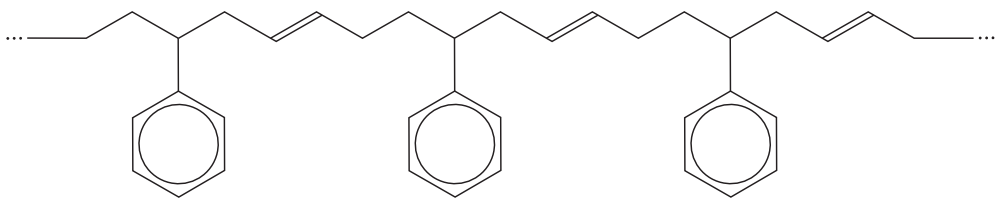
(3 marks)

(c) Draw a section of the polymer that forms when three styrene monomers undergo addition polymerisation.

(2 marks)

(d) Styrene reacts with alkenes to form polymers.

The structural formula of a section of one of these polymers is shown in the diagram below:



Under certain reaction conditions, cross-links form between polymer chains.

(i) On the diagram above, circle the feature that allows cross-links to form. (1 mark)

(ii) Name the type of bond formed in these cross-links.

_____ (1 mark)

(iii) Explain the likely effect that the cross-links would have on one physical property of this polymer.

_____

_____

_____ (2 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)(iii) continued).

Government of South Australia

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SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

2

12 pages, 4 questions

Wednesday 16 November: 9 am

Question Booklet 2

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

2

QUESTION 5 (15 marks)

Glucose can be used to make a variety of consumer goods.

(a) Glucose is produced during photosynthesis.

(i) Write an equation for the process of photosynthesis.

(2 marks)

(ii) In plants, glucose can be converted into polysaccharides.

Write an equation for the condensation of glucose to produce polysaccharides.

(2 marks)

(b) Glucose from sugar cane plants is used by the yeast *Saccharomyces cerevisiae* to produce ethanol, an important biofuel.

A dilute solution of glucose is used to produce ethanol by fermentation.

(i) Explain why this fermentation does not occur under aerobic conditions.

_____

_____

_____

_____ (2 marks)

(ii) One disadvantage of growing sugar cane plants to produce ethanol is that large areas of farming land are used.

Describe one possible consequence to society of using large areas of farming land for this purpose.

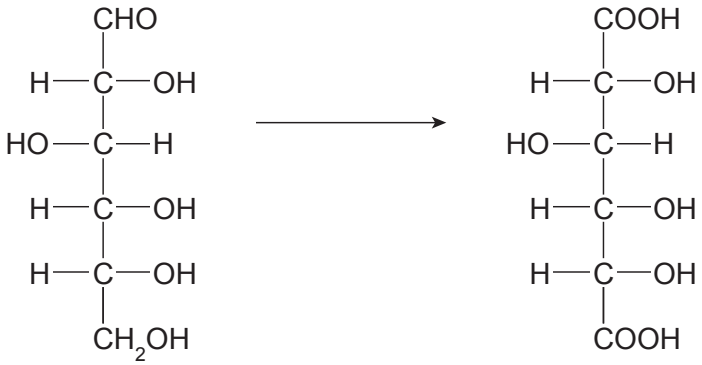
_____

_____

_____

_____ (2 marks)

(c) Glucose can be converted into glucaric acid, which is used to make polymers and adhesives. This conversion is shown below:



glucose **glucaric acid**

(i) Name the new functional group formed in this conversion.

_____ (1 mark)

(ii) State whether glucose is oxidised or reduced when converted into glucaric acid.

_____ (1 mark)

(iii) A chemical test was used to assess whether or not all of the glucose was converted into glucaric acid, and a silver mirror was produced.

(1) Name the reagent used to carry out this test.

_____ (1 mark)

(2) Explain whether or not all of the glucose was converted into glucaric acid.

_____

_____

_____

_____ (2 marks)

(iv) A student was given unlabelled samples of glucose and glucaric acid and asked to positively identify the glucaric acid.

Describe a chemical test that the student could use, and state the observation that would be made.

_____

_____

_____

_____ (2 marks)

QUESTION 6 (16 marks)

Iron (Fe) is extracted from iron (III) oxide (Fe_2O_3) by reacting it with coke (C) at high temperatures in a blast furnace.

(a) By referring to the activity series of metals, explain why Fe can be extracted using this method.

_____

_____

_____

_____ (2 marks)

(b) Coke reacts with Fe_2O_3 to produce CO and Fe.

(i) Write an equation for this reaction.

(2 marks)

(ii) Explain one reason why manufacturers capture the CO produced in this reaction.

_____

_____

_____

_____ (2 marks)

(c) High temperatures generated in blast furnaces enable nitrogen and oxygen to react and form nitric oxide, NO.

(i) By referring to the structure of the nitrogen molecule, state why this reaction requires high temperatures.

_____

_____

_____ (2 marks)

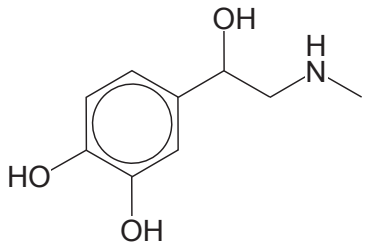
Credit will be given for answers to part (ii) which correctly use appropriate chemical terms and effectively communicate knowledge and understanding of chemistry, and include at least one equation.

(ii) Explain how emissions of NO from blast furnaces can lead to the formation of acid rain, and state two harmful environmental effects of acid rain.

(8 marks)

QUESTION 7 (12 marks)

Epinephrine can be injected into the human body to treat severe allergic reactions. The structural formula of epinephrine is shown below:



(a) The pH of epinephrine solution used in injections ranges from 2.2 to 5.0.

Explain why epinephrine in a solution of low pH is easily absorbed into the bloodstream.

_____

_____

_____

_____

_____

_____ (3 marks)

(b) Over time, the epinephrine in a solution oxidises and forms adrenochrome, which then polymerises and forms melanin, a brown precipitate.

epinephrine $\xrightarrow{\text{oxidation}}$ **adrenochrome** $\xrightarrow{\text{polymerisation}}$ **melanin polymer**

(i) Explain why melanin is present in the form of a precipitate.

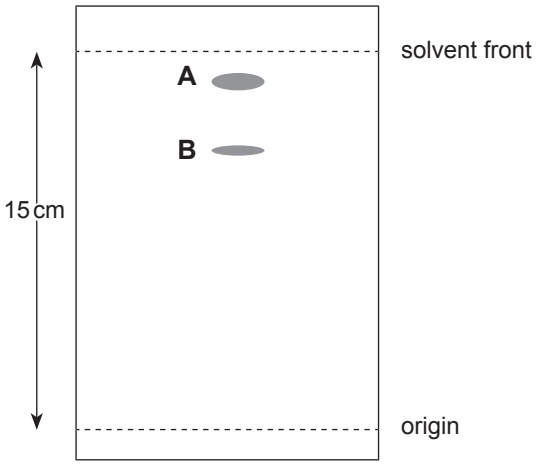
_____

_____

_____

_____ (2 marks)

(ii) The oxidised solution of epinephrine was subjected to thin layer chromatography. The chromatogram produced is represented below:



The R_F values for epinephrine and adrenochrome are shown in the table below:

Substance	R_F *value*
epinephrine	0.92
adrenochrome	0.74

(1) By referring to their R_F values, state and explain whether **A** or **B** represents adrenochrome.

_____

_____

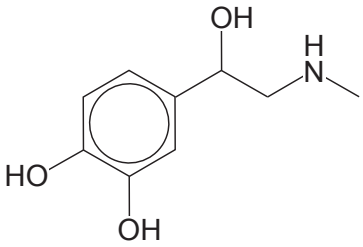
_____

_____ (2 marks)

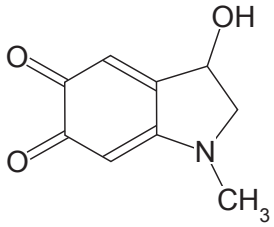
(2) Using the R_F value given, calculate the distance that adrenochrome has travelled along the stationary phase. Show your working.

(2 marks)

(3) The structural formulae of epinephrine and adrenochrome are shown below:



epinephrine



adrenochrome

By referring to the structural formulae of epinephrine and adrenochrome, state and explain whether the mobile phase is more polar or less polar than the stationary phase.

_____

_____

_____

_____

_____ (3 marks)

QUESTION 8 (16 marks)

Reactions involving nitric oxides influence the chemistry of the atmosphere.

(a) In the troposphere, NO_2 reacts to produce ozone.

(i) With the aid of an equation, describe how NO_2 reacts to produce ozone.

_____

_____

_____

_____

_____

_____ (3 marks)

(ii) State one harmful effect of the presence of ozone in the troposphere.

_____

_____ (1 mark)

(b) An experiment was conducted to investigate the following exothermic reaction that occurs in the stratosphere:

$$Cl_{2(g)} + 2NO_{(g)} \rightleftharpoons 2NOCl_{(g)}$$

(i) In one trial, 1.000 mol of NOCl was added to an empty 2.00 L flask. At equilibrium 0.056 mol of Cl_2 were present.

Calculate the equilibrium concentrations of Cl_2, NO, and NOCl, in mol L^{-1}.

(4 marks)

(ii) In a second trial, under different conditions, the concentrations of the three species in equilibrium ($Cl_{2(g)} + 2NO_{(g)} \rightleftharpoons 2NOCl_{(g)}$) were as shown in the table below:

Species	*Concentration ($mol\,L^{-1}$)*
Cl_2	0.024
NO	0.048
NOCl	0.354

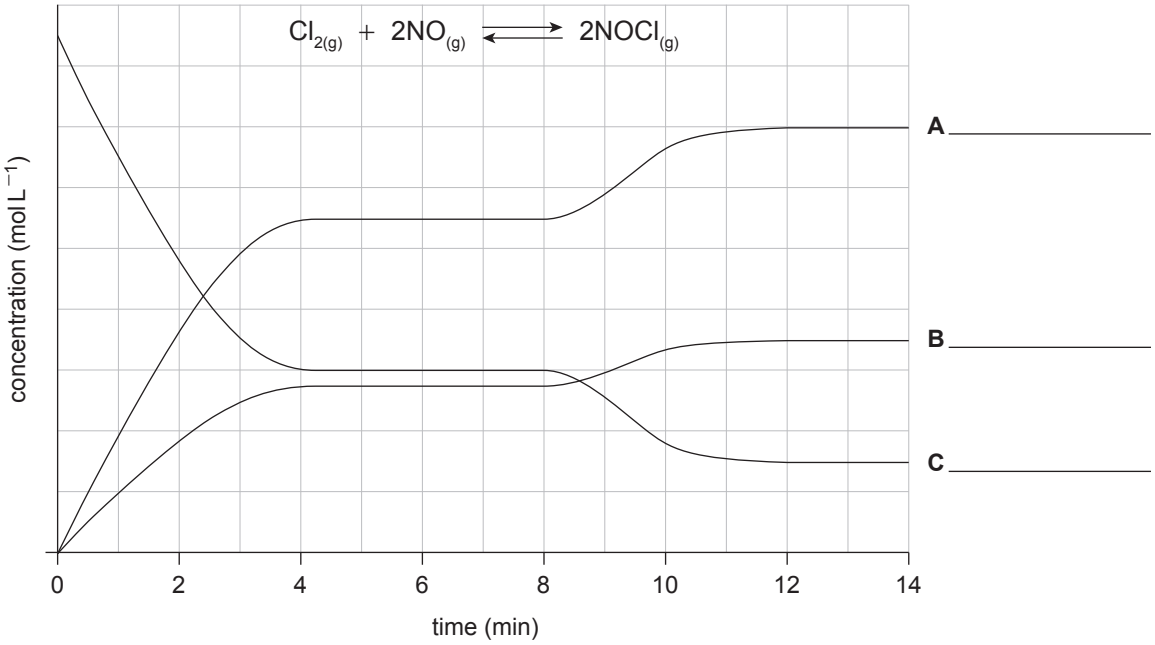
(1) Calculate the equilibrium constant for this reaction.

(2 marks)

(2) State the effect of an increase in temperature on the value of the equilibrium constant.

_____ (1 mark)

(iii) A third trial was conducted. The following graph shows the changes in concentration of the three species over time:



(1) On the graph above, identify **A**, **B**, and **C** as Cl_2, NO, or NOCl. (2 marks)

(2) Identify and explain the change that was made to the reaction conditions at 8 minutes.

_____

_____

_____

_____

_____

_____ (3 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(a)(i) continued).

Government of South Australia

SACE Board of SA

External Examination 2016

2016 CHEMISTRY

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CHEMISTRY

QUESTION BOOKLET

3

12 pages, 4 questions

Wednesday 16 November: 9 am

Question Booklet 3

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

3

SACE
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QUESTION 9 (13 marks)

Arsenic contamination of drinking water, caused by oxyanions of arsenic (AsO_3^{3-}, AsO_4^{3-}), is a major concern for human health in some countries.

(a) The maximum allowable concentration of arsenic in drinking water is 0.01 mg L^{-1}.

(i) Calculate this concentration in ppb.

(2 marks)

(ii) The safe daily limit of arsenic for an adult is 140 µg.

Calculate the volume of drinking water, in litres, that would contain this mass of arsenic.

(2 marks)

(b) The process of removing arsenic from drinking water begins with the oxidation of AsO_3^{3-} to AsO_4^{3-}.

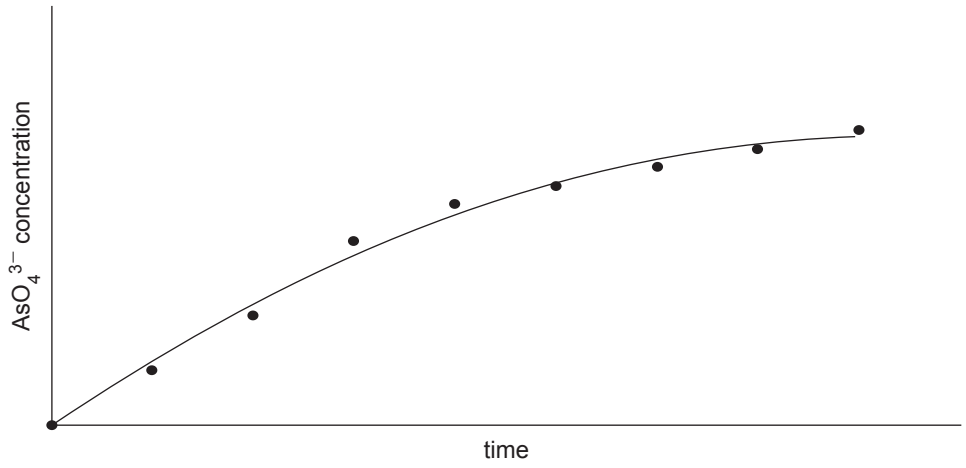
(i) Complete the following half-equation for the oxidation of AsO_3^{3-}.

$$AsO_3^{3-} \longrightarrow AsO_4^{3-}$$

(2 marks)

(ii) Citrate ions increase the rate of oxidation of AsO_3^{3-} to AsO_4^{3-}.

The graph below represents the rate of formation of AsO_4^{3-} in the absence of citrate ions.



Draw a curve on the graph that represents the rate of formation of AsO_4^{3-} in the presence of citrate ions. (1 mark)

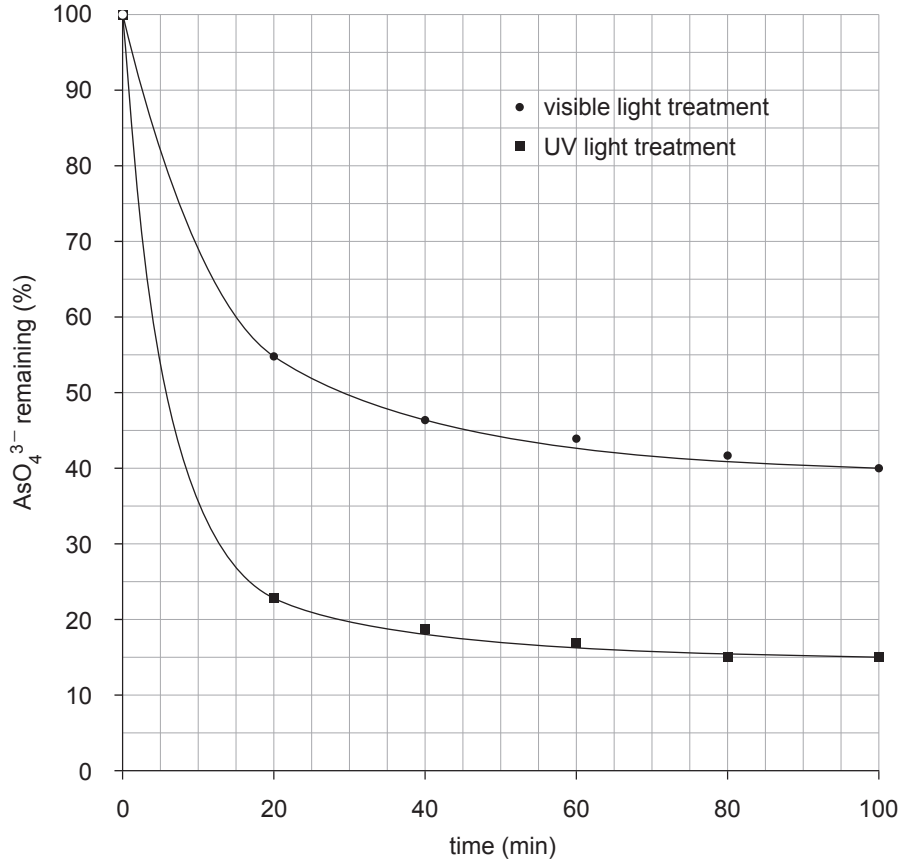
(c) AsO_4^{3-} can then be removed from drinking water.

An experiment was conducted to test if ultraviolet (UV) light treatment is more effective than visible light treatment at removing AsO_4^{3-} from drinking water.

(i) State the name given to the type of reaction that involves light.

_____ (1 mark)

(ii) The percentage of AsO_4^{3-} remaining in drinking water over time, with visible light treatment and with UV light treatment, is shown in the graph below:



(1) Determine the percentage of AsO_4^{3-} removed with UV light treatment at 100 minutes.

_____ (1 mark)

(2) Calculate the difference in the percentage of AsO_4^{3-} remaining at 100 minutes with visible light treatment and with UV light treatment.

(1 mark)

(3) State the dependent variable in this experiment.

_____ (1 mark)

(4) Describe one way in which the effect of random errors could be minimised in this experiment.

_____

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_____ (2 marks)

QUESTION 10 (17 marks)

Silicates and aluminosilicates contain oxygen and silicon, two of the most abundant elements in the Earth's crust.

(a) Muscovite, $KAl_3Si_3O_x(OH)_2$, is a common silicate mineral that gives some rocks a sparkly appearance.

(i) Using subshell notation, write the electron configuration for the potassium cation found in muscovite.

_____ (2 marks)

(ii) (1) Calculate the charge on the silicate anion, Si_3O_x.

(2 marks)

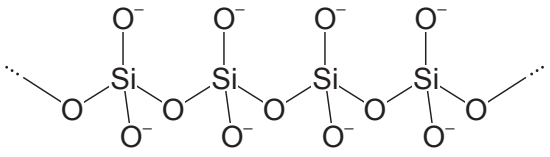
(2) Hence calculate the value of x in the silicate anion, Si_3O_x.

(1 mark)

(3) Name the shape of the arrangement of oxygen atoms around each silicon atom in this anion.

_____ (1 mark)

(b) Another silicate mineral, sodium silicate, is soluble in water. A section of this silicate anion has the following structural formula:



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

(ii) Using the repeating unit that you identified in part (b)(i), write the formula for sodium silicate.

_____ (2 marks)

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

(c) Until recently, sodium tripolyphosphate was commonly used in household detergent formulations. Sodium silicate is now used instead of sodium tripolyphosphate.

With reference to household detergent formulations:

- state two functions of sodium tripolyphosphate
- explain how sodium silicate performs the same functions as sodium tripolyphosphate
- explain the benefit to the environment of replacing sodium tripolyphosphate with sodium silicate.

(8 marks)

QUESTION 11 (15 marks)

Petrol and hydrogen can be used as fuels to power motor vehicles.

(a) One component of petrol is 2,2,4-trimethylpentane.

Draw the structural formula of 2,2,4-trimethylpentane.

(2 marks)

(b) Some information about 2,2,4-trimethylpentane, C_8H_{18}, is given below:

Enthalpy of combustion:	–5460 kJ mol^{-1}
Molar mass:	114.23 g mol^{-1}
Density:	692 g L^{-1}

(i) Calculate the moles of C_8H_{18} in 60.0 L.

(2 marks)

(ii) Hence calculate the mass of carbon dioxide produced by the complete combustion of 60.0 L of C_8H_{18}.

The complete combustion of 1 mol of C_8H_{18} releases 8 mol of carbon dioxide.

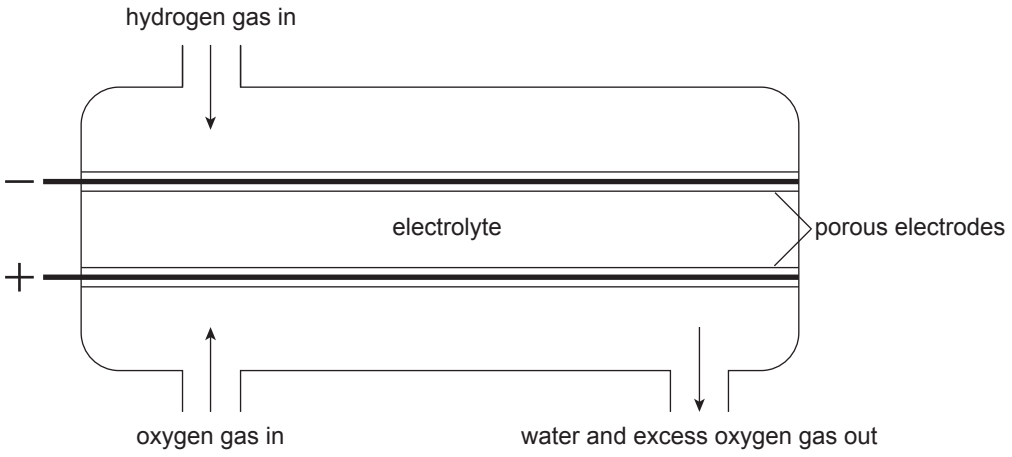
(2 marks)

(iii) Write a thermochemical equation for the complete combustion of C_8H_{18}.

(4 marks)

(c) The use of hydrogen fuel cells is one alternative to petrol-fuelled combustion engines.

The diagram below shows the components of a hydrogen fuel cell:



(i) State why the hydrogen fuel cell is classified as a galvanic cell.

_____

_____ (1 mark)

(ii) Explain the advantage of having porous electrodes with large surface areas.

_____

_____

_____

_____ (2 marks)

(iii) Explain one advantage to the environment of powering motor vehicles by hydrogen fuel cells rather than by petrol-fuelled combustion engines.

_____

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_____ (2 marks)

QUESTION 12 (16 marks)

The label on a bottle of household bleach states that the minimum concentration of hypochlorite ions, ClO^-, is 5% w/v.

(a) In the bleaching process ClO^- is reduced to Cl^-.

Write a half-equation for this process.

(2 marks)

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

(b) The concentration of ClO^- in this household bleach was determined by titration, using sodium thiosulfate ($Na_2S_2O_3.5H_2O$) and acidified potassium iodide (KI).

The steps for this procedure are shown below.

Step 1 A standard solution of 0.2034 mol L^{-1} sodium thiosulfate was prepared.

(i) Calculate the mass, in grams, of $Na_2S_2O_3.5H_2O$ crystals ($M = 248.18$ g mol^{-1}) used to prepare this standard solution in a 250.0 mL volumetric flask.

(3 marks)

Step 2 A volume of 20.00 mL of the bleach was diluted to 200.00 mL.

Step 3 25.00 mL of the diluted bleach was mixed with an excess of acidified KI solution to ensure that all of the ClO^- had reacted.

The equation for this reaction is shown below:

$$ClO^- + 2I^- + 2H^+ \longrightarrow I_2 + Cl^- + H_2O$$

Step 4 This mixture was then titrated with sodium thiosulfate solution to react with I_2.

The equation for this reaction is shown below:

$$2S_2O_3^{2-} + I_2 \longrightarrow 2I^- + S_4O_6^{2-}$$

(ii) The average titre of 0.2034 mol L^{-1} sodium thiosulfate solution obtained in Step 4 was 33.94 mL.

(1) Calculate the moles of $S_2O_3^{2-}$ in the average titre.

(2 marks)

(2) Hence calculate the moles of I_2 that reacted in Step 4.

(1 mark)

(3) Hence calculate the concentration, in % w/v, of ClO^- ($M = 51.45\ g\ mol^{-1}$) in the original bottle of household bleach.

(4 marks)

(4) Explain whether the concentration of ClO^- calculated would have been higher or lower if insufficient acidified KI solution had been added in Step 3.

_____

_____

_____

_____ (2 marks)

(iii) Suggest one reason why the actual concentration of ClO^- in bottles of household bleach is often higher than the concentration stated on their labels.

_____

_____ (1 mark)

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) continued).