Government of South Australia

SACE Board of SA

External Examination 2010

2010 CHEMISTRY

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

17 pages, 4 questions

Wednesday 10 November: 1.30 p.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (17 pages)
Question Booklet 2 (12 pages)
Question Booklet 3 (14 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 17 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 14 of Question Booklet 3 if you need more space to finish your answers.

4. There is no need to fill all the space provided; clearly written, well-expressed answers are required. If you delete part or all of an answer you should clearly indicate your final answer.

5. The total mark is 200. The twelve questions are of approximately equal value.

6. Attach your SACE registration number label to the box at the top of this page. Copy the information from your SACE registration number label into the boxes on the front covers of Question Booklet 2 and Question Booklet 3.

7. At the end of the examination, place Question Booklet 2 and Question Booklet 3 inside the back cover of Question Booklet 1.

STUDENT'S DECLARATION ON THE USE OF CALCULATORS

By signing the examination attendance roll I declare that:

- my calculators have been cleared of all memory;
- no external storage media are in use on these calculators.

I understand that if I do not comply with the above conditions for the use of calculators I will:

- be in breach of the rules;
- have my marks for the examination cancelled or amended;
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as the SACE Board of South Australia determines.

PERIODIC TABLE OF THE ELEMENTS

1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminium 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.90	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (97)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57[1] La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89[2] Ac Actinium (227)	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)							

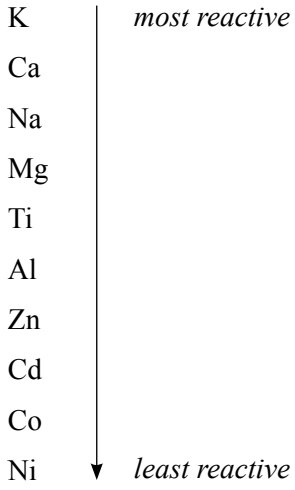
Lanthanide Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinide Series[2]	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

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
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}

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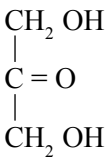
QUESTION 1

Carbohydrates are an important food group, whose main function is related to energy storage and production.

(a) Dihydroxyacetone is a simple carbohydrate. Its structural formula is shown below:



dihydroxyacetone

(i) Explain why dihydroxyacetone is a carbohydrate.

_____

_____

_____

_____ (2 marks)

(ii) Explain why dihydroxyacetone is soluble in water.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) Compound **X** has the same molecular formula as dihydroxyacetone but contains an aldehyde group.

(1) Draw the structural formula of Compound **X**.

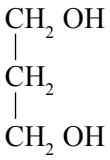
(2 marks)

(2) Name a reagent that can be used to show the presence of an aldehyde group, and state the observation that would indicate its presence.

Reagent: _____

Observation: _____ (2 marks)

(iv) Dihydroxyacetone can be converted into Compound **Y**. The structural formula of Compound **Y** is shown below:

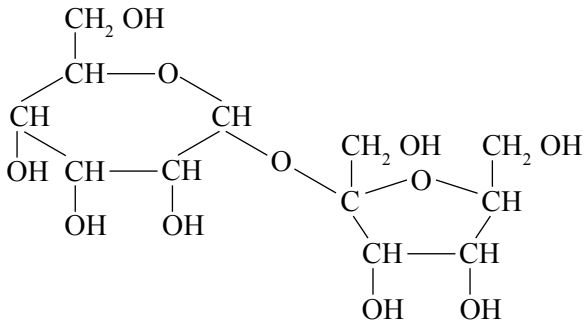


Compound Y

State the systematic name of Compound **Y**.

_____ (2 marks)

(b) The carbohydrate sucrose is extracted from sugar cane. Its structural formula is shown below:



sucrose

(i) State the molecular formula of sucrose.

_____ (1 mark)

(ii) State whether sucrose is a monosaccharide, a disaccharide, or a polysaccharide.

_____ (1 mark)

(iii) In sugar cane, sucrose is produced from the carbohydrate glucose ($C_6H_{12}O_6$), which is made from carbon dioxide and water.

(1) Name the reaction in which glucose is made from carbon dioxide and water.

_____ (1 mark)

(2) Write a balanced equation for the reaction in which glucose is made from carbon dioxide and water.

(2 marks)

(3) State whether energy is released or absorbed when glucose is made from carbon dioxide and water.

_____ (1 mark)

TOTAL: 17 marks

QUESTION 2

Organic compounds are used extensively as fuels. The table below shows the amount of heat produced, in kilojoules per gram, by the complete combustion of three carbon-based fuels:

Fuel	**Formula**	**kJ g^{-1}**
ethanol	C_2H_5OH	29.6
butane	C_4H_{10}	49.5
octane	C_8H_{18}	47.8

(a) Calculate the amount of heat released when 1 mole of butane undergoes complete combustion.

(2 marks)

(b) Explain why the boiling-point of octane is higher than the boiling-point of butane.

_____

_____

_____

_____ (2 marks)

(c) Under certain conditions fuels do not undergo complete combustion.

State two disadvantages of this incomplete combustion.

_____

_____

_____

_____ (2 marks)

(d) In some countries ethanol is added to petrol. Ethanol has an enthalpy of combustion of 1345 kJ mol^{-1}.

(i) One way in which ethanol is produced is by the fermentation of glucose.

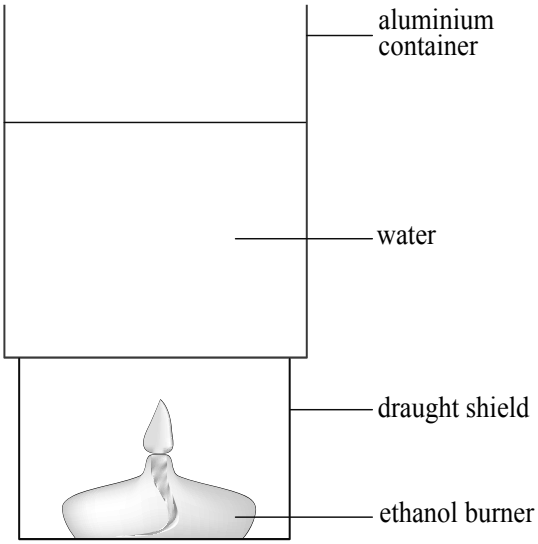
Write the equation for the production of ethanol by the fermentation of glucose.

(2 marks)

(ii) Write the thermochemical equation for the complete combustion of ethanol.

(4 marks)

(iii) Three students each used a calorimeter, as shown in the diagram below, to determine the enthalpy of combustion of ethanol:



(1) The enthalpy of combustion of ethanol was calculated from experimental data obtained using this apparatus.

Identify two systematic errors that could arise from the use of this apparatus.

_____

_____

_____

_____ (2 marks)

(2) Each student carried out four experiments and calculated the enthalpy of combustion (ΔH_{comb}) for each, as shown in the table below:

Experiment	**ΔH_{comb} (kJ mol^{-1})**		
	Student D	**Student E**	**Student F**
1	1200	1200	1235
2	1199	1209	1238
3	1203	1205	1245
4	1206	1206	1246
Average	1202	1205	1241

(A) State which set of data (from Student D, E, or F) was the most precise.

_____ (1 mark)

(B) State which student's results were the most accurate, and justify your answer.

_____

_____

_____

_____ (2 marks)

TOTAL: 17 marks

QUESTION 3

Over the last century there has been a considerable increase in the use of titanium. The main source of titanium is the mineral rutile, TiO_2.

(a) Explain why TiO_2 is a solid with a high melting-point.

_____

_____

_____

_____ (2 marks)

(b) TiO_2 reacts with hydrochloric acid.

Write an equation for this reaction.

(2 marks)

(c) In the production of titanium, TiO_2 is treated with coke and chlorine gas to form titanium tetrachloride, $TiCl_4$.

(i) Carbon tetrachloride, CCl_4, is formed as a by-product of this reaction.

Draw a diagram to show the bonding and shape of the CCl_4 molecule.

(2 marks)

(ii) Calculate the oxidation state of titanium in TiO_2 and $TiCl_4$, and hence deduce whether titanium has undergone oxidation or reduction, or neither, in this process.

Deduction: _____ (3 marks)

(d) The production of titanium from $TiCl_4$ involves reaction with magnesium metal at 800°C to 850°C. The unbalanced equation for this reaction is shown below:

$$TiCl_{4\,(g)} + Mg_{(s)} \longrightarrow Ti_{(s)} + MgCl_{2(s)}$$

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

(ii) Write the half-equation for the oxidation of magnesium.

(2 marks)

(iii) Explain why sodium could be used instead of magnesium in the production of titanium by this method.

_____

_____

_____

_____ (2 marks)

(iv) The magnesium chloride produced in this process can be electrolysed in the molten state to regenerate magnesium.

(1) Explain why it is necessary for molten magnesium chloride, rather than an aqueous solution, to be used.

_____

_____

_____

_____ (2 marks)

(2) Chlorine is also produced in this electrolysis process.

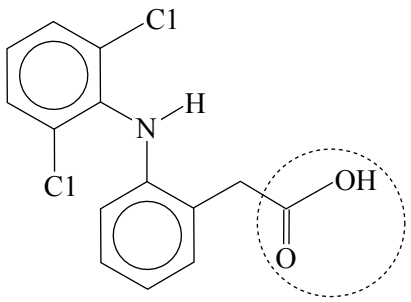
State the sign of the electrode at which chlorine would be produced.

_____ (1 mark)

TOTAL: 17 marks

QUESTION 4

Diclofenac is an anti-inflammatory drug used for human beings and animals. The structural formula of diclofenac is shown below:



diclofenac

(a) State whether the amine group present is a primary, secondary, or tertiary amine.

_____ (1 mark)

(b) Name the functional group circled.

_____ (1 mark)

(c) Name a reagent that would allow you to demonstrate the presence of the circled functional group, and state the expected observation.

Reagent: _____

Observation: _____

_____ (2 marks)

(d) Diclofenac is taken in the form of its sodium or potassium salt.

Explain why the salt is more soluble in water than the molecular form.

_____

_____

_____

_____ (2 marks)

(e) Diclofenac can react with hydrochloric acid.

(i) A solution of hydrochloric acid was found to have a pH of 2.1.

Calculate the concentration of *chloride* ions in this solution.

(3 marks)

(ii) Draw the structural formula of the ion formed when diclofenac reacts with hydrochloric acid.

(2 marks)

(f) Two functional groups in 1 molecule of diclofenac can react to form an amide.

Draw the structural formula of the amide formed.

(2 marks)

(g) Diclofenac undergoes decomposition in the liver. A range of enzymes catalyse this decomposition. Explain the effect of catalysts on the rate of chemical reactions.

_____

_____

_____

_____

_____

_____ (3 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. 2(d)(iii)(2)(B) continued).

Government of South Australia

SACE Board of SA

External Examination 2010

2010 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

2

12 pages, 4 questions

Wednesday 10 November: 1.30 p.m.

Question Booklet 2

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

QUESTION 5

Chlorine and its compounds are used for water purification.

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

(a) Analysis was undertaken to determine the concentration of ClO^- ions in a 200.0 mL sample of swimming-pool water. Excess iodide that was added reacted with ClO^- ions in the sample, as shown in Equation 1 below:

Equation 1 $\quad ClO^- + 2\,I^- + 2\,H^+ \longrightarrow I_2 + Cl^- + H_2O$

The amount of I_2 produced was determined by titration with 0.00115 mol L^{-1} $Na_2S_2O_3$.
The reaction that occurred is shown in Equation 2 below:

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

It was found that 16.25 mL of $Na_2S_2O_3$ solution was required to react with all the I_2.

(i) Name the apparatus used to deliver the 16.25 mL of $Na_2S_2O_3$ solution.

_____ (1 mark)

(ii) Calculate the number of moles of $S_2O_3^{2-}$ in the 16.25 mL of 0.00115 mol L^{-1} $Na_2S_2O_3$ solution.

(2 marks)

(iii) Calculate the number of moles of I_2 required to react with the $Na_2S_2O_3$ solution.

(2 marks)

(iv) Calculate the concentration, in mol L^{-1}, of ClO^- in the swimming-pool water.

(2 marks)

(v) Express the concentration of ClO^- in ppm.

(3 marks)

(b) Sodium chloride is added to some swimming pools to reduce microbial growth in the water. Electrolytic pool chlorinators are used to produce chlorine gas, which then reacts with water, as shown in the equation below:

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

A saturated aqueous solution of chlorine was analysed and found to contain the following equilibrium concentrations:

$[Cl_2] = 0.062$ mol L^{-1}, $[H_2O] = 55$ mol L^{-1}, $[HClO] = 0.030$ mol L^{-1}, and $[HCl] = 0.030$ mol L^{-1}.

(i) Calculate the K_c value for the saturated solution of chlorine.

(3 marks)

(ii) Explain the effect that the addition of OH^- to the solution would have on the equilibrium concentration of Cl_2.

_____

_____

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_____

_____

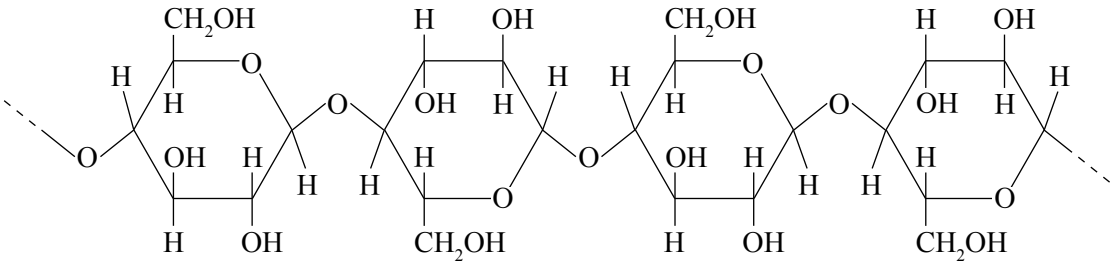
_____ (3 marks)

TOTAL: 17 marks

QUESTION 6

The acidic nature of paper causes it to degrade when books are stored for long periods.

(a) Paper is largely composed of cellulose. The structural formula of a section of cellulose is shown below:



(i) On the structural formula above, use brackets to indicate the repeating unit of cellulose.
(1 mark)

(ii) Paper degrades as a result of hydrolysis under acidic conditions.

Draw the structural formula of the monosaccharide formed from this hydrolysis.

(2 marks)

(b) The reaction of aluminium compounds that are commonly used in the production process is one cause of acidity in paper. Under warm and humid (moist) conditions the following reaction occurs in paper:

$$Al(H_2O)_6^{3+} + H_2O \rightleftharpoons Al(H_2O)_5OH^{2+} + H_3O^+$$

(i) State how this equation shows that $Al(H_2O)_6^{3+}$ is an acid.

_____

_____ (1 mark)

(ii) For this reaction $K_c = 2 \times 10^{-7}$.

Explain how this indicates that $Al(H_2O)_6^{3+}$ is a *weak* acid.

_____

_____

_____

_____ (2 marks)

(iii) Explain why high humidity leads to the production of more H_3O^+ in paper.

_____

_____

_____

_____

_____

_____ (3 marks)

(c) Several methods may be used to slow the degradation of paper.

(i) Books may be stored at low temperatures.

Explain why storing books at low temperatures reduces the rate of degradation of the paper.

_____

_____

_____

_____

_____

_____ (3 marks)

(ii) Magnesium hydrogencarbonate may be used to slow the degradation of paper. It works by slowly breaking down and depositing magnesium oxide in the paper, releasing carbon dioxide and water vapour.

(1) Write an equation for the breakdown of magnesium hydrogencarbonate.

(2 marks)

(2) Explain how magnesium oxide reduces the acidity of paper.

_____

_____

_____

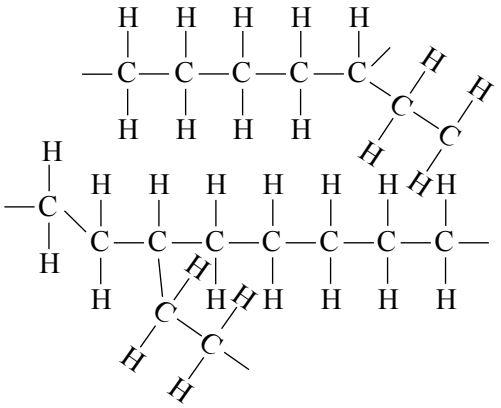
_____(2 marks)

TOTAL: 16 marks

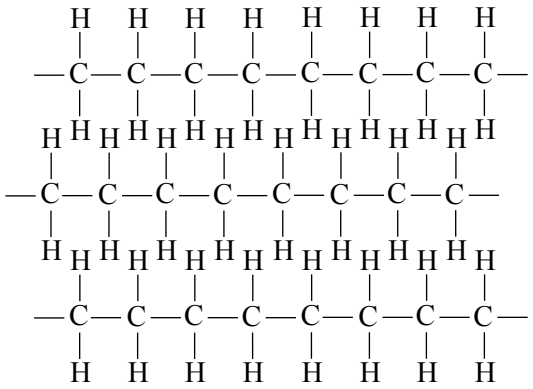
QUESTION 7

Synthetic polymers are used for many purposes.

(a) Polythene (polyethene) is produced industrially in two major forms, LDPE (melting-point approximately 115°C) and HDPE (melting-point approximately 135°C), under different reaction conditions. Differences in structures of the two forms are shown below:



A section of the LDPE polymer



A section of the HDPE polymer

(i) Polythene is produced by an addition reaction.

Explain why the monomer can undergo addition whereas the polymer is unable to react in this way.

_____

_____

_____

_____

_____ (2 marks)

(ii) With reference to the diagrams above, explain why the melting-point of HDPE is higher than the melting-point of LDPE.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) LDPE is produced with a very high pressure of 1500 to 3000 atmospheres.

Explain the effect of the very high pressure on the rate of the reaction.

_____

_____

_____

_____ (2 marks)

(iv) The polymerisation reaction is exothermic.

(1) Explain why the exothermic nature of the polymerisation reaction is beneficial for the manufacturer.

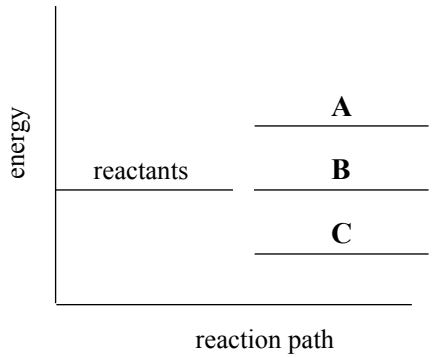
_____

_____

_____

_____ (2 marks)

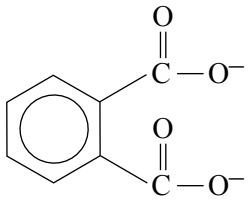
(2) The energy profile for the polymerisation reaction is shown in the diagram below:



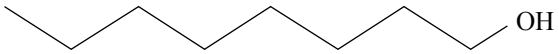
State whether the products are represented by **A**, **B**, or **C**, given that the reaction is exothermic.

_____ (1 mark)

(b) Phthalate esters are used to improve the flexibility of plastic wraps. Hydrolysis of one of the phthalate esters produces the phthalate ion and an alcohol. The structural formulae of these two products are shown below:



phthalate ion



alcohol

(i) State two conditions used for the hydrolysis of the ester.

_____

_____ (2 marks)

(ii) Draw the structural formula of the original phthalate ester.

(2 marks)

(iii) The alcohol produced in the hydrolysis can be oxidised.

State the systematic name of one product of this oxidation.

_____ (2 marks)

TOTAL: 16 marks

QUESTION 8

Various chemicals are used to improve water for different uses.

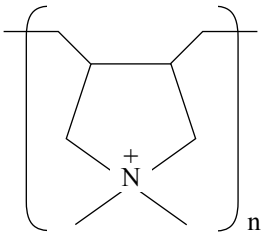
(a) Fine clay particles can be removed from water in different ways.

(i) State one advantage of removing fine clay particles from water.

_____ (1 mark)

(ii) In some regions polyDADMAC is used to remove fine clay particles from water.

The structural formula of one repeating unit of a polyDADMAC chain is shown below:



(1) Explain how polyDADMAC removes fine clay particles from water.

_____

_____

_____

_____

_____

_____ (3 marks)

(2) Aluminium sulfate is another material that is often used to remove fine clay particles from water.

Suggest, giving reasons, whether polyDADMAC or Al^{3+} would be more effective in removing fine clay particles from water.

_____

_____

_____

_____

_____ (2 marks)

(b) $Na_3P_3O_9$ is added to some commercial detergent formulations to remove Ca^{2+} from washing water.

(i) Explain one advantage of removing Ca^{2+} from washing water.

(2 marks)

Credit will be given for answers to part (ii) which show clear, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer should be confined to the space provided and should take approximately 12 minutes.

(ii) Describe the potential environmental consequences of adding $Na_3P_3O_9$ to commercial detergent formulations.

(8 marks)

TOTAL: 16 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. 6(c)(ii)(2) continued).

Government of South Australia

SACE Board of SA

External Examination 2010

2010 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

3

14 pages, 4 questions

Wednesday 10 November: 1.30 p.m.

Question Booklet 3

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

QUESTION 9

Triglycerides, commonly known as oils and fats, are an essential part of the human diet.

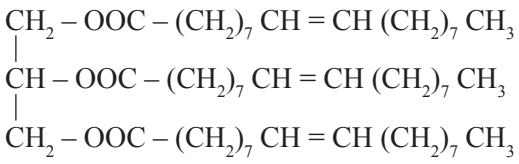
(a) One gram of a fat provides 37 kJ of energy.

Calculate the increase in the body temperature of a 70 kg person who consumes 5 g of fat that is used solely to generate heat.

Assume that the body behaves in the same way as water (i.e. 4.18 J of energy is needed to raise the temperature of 1.0 g by 1.0°C).

(3 marks)

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



(i) This triglyceride can be converted into glycerol and a carboxylate salt.

(1) State the systematic name of glycerol.

_____ (2 marks)

(2) Identify one reagent that could convert the triglyceride into glycerol and a carboxylate salt.

_____ (1 mark)

(3) Name the reaction in which a triglyceride is converted into glycerol and a carboxylate salt.

_____ (1 mark)

(4) Draw the structural formula of the carboxylate anion produced in this reaction.

(2 marks)

(ii) The triglyceride was reacted with hydrogen to produce a saturated product.

(1) State one reaction condition necessary for reaction of the triglyceride with hydrogen.

_____ (1 mark)

(2) Describe one difference between the physical properties of the triglyceride and the physical properties of the saturated product.

_____

_____

_____

_____ (2 marks)

(iii) 0.1 g of the triglyceride was shaken in a nonpolar solvent and reacted completely with 0.01 mol L^{-1} iodine solution.

(1) Calculate the number of moles of triglyceride in the 0.1 g, given that its molar mass is 885.4 g mol^{-1}.

(2 marks)

(2) Calculate the volume of iodine solution required to react completely with the 0.1 g of triglyceride.

(3 marks)

TOTAL: 17 marks

QUESTION 10

Selenium (Se) is an important micronutrient. Selenium compounds are often added to fertilisers and food to supplement natural sources of the element.

(a) Write the electronic configuration of Se, using subshell notation.

_____ (2 marks)

(b) SeO_2 is used to produce Na_2SeO_3, which is added to fertilisers.

(i) The SeO_2 in soils is almost insoluble in water.

State why Se in this form is not available to plants.

_____

_____ (1 mark)

(ii) SeO_2 reacts with NaOH to form Na_2SeO_3.

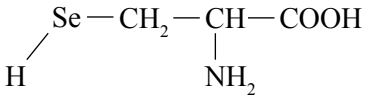
(1) Write an equation for this reaction.

(2 marks)

(2) State the property of *selenium* that is demonstrated by this reaction.

_____ (1 mark)

(c) Se is used to synthesise selenocysteine in cells. The structural formula of selenocysteine is shown below:



(i) Explain why the atoms bonded to the Se are arranged in a V-shape.

_____

_____

_____

_____

_____

_____ (3 marks)

(ii) Explain why selenocysteine can be described as an amino acid.

_____

_____

_____

_____(2 marks)

(iii) Selenocysteine exists in self-ionised form in neutral aqueous solution.

(1) Draw the structural formula of selenocysteine in the self-ionised form.

(2 marks)

(2) Explain why selenocysteine is able to self-ionise.

_____

_____

_____

_____(2 marks)

(iv) Selenocysteine is found in certain enzymes that are polymers of amino acids.
Draw a segment of a polymer chain that contains the selenocysteine unit.

(2 marks)

TOTAL: 17 marks

QUESTION 11

The transition metals are important to human beings in many ways.

(a) Cobalt (Co) is an essential element for most living organisms.

(i) State the block of the periodic table to which Co belongs.

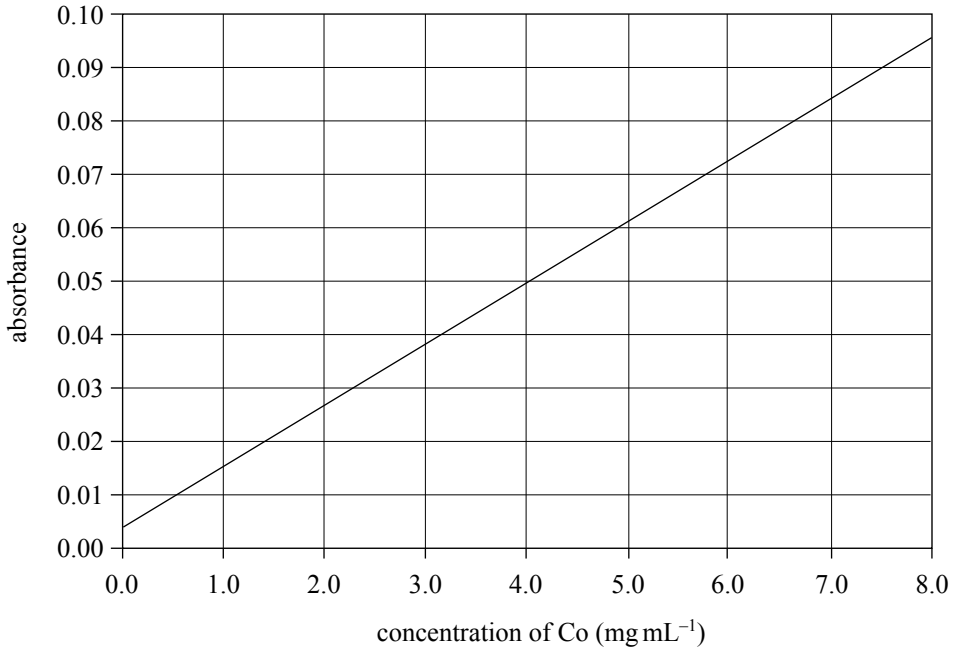
_____ (1 mark)

(ii) There is one Co atom in each molecule of vitamin B_{12} (molar mass = 1355 g mol^{-1}). Human beings need 0.0015 mg of vitamin B_{12} per day for good health.

Calculate the mass of Co in 0.0015 mg of vitamin B_{12}.

(3 marks)

(b) Co is obtained from sulfide ores. Atomic absorption spectroscopy (AAS) was used to determine the percentage of Co in an ore. The following calibration graph was drawn using the absorbance of samples with known concentrations of Co:



10.0 g of the ore was crushed, dissolved, and made up to a 100 mL solution. Some of this solution was injected into the flame of the AAS and an absorbance of 0.08 was recorded.

(i) Using the calibration graph on the page opposite, determine the concentration of Co in the solution, in $mg\,mL^{-1}$.

_____ (1 mark)

(ii) Calculate the mass of Co in the 100 mL of solution.

(1 mark)

(iii) Hence calculate the percentage by mass (% w/w) of Co in the 10.0 g of ore.

(2 marks)

(iv) Nickel atoms were also present in the 10.0 g sample of ore.

Explain why the presence of nickel does not interfere with the determination of Co by AAS.

_____

_____

_____

_____ (2 marks)

(v) In the production of Co, sulfur dioxide is formed.

Explain how the release of sulfur dioxide can lead to the mobilisation of toxic cations in soil.

_____

_____

_____

_____

_____

_____ (3 marks)

(c) The transition metals cadmium and nickel are used in rechargeable electrochemical cells in which the following electrode reactions occur when the cell is discharging:

Electrode A $Cd + 2\,OH^- \longrightarrow Cd(OH)_2 + 2e^-$

Electrode B $2\,NiO(OH) + 2\,H_2O + 2e^- \longrightarrow 2\,Ni(OH)_2 + 2\,OH^-$

(i) State whether A or B is the cathode when the cell is discharging.

_____ (1 mark)

(ii) Potassium hydroxide is used as the electrolyte in the salt bridge.

State the role of the salt bridge in an electrochemical cell.

_____ (1 mark)

(iii) Determine the overall equation for the reaction that occurs when this cell is being recharged.

(2 marks)

TOTAL: 17 marks

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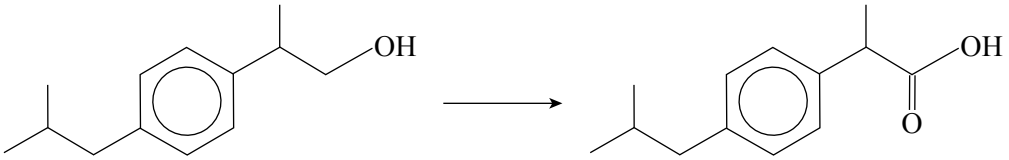
QUESTION 12

Ibuprofen is commonly used in analgesics. In one method of production, the final step is the conversion of Compound **Z** into ibuprofen, as shown below:



Compound Z **ibuprofen**

(a) State the molecular formula of ibuprofen.

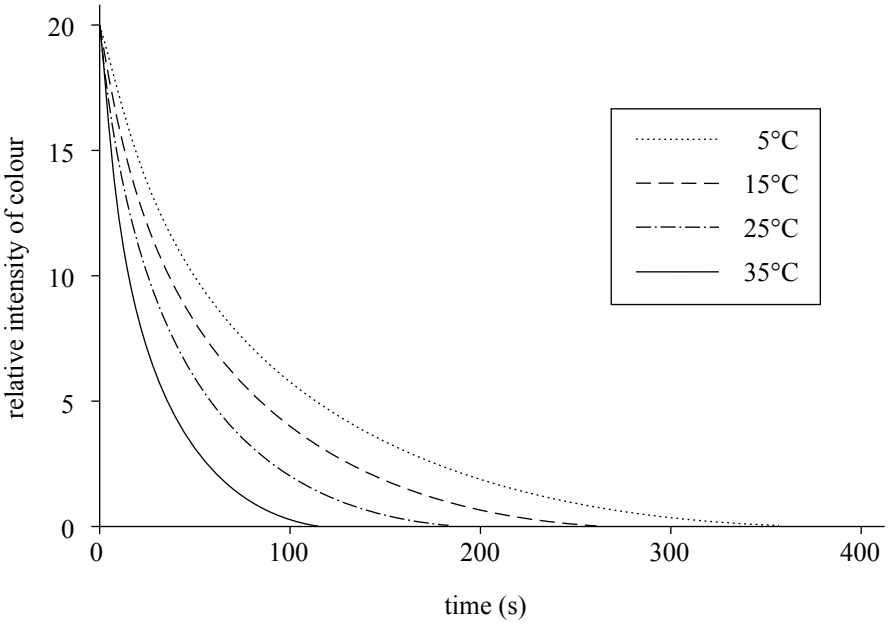
_____ (2 marks)

(b) Identify the type of reaction in which Compound **Z** is converted into ibuprofen.

_____ (1 mark)

(c) One method of converting Compound **Z** into ibuprofen involves the use of a reagent that loses colour during the reaction. This loss of colour can be used to indicate the progress of the reaction.

A student wanted to investigate the effect of temperature on the rate of the reaction. The student carried out the reaction at four different temperatures and recorded the intensity of the colour during the reaction. The results are shown in the graph below:



(i) Identify one factor that would need to be set at the same initial value in all four reactions.

_____ (1 mark)

(ii) State the independent variable in this investigation.

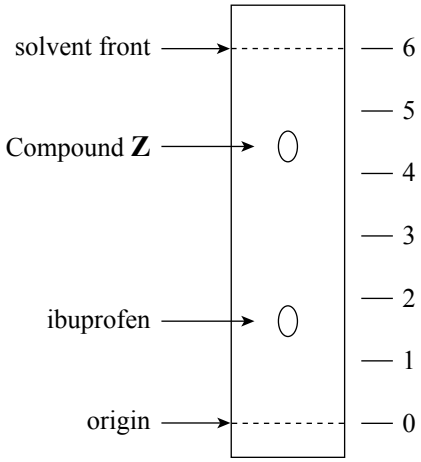
_____ (1 mark)

(iii) Construct a table for recording the time required for the reaction to reach completion at the four different temperatures.

There is no need to add the data to the table.

(2 marks)

(d) The reaction was also monitored using thin-layer chromatography on a polar stationary phase. A sample of the mixture was spotted onto the chromatography plate. The chromatogram obtained is shown below:



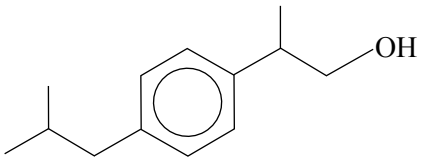
(i) Determine the R_F of ibuprofen.

(2 marks)

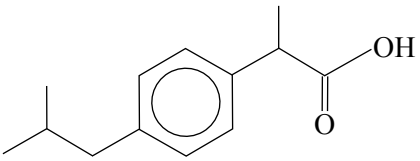
Credit will be given for answers to part (ii) which show clear, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer should be confined to the space provided and should take approximately 12 minutes.

(ii) The structural formulae of Compound **Z** and ibuprofen are shown below. You may wish to use them in answering this part of the question.



Compound Z



ibuprofen

Describe how the chromatogram shown on the page opposite was obtained by using the reaction mixture and the chromatography plate. Explain the relative positions of ibuprofen and Compound **Z**.

(8 marks)

TOTAL: 17 marks

You may write on this page if you need more space to finish your answers to Question Booklet 3. Make sure to label each answer carefully (e.g. 10(c)(iii)(2) continued).