1

Government of South Australia

SACE Board of SA | South Australian Certificate of Education

Chemistry
November 2018 sample paper

Question Booklet 1

- (Questions 1 to 4) 60 marks
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 14 if you need more space
- Allow approximately 60 minutes

Examination information

Materials

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

Reading time

- 10 minutes

Writing time

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

Total marks 120

Attach your SACE registration number label here

For office use only

Supervisor check	Re-marked

SACE
BOARD
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AUSTRALIA

This sample Chemistry paper shows the format of the examination for November 2018.

PERIODIC TABLE OF THE ELEMENTS

1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminium 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.90	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (97)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57[1] La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89[2] Ac Actinium (227)	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

[1]Lanthanide series	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
[2]Actinide series	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.

Metal activity

K	*most reactive*
Ca	
Na	
Mg	
Al	
Zn	
Cd	
Co	
Ni	
Bi	
Cu	
Hg	
Ag	
Au	*least reactive*

Table of SI prefixes

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}

Symbols of common quantities

amount of substance	n
mass	m
molar concentration	c
change in enthalpy	ΔH
molar mass	M
volume	V
heat energy	Q
specific heat capacity	C
temperature	T

Magnitude of physical constants

Avogadro's number	6.02×10^{23} mol^{-1}
heat capacity of water	4.18 J g^{-1} K^{-1}

Mathematical relationships

$$n = \frac{m}{M}$$

$$c = \frac{n}{V}$$

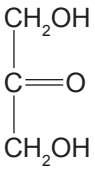
$$Q = mC\Delta T$$

$$\Delta H = \frac{Q}{n}$$

$$pH = -\log\left[H^{+}\right]$$

1. Carbohydrates form 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.



(i) Explain why dihydroxyacetone is a carbohydrate.

_____

_____ (2 marks)

(ii) Explain why dihydroxyacetone is soluble in water.

_____

_____

_____

_____

_____

_____ (3 marks)

(iii) Compound X is a diol. It has the same molecular formula as dihydroxyacetone, but contains an aldehyde group.

(1) Draw the structural formula of compound X.

(2 marks)

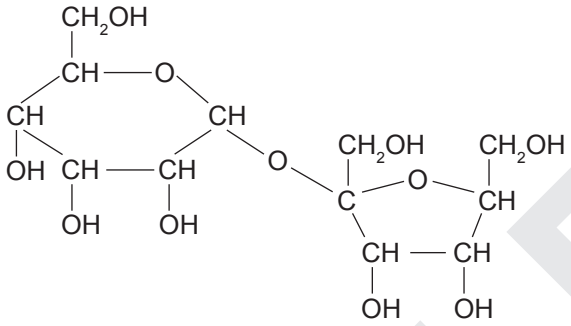
(2) (A) Name *one* chemical reagent that can be used to react with a compound to indicate the presence of an aldehyde group.

_____ (1 mark)

(B) State the observation during this reaction that would indicate the presence of an aldehyde group.

_____ (1 mark)

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



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

_____ (1 mark)

(ii) Sugar cane also contains the carbohydrate glucose, which is produced in a reaction between carbon dioxide and water.

(1) Write a balanced equation for this reaction.

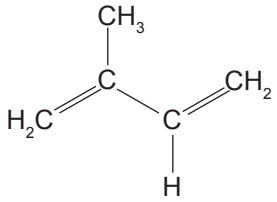
(2 marks)

(2) State whether this reaction is exothermic or endothermic.

_____ (1 mark)

2. Natural and synthetic rubbers have a wide range of uses.

(a) Natural rubber is derived from latex, a milky substance produced by some plants. Latex is an addition polymer made from isoprene (C_5H_8), which has the structural formula shown below.



(i) State the feature of the latex molecule that allows it to undergo addition polymerisation.

_____ (1 mark)

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

Determine the average number of isoprene units in the latex polymer.

(2 marks)

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

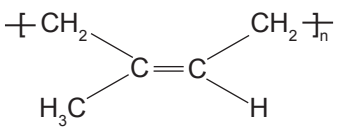
_____ (1 mark)

(iv) Natural rubber deforms easily when heated.

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

_____ (1 mark)

(v) The structural formula of the latex polymer is shown below.



Explain why natural rubber is biodegradable.

_____

_____

_____

_____ (2 marks)

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(b) Natural rubber is made from monomers produced from plants, but synthetic rubber is made from monomers derived from petroleum.

Describe *one* advantage to society of producing rubber from plants rather than from petroleum.

_____

_____

_____

_____ (2 marks)

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

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

_____

_____

_____

_____ (2 marks)

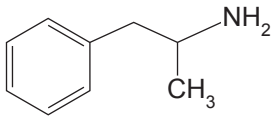
(ii) Explain why vulcanised rubber is more difficult than non-vulcanised rubber to recycle.

_____

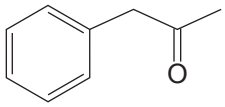
_____ (2 marks)

3. Chromatography techniques are commonly used in forensic science to separate organic molecules.

(a) A tablet containing 1-phenylpropan-2-amine was tested for the presence of a contaminant, 1-phenylpropan-2-one, using HPLC. The structures of these two molecules are shown below.

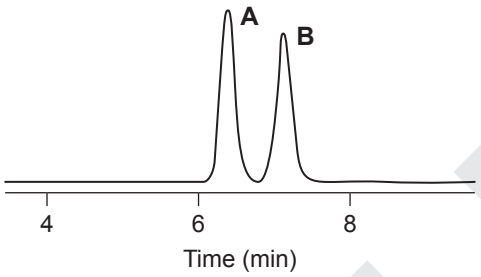


1-phenylpropan-2-amine



1-phenylpropan-2-one

HPLC, using a non-polar stationary phase, was used to identify these two molecules. A section of the chromatogram obtained is shown below.



(i) State the retention time for peak **A**.

_____ (1 mark)

(ii) State and explain which peak represents 1-phenylpropan-2-one.

_____

_____

_____

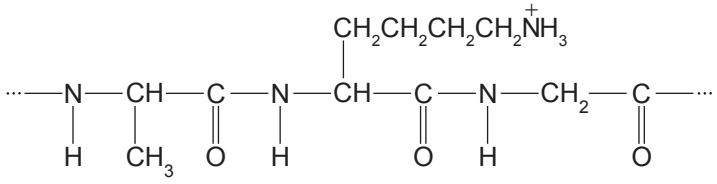
_____

_____

_____ (3 marks)

(b) Ion exchange chromatography can be used to identify proteins in body fluids of criminal suspects. Buffer solutions are used to prepare the proteins for the separation process by assigning them either a net positive or a net negative charge.

(i) A section of protein chain in a buffer solution is shown below.



Explain whether the pH of this protein's environment has likely been increased or decreased by the buffer solution.

_____

_____

_____

_____ (2 marks)

(ii) Buffer solutions only slightly alter pH.

Explain why pH must ***not*** be altered significantly when preparing proteins for separation.

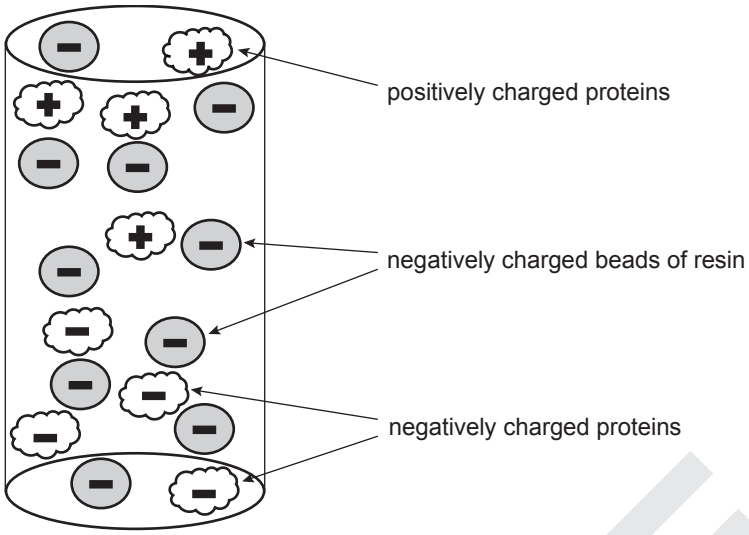
_____

_____

_____

_____ (2 marks)

(iii) Ion exchange resins are used in ion chromatography, and may contain a cation or an anion exchange surface. A diagram of a column that uses a resin with a cation exchange surface is shown below.



(1) With reference to the diagram, explain the relative positions of positively and negatively charged proteins as they move through this column.

(3 marks)

(2) Proteins that have a net positive charge can be removed from the surface of the resin by passing a concentrated solution of NaCl through the column, as shown below.

$$protein^{+}_{(resin)} + Na^{+}_{(aq)} \rightleftharpoons protein^{+}_{(aq)} + Na^{+}_{(resin)}$$

Explain how an increase in the concentration of $Na^{+}_{(aq)}$ results in the removal of proteins that have a net positive charge from the surface of the resin.

(3 marks)

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4. Methanol and ethanol are alcohols that have a variety of uses.

(a) The table below shows some data for methanol and ethanol.

Fuel	*Formula*	*Molar mass ($g\ mol^{-1}$)*	*Density ($g\ L^{-1}$)*	*Energy released ($kJ\ g^{-1}$)*
methanol	CH_3OH	32.040	792	22.7
ethanol	C_2H_5OH	46.068	789	29.6

(i) Calculate the amount of heat released when 1 mol of methanol undergoes complete combustion.

(1 mark)

(ii) Ethanol has an enthalpy of combustion of 1345 kJ mol^{-1}.

(1) Complete the following thermochemical equation for the complete combustion of ethanol:

$$C_2H_5\,OH \quad + \quad O_2 \longrightarrow \quad CO_2 \quad + \quad H_2O \qquad \Delta H = -1345\ kJ\ mol^{-1}$$

(2 marks)

(2) Calculate the volume of water that could be heated from 20°C to boiling point (100°C) if 1 L of ethanol underwent complete combustion and all the heat was absorbed by the water.

(4 marks)

(3) State *one* reason why, in practice, 1 L of ethanol will not be sufficient fuel to heat this volume of water to boiling point.

_____

_____ (1 mark)

(b) 'Bioethanol' is ethanol produced by the fermentation of glucose.

Write an equation for the production of bioethanol by the fermentation of glucose.

(2 marks)

Credit will be given for answers to part (c) that are coherent and contain only relevant information.

(2 marks)

(c) Methanol is a primary alcohol that is used mainly as a feedstock for the manufacture of chemicals. The industrial production of methanol uses a reaction between carbon monoxide and hydrogen gases. The equation for the overall reaction is shown below.

Reaction 1 $CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$

Manufacturers prefer production methods that will maximise their profits, and so researchers are trialling different processes for methanol production. One process produces methanol from the oxidation of methane by certain bacteria, in aqueous conditions. The equation for the overall reaction is shown below.

Reaction 2 $2CH_{4(g)} + O_{2(g)} \longrightarrow CH_3OH_{(l)}$

Discuss the factors that manufacturers would need to consider when deciding which of these two processes will maximise their yield of methanol (and hence their profits).

(8 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) continued).

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