VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2021

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

Letter

STUDENT NUMBER

CHEMISTRY

Written examination

Tuesday 1 June 2021

Reading time: 10.00 am to 10.15 am (15 minutes)
Writing time: 10.15 am to 12.45 pm (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	10	10	90
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied
- Question and answer book of 39 pages
- Data book
- Answer sheet for multiple-choice questions

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

The following table shows a number of fuels and a common method of production or source for each fuel.

Fuel	Common method of production or source
liquefied petroleum gas (LPG)	extracted during production of natural gas
kerosene	fractional distillation from crude oil
biodiesel	converted from fat
ethanol	fermentation of corn
hydrogen	electrolysis of water
natural gas	extracted from shale
methane	chemical breakdown of organic material by anaerobic bacteria

Based on the information provided in the table above, which of the following lists only fossil fuels?

A. hydrogen, kerosene, LPG
B. kerosene, LPG, natural gas
C. ethanol, methane, natural gas
D. biodiesel, hydrogen, methane

Question 2

Calcium metal can be obtained from the electrolysis of molten calcium chloride.

During this process, calcium ions flow to the

A. anode and are reduced to calcium metal.
B. anode and are oxidised to calcium metal.
C. cathode and are reduced to calcium metal.
D. cathode and are oxidised to calcium metal.

Question 3

Which one of the following statements about rechargeable batteries is most correct?

A. Side reactions at the electrodes reduce battery life.

B. During discharge the battery operates as an electrolytic cell.

C. Battery life is in direct proportion to the temperature when the battery is in use.

D. During discharge the cell voltage is higher than the voltage being used to recharge the cell.

Question 4

When egg whites are beaten, changes in their appearance occur. The egg whites will change from a clear liquid to a firm, white peak.

Which protein structure(s) is altered when this change occurs?

A. the primary, secondary and tertiary structures

B. the secondary and tertiary structures

C. the primary structure only

D. the tertiary structure only

Question 5

A single 10 g piece of iron metal is completely submerged in 50 mL of 0.2 M nitric acid, HNO_3, contained in a 100 mL beaker. The experiment is performed at standard laboratory conditions (SLC).

The reaction that occurs is

$$Fe(s) + 2HNO_3(aq) \rightarrow Fe(NO_3)_2(aq) + H_2(g)$$

The rate of the reaction would most likely increase if the

A. reaction was performed in a fume cupboard to remove the hydrogen gas formed.

B. single piece of iron metal was replaced with 70 pieces (0.1 g each) of iron metal.

C. volume of the acid was increased by adding 20 mL of water.

D. experiment was performed at 10 °C.

Question 6

Which one of the following formulas best represents glycine in a solution at pH 4?

A. $^{+}NH_3CH_2COOH$

B. NH_2CH_2COOH

C. $^{+}NH_3CH_2COO^{-}$

D. $NH_2CH_2COO^{-}$

Question 7

Ammonium nitrate, NH_4NO_3, can be used in chemical cold packs that are often found in first-aid kits.

A calorimeter was electrically calibrated using 100 mL of pure water and was then used to determine the molar heat of solution of NH_4NO_3.

If the water was replaced prior to determination of the molar heat of solution and, instead of 100 mL, only 90 mL was added to the calorimeter, the molar heat of solution determined would be

A. lower due to the temperature change being smaller.

B. lower due to the temperature change being greater.

C. higher due to the temperature change being smaller.

D. higher due to the temperature change being greater.

Question 8

Which one of the following fuels is expected to have the highest viscosity at SLC?

A. petrodiesel

B. bioethanol

C. biodiesel

D. petrol

Use the following information to answer Questions 9 and 10.

A chemist is titrating a volume of an unknown monoprotic organic acid against 50 mL of 0.30 M sodium hydroxide, NaOH, using methyl red as an indicator. The chemist observes the first permanent colour change at 23.65 mL.

Question 9

A valid conclusion that can be drawn from this information is that

A. the concentration of the unknown compound is 0.14 M.

B. a redox titration on the unknown compound will not produce a colour change.

C. using phenolphthalein as an indicator will produce the same titre.

D. if 0.10 M NaOH is used in the titration, the results will be more precise.

Question 10

If the titration is repeated several times, averaging the results will reduce the

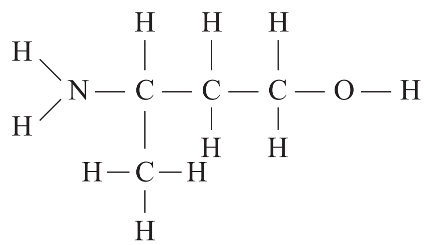
A. accuracy of the results.

B. reliability of the results.

C. effect of random errors.

D. effect of systematic errors.

Question 11



What is the IUPAC systematic name for the molecule shown above?

A. 3-aminobutan-1-ol

B. 4-hydroxybutan-2-amine

C. 3-methyl-3-aminopropan-1-ol

D. 3-hydroxy-1-methylpropan-1-amine

Question 12

Which one of the following molecules can be oxidised to produce a carboxylic acid?

A. propan-2-ol

B. 1-chlorobutan-1-ol

C. 2,2-dichloroethanol

D. 2-methylpropan-2-ol

Question 13

Over 40 countries around the world use E10 unleaded fuel, which consists of a blend of 90% m/m octane and 10% m/m ethanol.

A full tank of E10 unleaded fuel produces 2396 MJ of energy when it undergoes complete combustion at SLC.

The mass of fuel that produces this amount of energy is

A. 5.0×10^{-2} tonnes.

B. 5.2×10^{-2} tonnes.

C. 7.6×10^{-2} tonnes.

D. 8.1×10^{-2} tonnes.

Question 14

A student investigated the rate of reaction between dilute hydrochloric acid, HCl, and calcium carbonate, $CaCO_3$. The student performed two experiments using two pieces of $CaCO_3$ of different shapes.

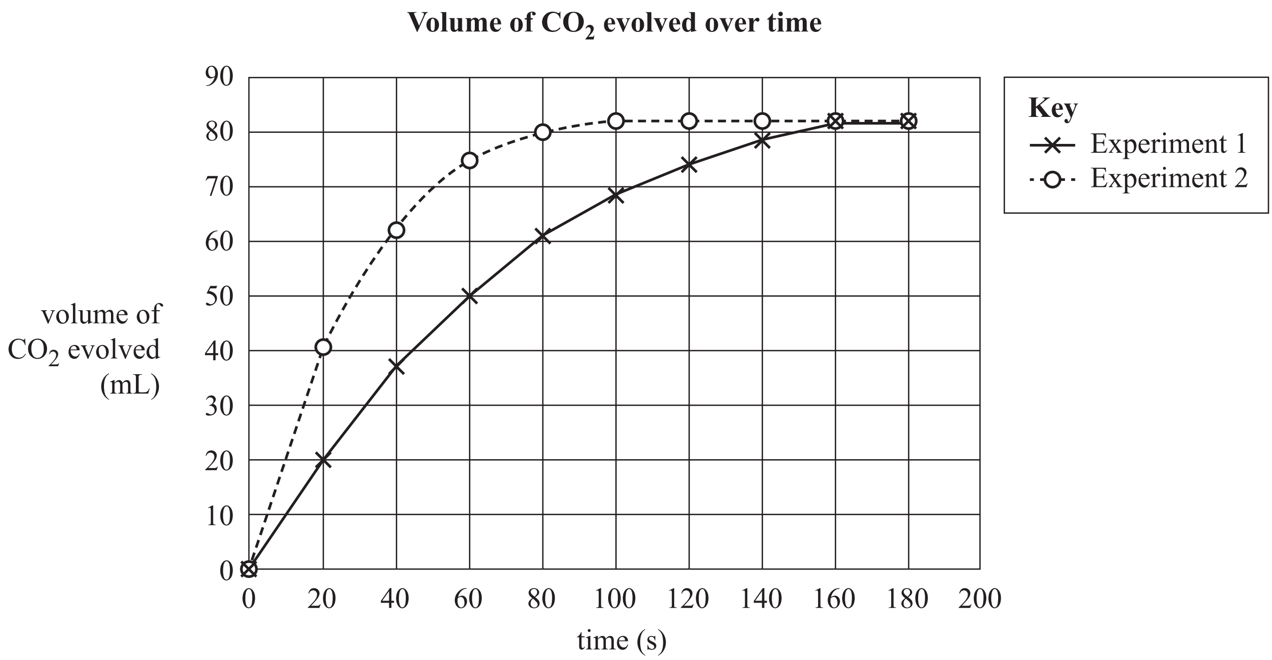
In each experiment, Experiment 1 and Experiment 2, 0.34 g of $CaCO_3$ and 12.0 mL of 0.50 M HCl was used and the volume of gas produced at SLC was measured at 10 s intervals.

The following reaction takes place.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The molar mass of $CaCO_3$ is 100.1 g mol^{-1}.

The student plotted the results and produced the graph shown below.



At 160 s the two lines meet.

This is because

A. both reactions have reached equilibrium.

B. the $CaCO_3$ has completely reacted and there is some acid remaining.

C. the acid has completely reacted and there is some $CaCO_3$ remaining.

D. both reactions have stopped because all reactants have been consumed.

Question 15

A 20.00 mL sample of vinegar is diluted in a volumetric flask. The volumetric flask is then filled up to the line marking its designated volume. A 20.00 mL aliquot of the diluted sample of vinegar is titrated against a 0.102 M solution of potassium hydroxide, KOH, using a phenolphthalein indicator.

If the undiluted sample of vinegar has a concentration of 3.16% m/v acetic acid, CH_3COOH, which volumetric flask should be selected to be able to dilute the original sample of vinegar and obtain titres of about 20 mL?

A. 100 mL volumetric flask

B. 200 mL volumetric flask

C. 250 mL volumetric flask

D. 1000 mL volumetric flask

Question 16

Carbon monoxide, CO, and oxygen, O_2, dissociate from haemoglobin, represented by Hb, in the blood according to two reactions.

Reaction 1 $Hb(O_2)_4 \rightleftharpoons Hb + 4O_2$ K_1

Reaction 2 $Hb(CO)_4 \rightleftharpoons Hb + 4CO$ K_2

Which one of the following statements is true?

A. K_2 is much greater than K_1.

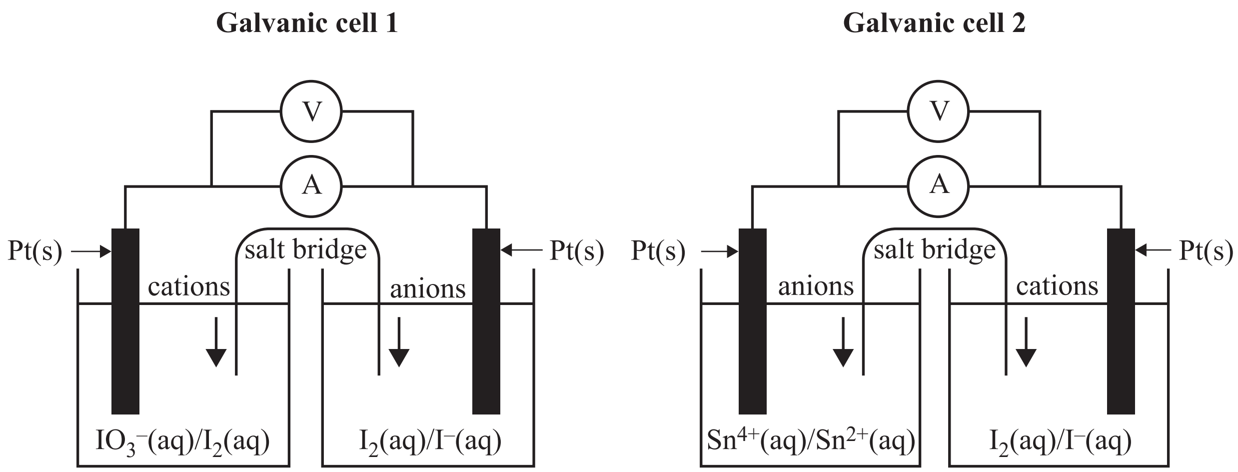
B. O_2 binds more readily to Hb than CO.

C. Increased levels of CO in the blood favour the forward reaction for Reaction 1.

D. Breathing 100% O_2 increases the amount of free Hb in a person exposed to CO.

Use the following information to answer Questions 17 and 18.

The following diagrams show two galvanic cells, Galvanic cell 1 and Galvanic cell 2, with platinum, Pt, electrodes and 1.0 M concentrations of salt solutions. Both cells were set up at SLC. A voltage was produced in each cell. The direction of movement of the ions in the salt bridge is indicated in each diagram.



Question 17

Which one of the following statements is true?

A. The weakest reducing agent is Sn^{2+}.

B. The strongest oxidising agent is I^-.

C. The strongest oxidising agent is IO_3^-.

D. The weakest reducing agent is I^-.

Question 18

A correctly balanced half-equation occurring in Galvanic cell 1 is

A. $IO_3^-(aq) + 6H^+(aq) + 6e^- \rightarrow I^-(aq) + 3H_2O(l)$

B. $I^-(aq) + 3H_2O^+(l) \rightarrow IO_3^-(aq) + 6H^+(aq) + 6e^-$

C. $I_2(aq) + 6H_2O(l) \rightarrow 2IO_3^-(aq) + 12H^+(aq) + 10e^-$

D. $2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(aq) + 6H_2O(l)$

Question 19

The number of unbranched esters that have a molecular formula of $C_4H_8O_2$ is

A. 2

B. 3

C. 4

D. 5

Question 20

The value of the equilibrium constant K_c at 1000 K for the dissociation of iodine gas, I_2, to iodine atoms, I, in a sealed container is 3.76×10^{-3}. The equation is given below.

$$I_2(g) \rightleftharpoons 2I(g)$$

Which one of the following statements applies to this system when it has reached equilibrium at 1000 K?

A. Adding an inert gas changes the equilibrium constant.

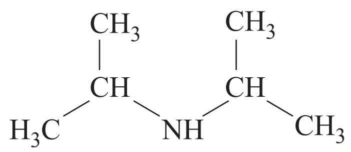
B. The dissociation of I_2 gas to I atoms will occur continuously.

C. The equilibrium constant is dependent on the pressure in the container.

D. The rate of the forward reaction is slower than the rate of the reverse reaction.

Question 21

Two compounds, hexan-1-ol and di-isopropyl amine, have similar molar masses, yet they have different boiling points. This information is summarised in the table below.

Compound	Molar mass (g mol^{-1})	Boiling point (°C)
hexan-1-ol $CH_3CH_2CH_2CH_2CH_2CH_2—OH$	102	157
di-isopropyl amine 	101	83

Which one of the following is the main reason for the difference in boiling point?

A. the number of carbon atoms in each compound

B. the strength of the dispersion forces of each compound

C. the different chemical reactivities of each compound

D. the N–H bond is less polar in the amine than the O–H bond in hexan-1-ol

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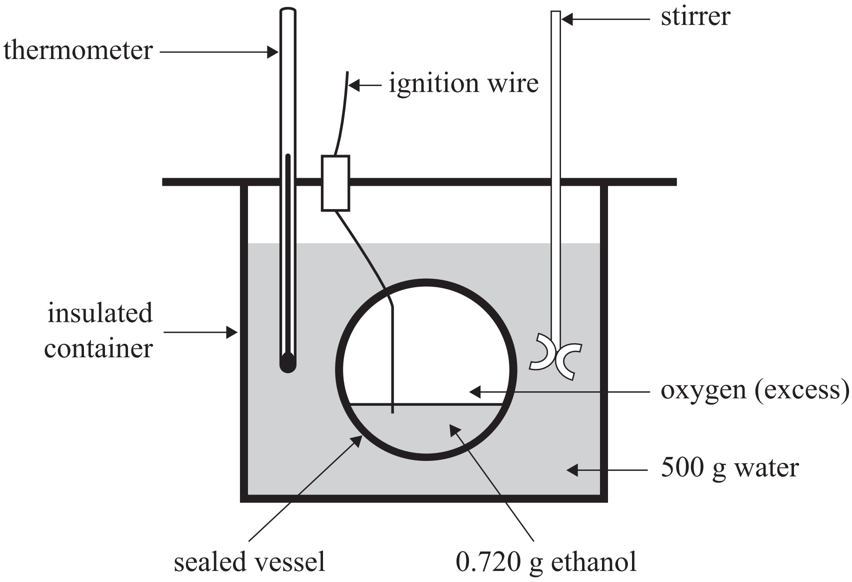
Use the following information to answer Questions 22 and 23.

The diagram below shows the apparatus for a bomb calorimeter.



Question 22

The bomb calorimeter containing 500 g of water was chemically calibrated by combusting 0.720 g of ethanol with an excess of oxygen. The increase in temperature was found to be 22.0 °C.

Which one of the following best explains these results?

A. The stirrer was not working.

B. The calorimeter actually contained 450 g of water.

C. The temperature in the calorimeter was still rising after the final temperature was noted.

D. Some of the ethanol evaporated after it was weighed, but before it was added to the calorimeter.

Question 23

The bomb calorimeter was recalibrated using benzoic acid and was found to have a calibration factor of 1.67 kJ $°C^{-1}$.

If 1.5 g of a food containing 63% m/m fat and 37% m/m protein was combusted in the bomb calorimeter, by how much would the temperature be expected to rise?

A. 33 °C

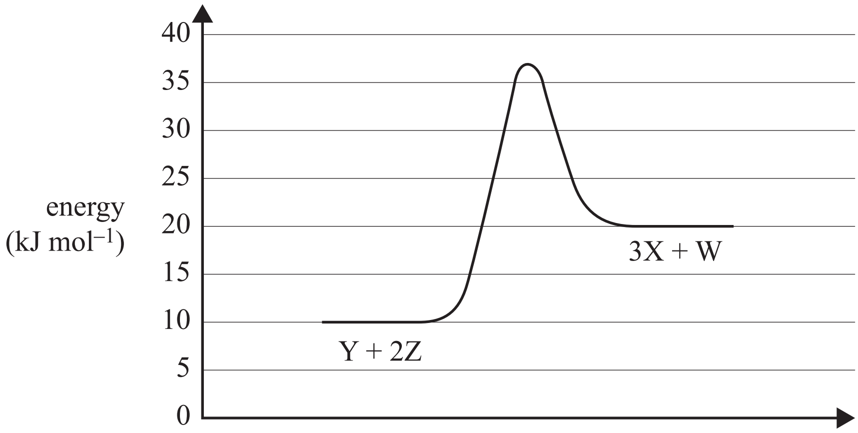
B. 27 °C

C. 17 °C

D. 15 °C

Question 24

Below is an energy profile diagram for an uncatalysed reversible reaction.



A catalyst was added to the system, causing the rate of the forward and reverse reactions to increase.

Which one of the following could be true for the catalysed reaction?

A. The activation energy to produce 1 mol of W is 29 kJ.

B. The activation energy to produce 1 mol of Z is 12 kJ.

C. The activation energy to produce 0.5 mol of X is 5 kJ.

D. The activation energy to produce 9 mol of Y is 120 kJ.

Question 25

$$CH_3COOH + \boxed{\text{Reactant X}} \longrightarrow \boxed{\text{Product Y}} + H_2O$$

Which of the following identifies Reactant X and Product Y in the condensation reaction shown above?

	Reactant X	**Product Y**
A.	CH_3CH_2OH	$CH_3CHOHCH_2CH_3$
B.	$CH_3CH_2NH_2$	$CH_3CH_2CONHCH_3$
C.	CH_3CH_3	$CH_3COCH_2CH_3$
D.	CH_3NH_2	$CH_3CONHCH_3$

Question 26

Consider all of the components involved in the production of biofuels.

The **most** accurate statement about all biofuels is that they

A. are not sustainable sources of energy.

B. produce greenhouse gas emissions when burnt.

C. produce the same amount of energy per unit of mass as fossil fuels.

D. release less carbon dioxide per unit of energy produced than fossil fuels.

Question 27

A high-performance liquid chromatography (HPLC) column has a non-polar stationary phase and a polar solvent as the mobile phase.

Which one of the following substances would have the lowest retention time?

A. tetrachloromethane

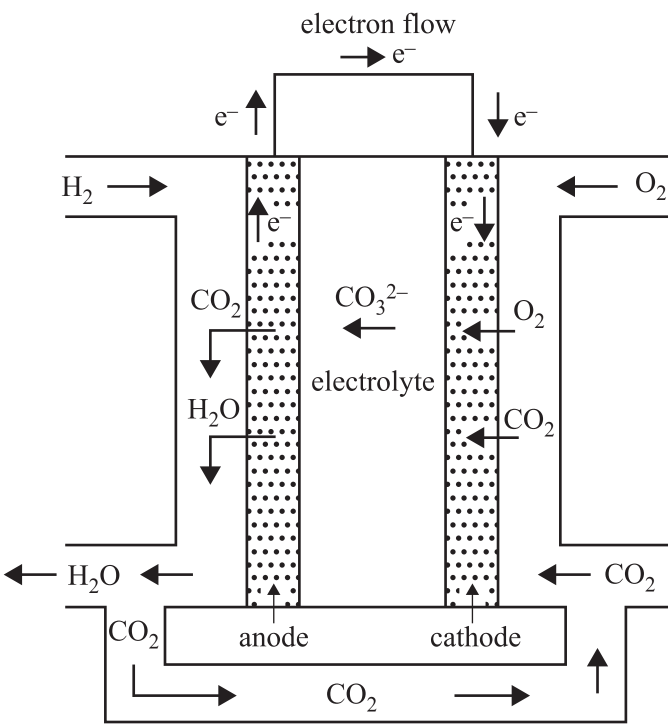
B. chloromethane

C. bromomethane

D. hexane

Use the following information to answer Questions 28 and 29.

Scientists have developed a new type of hydrogen fuel cell for use on a large scale in factories and manufacturing plants, as shown in the diagram below. The fuel cell operates at 600 °C.



Question 28

The equation for the half-cell reaction occurring at the positive electrode in the diagram above is

A. $2CO_2 + 4H_2O + 4e^- \rightarrow O_2 + 2CO_3^{2-} + 8H^+$

B. $H_2 + CO_3^{2-} \rightarrow CO_2 + H_2O + 2e^-$

C. $H_2O + CO_2 + 2e^- \rightarrow CO_3^{2-} + H_2$

D. $O_2 + 2CO_2 + 4e^- \rightarrow 2CO_3^{2-}$

Question 29

Which one of the following statements is accurate for this type of hydrogen fuel cell?

A. Heat is a by-product of this hydrogen fuel cell.

B. O_2 is oxidised to produce CO_2.

C. The enthalpy of the reactants is less than the enthalpy of the products.

D. CO_2 is released into the environment.

Question 30

The glycaemic index of a food can be

A. determined using a bomb calorimeter.

B. calculated if the amount of glucose present in the food is known.

C. determined experimentally using human subjects with varied rates of metabolism.

D. determined in the laboratory by hydrolysing a food sample and measuring the yield of glucose after two hours.

END OF SECTION A

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SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, $NaCl(s)$.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (9 marks)

Macromolecules perform different functions in the human body.

a. What is the name of the macromolecule that is formed from glucose and is used to store energy in the human body? 1 mark

b. **i.** What is the function of a peptide bond in the structure of a protein? 1 mark

ii. Each protein is unique.

Describe what makes each protein unique. 1 mark

c. DNA polymerase is an example of a protein that has a quaternary structure.

Describe the quaternary structure of a protein. 2 marks

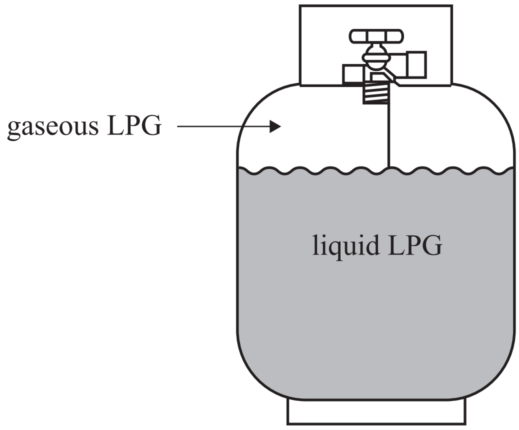
d. Enzymes are specific types of proteins.

Explain how the induced fit model describes the action of an enzyme during a reaction. You may include diagrams in your answer. 2 marks

e. Some enzymes require a coenzyme in order to perform their function.

Identify **two** functions of a coenzyme during a reaction. 2 marks

Question 2 (7 marks)



Liquefied petroleum gas (LPG) is found in the gas bottles used for barbecues and outdoor heaters. LPG can be propane, butane or a mixture of both. LPG that is used domestically in Australia is typically propane. It is supplied in 17.00 L cylinders that are filled to a mass of 8.50 kg.

LPG is stored under pressure and exists in both liquid and gas form in the cylinder. The pressure in the cylinder will remain the same from when the cylinder is full until the last of the liquid LPG is vaporised to gas.

It is important to have adequate ventilation whenever propane is burnt in an enclosed area.

a. On a cold and rainy day, a propane LPG heater was used to heat a small, enclosed, outdoor area.

Write a balanced chemical equation for the incomplete combustion of propane gas, where carbon monoxide is the only carbon product. 1 mark

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b. At a temperature of 27.0 °C, the pressure in a domestic propane LPG cylinder is 883 kPa. The density of liquid propane is 489.3 g L^{-1}.

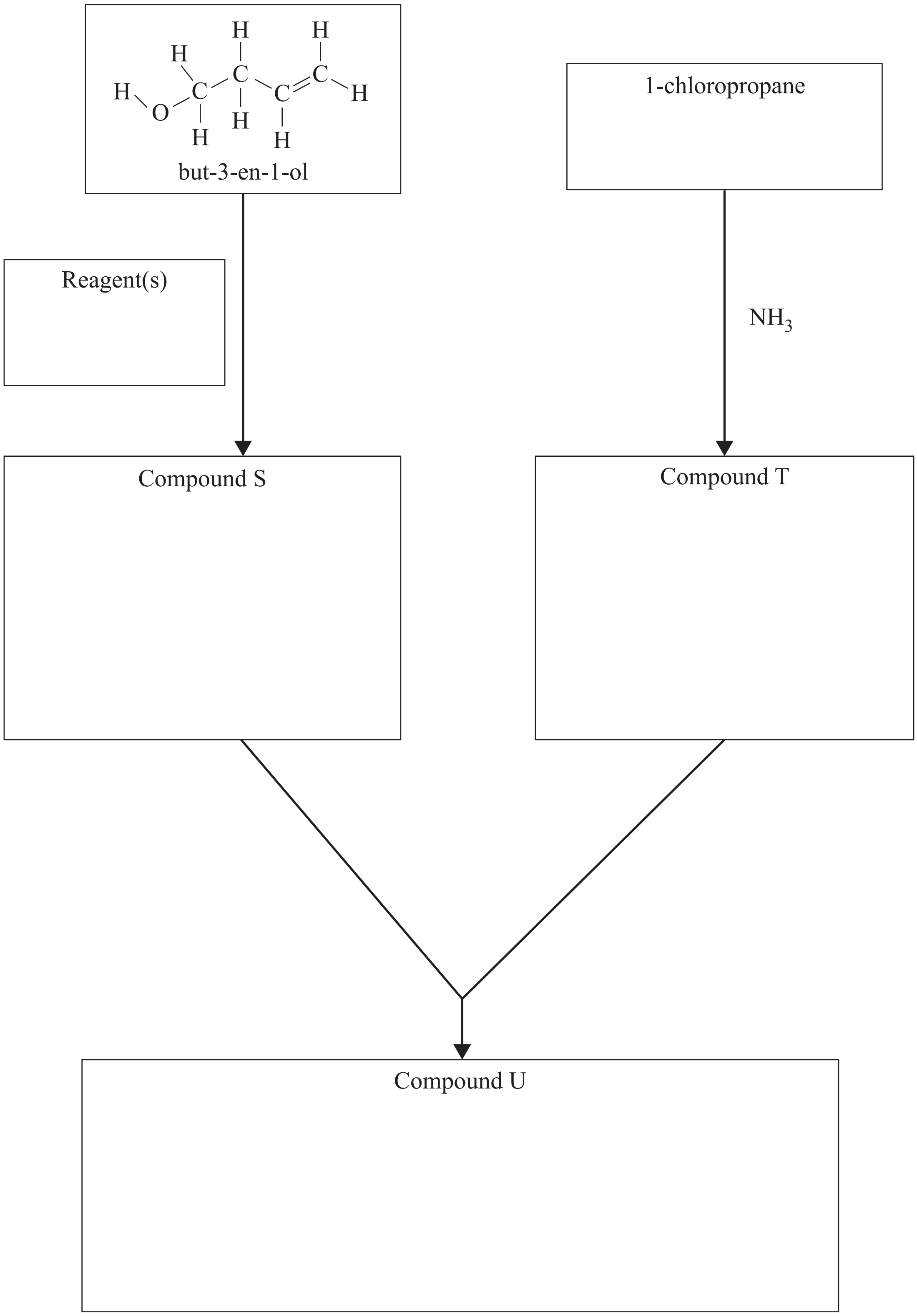
If the cylinder is filled to 50% of its capacity by volume with liquid propane, determine the total mass of propane, both liquid and gas, in kilograms, in the cylinder. 4 marks

c. An LPG cylinder containing a propane liquid and gas mixture is more suitable for use in cold weather than a butane liquid and gas mixture.

Explain why, in terms of the structure and properties of the two molecules. 2 marks

Question 3 (8 marks)

The reaction pathway below represents the synthesis of Compound U.



a. But-3-en-1-ol has the molecular formula C_4H_8O.

Excluding but-3-en-1-ol, how many other stereoisomers of this compound exist? Give your reasoning. 2 marks

b. When Compound S is mixed with a solution of sodium carbonate, Na_2CO_3, bubbles of gas are observed.

Write the chemical formula(s) of the reagent(s) in the box provided on page 18. 1 mark

c. Draw the structural formula of Compound S in the box provided on page 18. 1 mark

d. Identify the type of reaction that forms Compound T. 1 mark

e. Write the semi-structural formula of Compound T in the box provided on page 18. 1 mark

f. Write the skeletal formula of Compound U in the box provided on page 18. 2 marks

Question 4 (9 marks)

Chia is a type of plant seed that was used by the Aztecs and Mayans in Mexico and Guatemala over 5000 years ago as a food source to provide endurance and energy. This seed has been called a 'superfood' and it is one of the latest health trends, with chia seeds being used in juices, smoothies, yoghurts and salads.

The table below shows the nutrition information for dried chia seeds.

	Per 100 g of dried chia seeds
Protein	16.5 g
Carbohydrates	42.1 g (80% insoluble dietary fibre)
Saturated fat	3.33 g
Monounsaturated fat	2.31 g
Polyunsaturated fat	23.7 g
Trans fat	0.14 g

a. Calculate the amount of energy, in kilojoules, in 100 g of dried chia seeds, that can be accessed by the human body. 2 marks

b. Amylose is a carbohydrate that is one of the constituents of chia seeds.

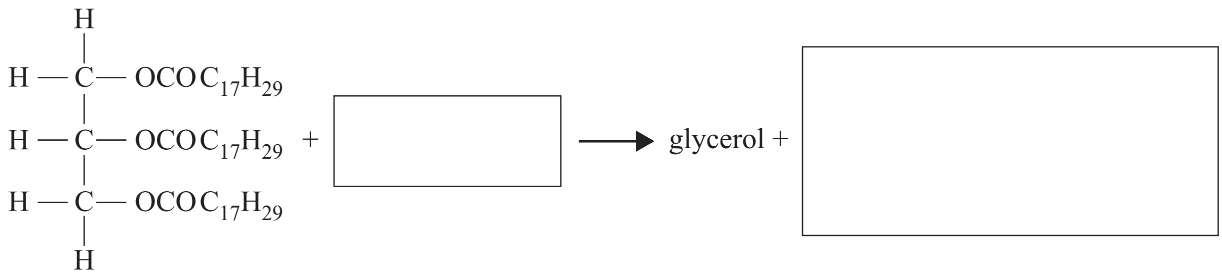
State why amylose contributes to chia seeds having a low glycaemic index. 1 mark

c. Fats have a high energy content.

Give **one** reason why a moderate intake of fats is required in our diets. 1 mark

d. The chemical structure of a fat molecule found in chia seeds is shown in the incomplete hydrolysis equation below.

Write the two missing chemical formulas in the boxes provided to complete the hydrolysis equation. 2 marks



e. Some unsaturated fatty acids can be classified as omega-3 or omega-6 fatty acids.

What is the difference between these fatty acids in terms of their chemical structure? 1 mark

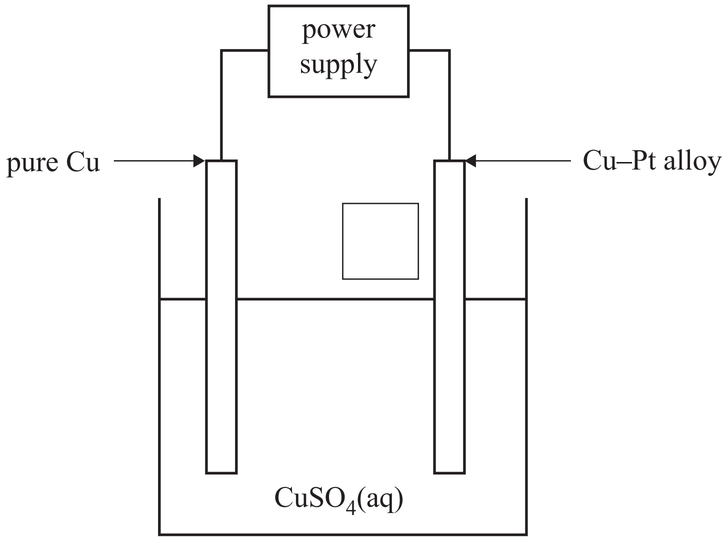
f. Chia seeds contain a small amount of vitamin C. Vitamin C is a water-soluble compound whereas vitamin D is a fat-soluble compound.

Explain why there is a difference in the solubilities of these two vitamins with reference to their chemical structures. 2 marks

Question 5 (10 marks)

Platinum, Pt, is a precious metal used in catalytic converters in cars. One way of recovering this Pt may be to melt scrap catalytic converters with copper, Cu, and then electrolyse the resultant Cu–Pt alloy.

The diagram below shows an electrolysis cell set up to recover Pt from an alloy containing 99.4% m/m Cu and 0.6% m/m Pt. The Pt is evenly distributed throughout the alloy.



The reaction $Pt^{2+}(aq) + 2e^- \rightleftharpoons Pt(s)$ has an E^0 of 1.20 V at 25 °C.

a. A power supply is connected across the electrodes.

Label the polarity of the Cu–Pt alloy electrode in the box provided on the diagram above. 1 mark

b. What happens at the Cu–Pt alloy electrode as the current is applied to the electrolysis cell? Give your reasoning. 2 marks

c. Write the half-equation that occurs at the cathode. 1 mark

d. Explain why an aqueous solution of copper(II) sulfate, $CuSO_4$, is used as the electrolyte. 2 marks

e. Calculate how long, in hours, a current of 2.00 A would need to be applied to recover the Pt in 356.0 g of the alloy. 4 marks

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Question 6 (9 marks)

5.0 mol of oxygen, O_2, and 10.0 mol of sulfur dioxide, SO_2, are injected into a 5.0 L evacuated and sealed container at standard laboratory conditions (SLC) and allowed to achieve equilibrium. The equation for this reaction is given below.

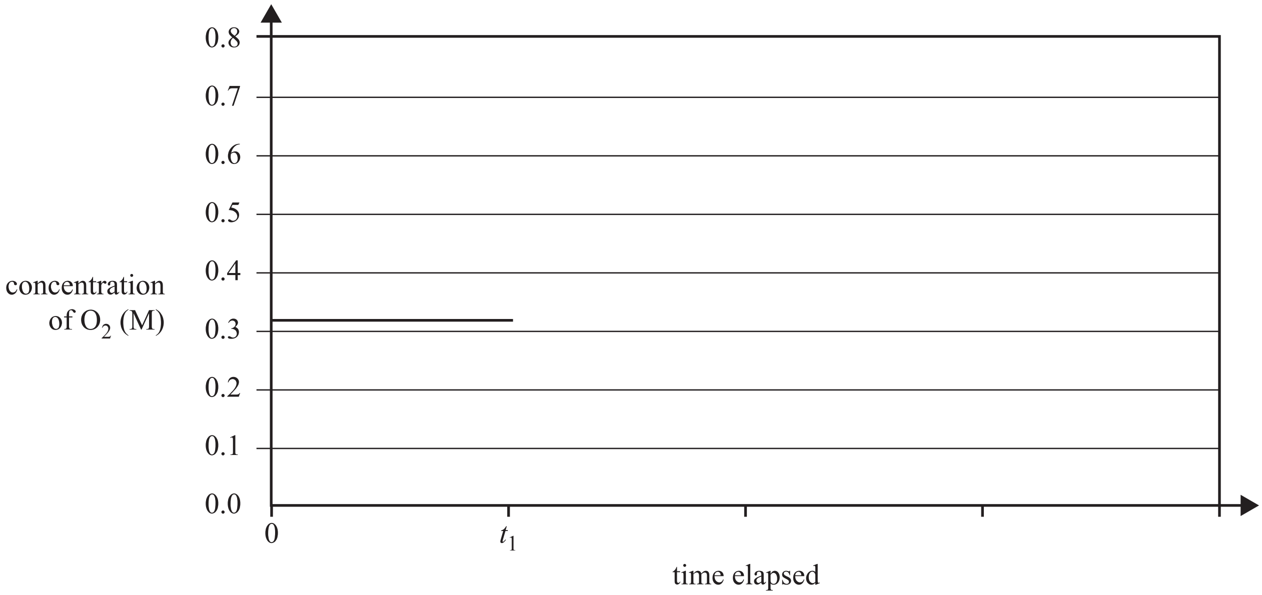
$$O_2(g) + 2SO_2(g) \rightleftharpoons 2SO_3(g)$$

a. At equilibrium, the concentration of O_2 is 0.32 M.

Calculate the equilibrium constant, K_c. 3 marks

b. At time t_1 after equilibrium has been achieved, the volume of the container is expanded to 10.0 L at constant temperature.

i. On the graph below, draw the concentration of O_2 after time t_1 until equilibrium is re-established. 2 marks

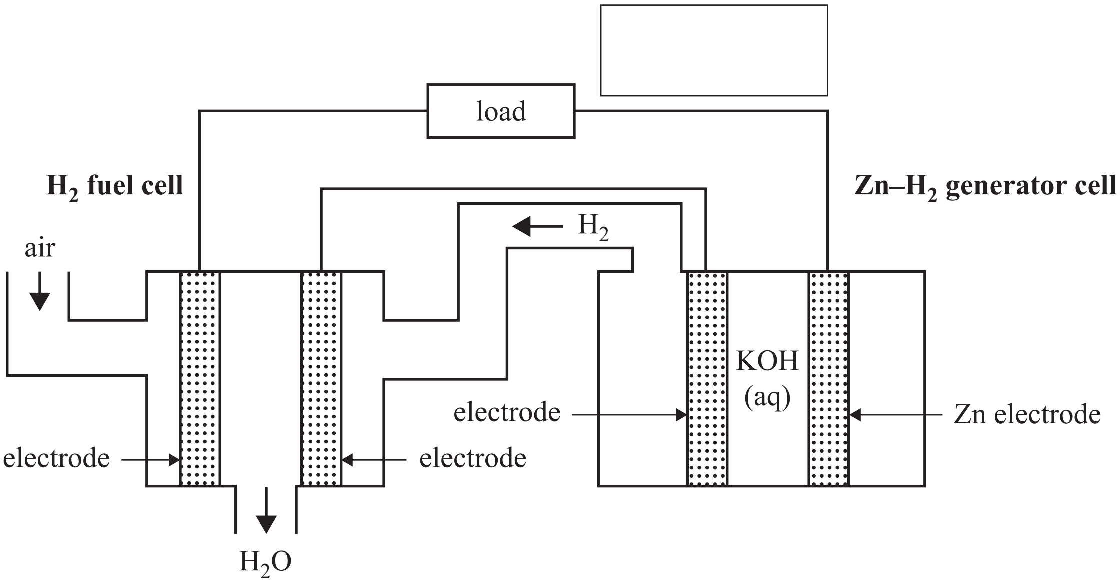


ii. Justify your answer to **part b.i.** using Le Chatelier's principle. 2 marks

iii. What is the effect of the expansion of the container on the rate of the forward reaction? Give your reasoning using collision theory. 2 marks

Question 7 (9 marks)

Researchers have investigated generating hydrogen, H_2, gas for hydrogen fuel cells by reacting zinc, Zn, and water, H_2O, in an electrochemical cell in series with an H_2 fuel cell. The diagram below represents an alkaline H_2 fuel cell in series with a Zn–H_2 generator cell.



The reactions that occur at each electrode in the Zn–H_2 generator cell are given below.

$$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

$$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$$

a. Write the overall reaction for the production of H_2 gas in the Zn–H_2 generator cell. 1 mark

b. Write the half-equation that occurs at the anode of the alkaline H_2 fuel cell. 1 mark

c. In the box provided in the diagram above, draw an arrow to show the direction of the flow of electrons. 1 mark

d. In terms of H_2 gas flow and electron flow, explain why it is theoretically possible to connect the H_2 fuel cell in series with the Zn–H_2 generator cell. 2 marks

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e. Explain why the $Zn–H_2$ generator cell must be well-sealed to prevent contact with the atmosphere in order to produce H_2. Include any relevant equations in your answer. 2 marks

f. Assuming the system is 100% efficient, describe all of the energy conversions that occur in a combined $Zn–H_2$ generator cell and H_2 fuel cell system. 2 marks

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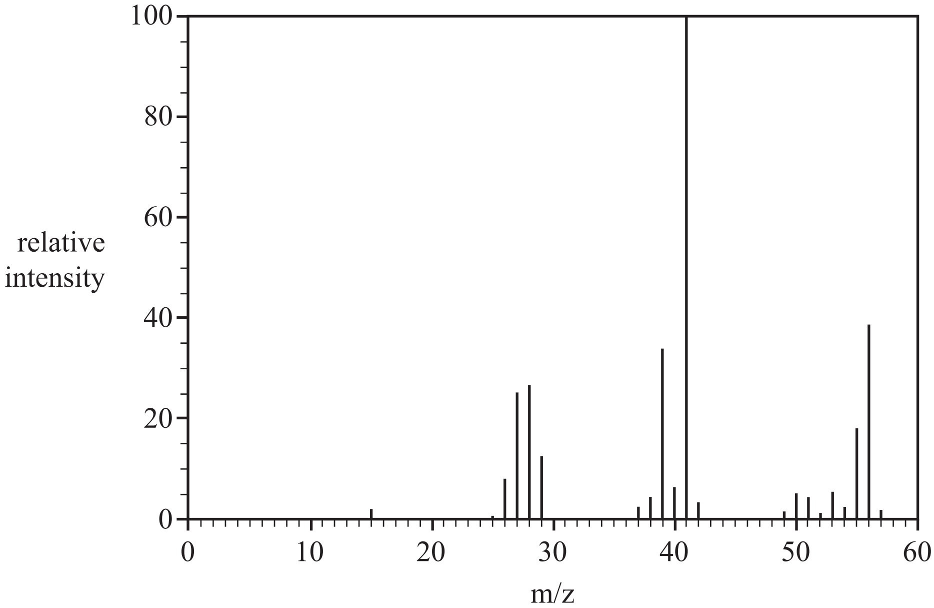
Question 8 (9 marks)

A chemist has a sample of an unknown hydrocarbon, Molecule L. The diagram below shows the mass spectrum of Molecule L.

Mass spectrum



Data: National Institute of Standards and Technology, NIST Chemistry WebBook, <https://webbook.nist.gov/chemistry>

a. **i.** What is the m/z of the base peak? 1 mark

____

ii. What is the molecular formula of Molecule L? 1 mark

____

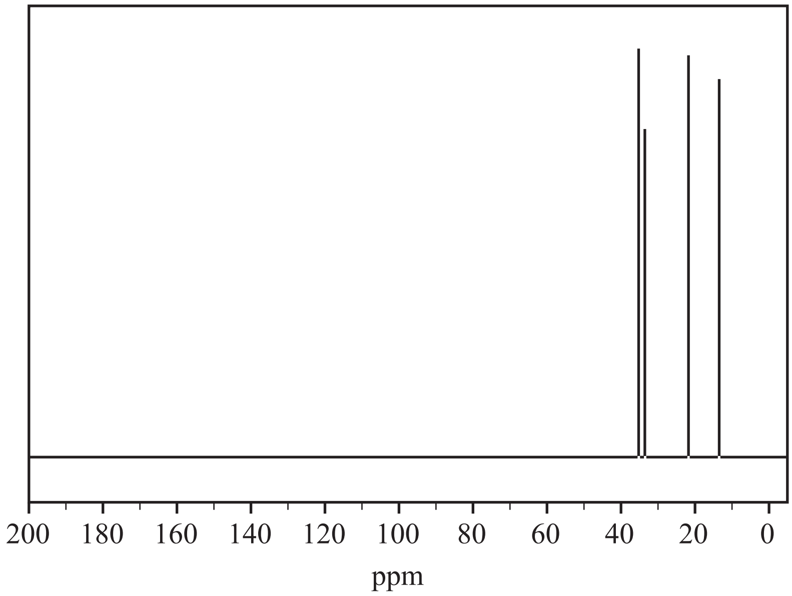
iii. Identify the fragment that produces the peak at 41 m/z. 1 mark

____

b. Draw the structural formulas for two isomers of Molecule L. 2 marks

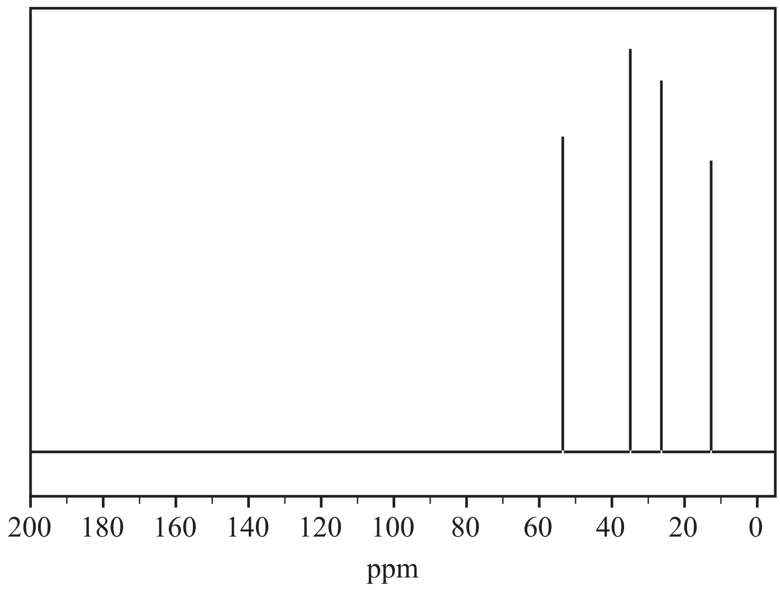
The chemist finds that Molecule L reacts with hydrogen bromide, HBr, to form two products that are isomers. The ^{13}C NMR spectra of the two products are shown below.

Product 1



Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

Product 2



Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

c. **i.** Draw the structural formula of Molecule L. 1 mark

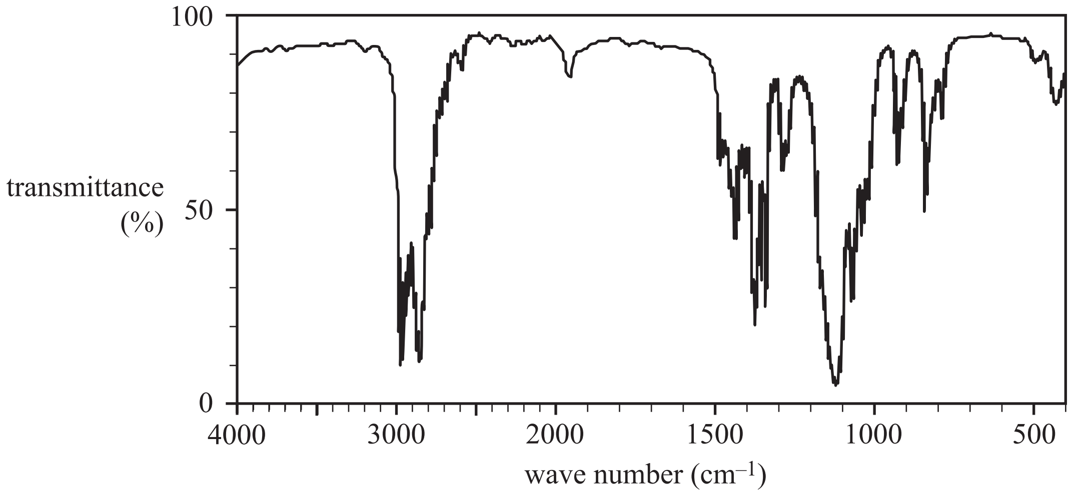
ii. The information for the ^{1}H NMR spectrum of Product 1 is shown below.

Chemical shift	Relative peak area
3.4	2
1.8	2
1.5	2
0.9	3

Use this information to give the IUPAC systematic name for Product 1. 1 mark

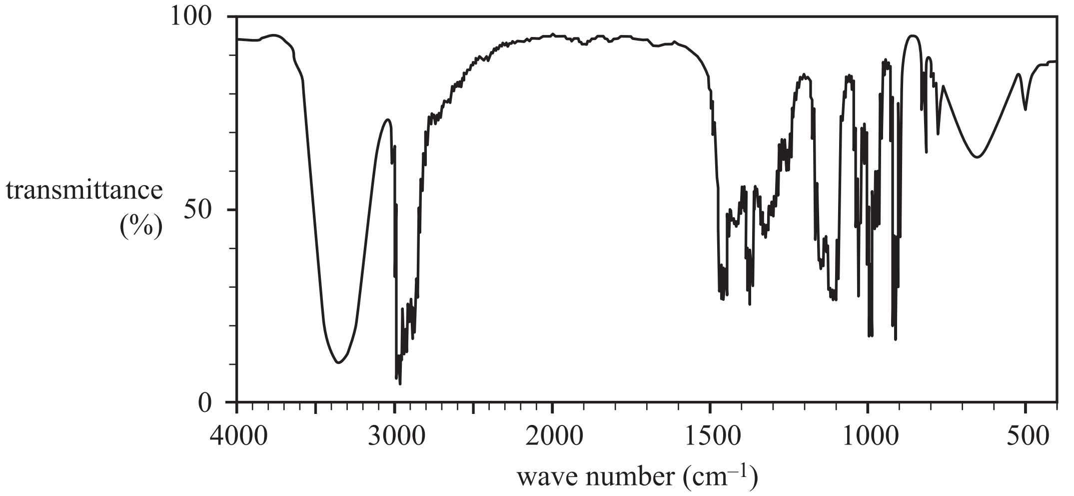
d. Molecule L undergoes a hydration reaction. Spectrum X, Spectrum Y and Spectrum Z are the spectra for three different compounds.

Spectrum X



Data: SDBS Web, <https://sdbs.db.aist.go.jp>, National Institute of Advanced Industrial Science and Technology

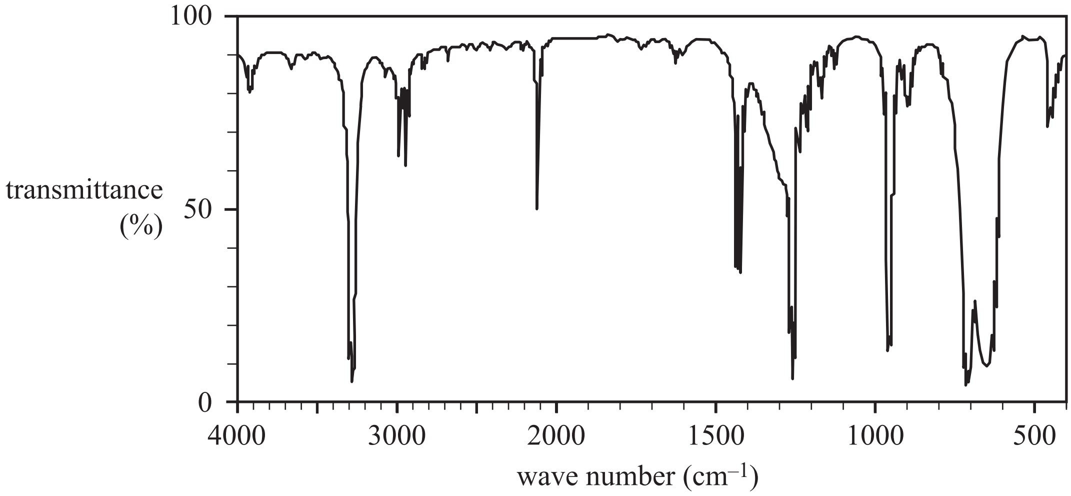
Spectrum Y



Data: SDBS Web, <https://sdbs.db.aist.go.jp>, National Institute of Advanced Industrial Science and Technology

DO NOT WRITE IN THIS AREA

Spectrum Z



Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

Which of the spectra shown on pages 32 and 33 is consistent with a product of the hydration reaction for Molecule L? Your answer should make reference to the information in the spectra. 2 marks

Question 9 (12 marks)

For an experimental extended research investigation, a group of students performed experiments over three days to investigate the stability of ascorbic acid, $C_6H_8O_6$, in freshly prepared pineapple juice.

Part of the report submitted by one of the students is shown below.

Research

The concentration of $C_6H_8O_6$ in pineapple juice is determined by performing a titration with a standardised iodine, I_2, solution. The $C_6H_8O_6$ reacts with I_2 to form dehydroascorbic acid, $C_6H_6O_6$, and iodide ions, I^-. This reaction is represented by the balanced equation

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow 2I^-(aq) + C_6H_6O_6(aq) + 2H^+(aq)$$

Aim

To investigate the effect of temperature on the stability of $C_6H_8O_6$ in freshly prepared pineapple juice over three days

Method

Part A – Preparation of fresh pineapple juice

1. Cut a whole pineapple into 2 cm pieces.
2. Blend the pineapple pieces using a food processor for two minutes and filter the mixture through a microfibre cloth.

Part B – Determination of the concentration of $C_6H_8O_6$ at the beginning of the investigation

1. Accurately weigh 5.00 g of the filtered pineapple juice in a clean 100 mL conical flask.
2. Add 25 mL of deionised water and 10 drops of 0.5% starch indicator solution to the conical flask.
3. Shake the flask to ensure that the contents are mixed.
4. Fill a clean burette with a 2.50×10^{-4} M solution of I_2. Record the initial volume.
5. Carefully titrate the pineapple juice solution with the iodine solution until a permanent blue colour is observed. Record the final volume and calculate the titre.
6. Repeat steps 1–5 until concordant titres are obtained.

Part C – Set-up of pineapple juice samples, days 1–3

1. Wrap the outside of nine clean 100 mL conical flasks with aluminium foil.
2. Label three of the conical flasks '5 °C', label another three of the conical flasks '15 °C' and label the remaining three conical flasks '30 °C'.
3. Accurately weigh 40.00 g of filtered pineapple juice into each of the nine conical flasks.
4. Seal each conical flask with silicone film.
5. Place each labelled set of three conical flasks into the appropriate 5 °C, 15 °C and 30 °C incubator.
6. At the end of each day, remove a conical flask for that day from each incubator and determine the concentration of $C_6H_8O_6$ in each of the three removed flasks, as prescribed in steps 1 to 6 in Part B.

Conclusion

An increase in temperature decreases the stability of ascorbic acid in freshly prepared pineapple juice.

DO NOT WRITE IN THIS AREA

a. Identify a controlled variable used in this investigation. 1 mark

b. Identify the dependent variable in this investigation. How was the dependent variable measured? 2 marks

c. Consider the method performed by the student to determine the concentration of ascorbic acid in this investigation. Identify **one** step in the stated method that improves the reliability of the results. 1 mark

Part B – Results

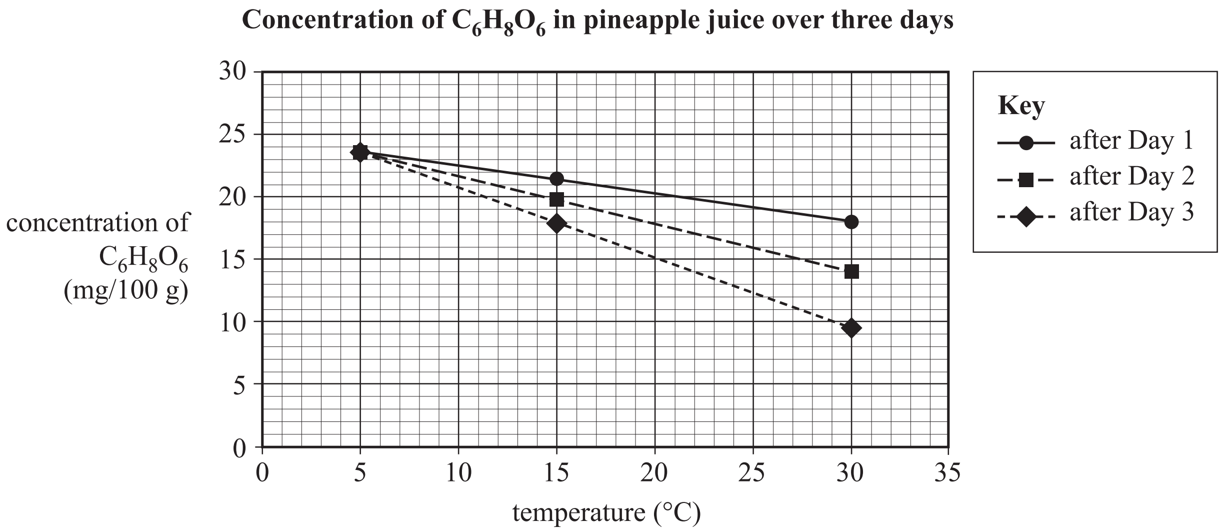
concentration of I_2 = 2.50×10^{-4} M

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Mass of pineapple juice (g)	5.00	5.00	5.00	5.00	5.00
Volume of titre of I_2 (mL)	28.65	27.27	27.12	27.35	27.32

d. Using the results above, calculate the concentration, in milligrams per 100 g, of ascorbic acid in fresh pineapple juice at the beginning of the investigation. 3 marks

e. Comment on the precision of the titration results. Give your reasoning. 2 marks

The student represented the results of the investigation on a graph, as shown below.



f. How does the graph support the student's conclusion? 1 mark

____

____

g. What is the most appropriate way of graphing the results to achieve the aim of this investigation? Give your reasoning. 2 marks

____

____

____

____

____

Question 10 (8 marks)

Implantable glucose fuel cells can be designed for use inside the body. Implantable glucose fuel cells use the glucose and oxygen dissolved in the bloodstream as fuel.

In an alkaline glucose fuel cell, glucose, $C_6H_{12}O_6$, reacts to form gluconic acid, $C_6H_{12}O_7$, according to the equation

$$C_6H_{12}O_6(aq) + 2OH^-(aq) \rightarrow C_6H_{12}O_7(aq) + H_2O(l) + 2e^-$$

Due to copyright restrictions, this material is not supplied.

Source: adapted from O Santiago, E Navarro, MA Raso and TJ Leo, 'Review of implantable and external abiotically catalysed glucose fuel cells and the differences between their membranes and catalysts', *Applied Energy*, 179, 2016, pp. 497–522

The excerpt above outlines some of the benefits and difficulties associated with glucose fuel cells. Answer the following questions using the information provided and your knowledge of chemistry.

a. Discuss the efficiency of the utilisation of the chemical energy of glucose in implantable glucose fuel cells. Compare this to the efficiency of the utilisation of chemical energy in the metabolism of glucose in the human body and in external glucose fuel cells. Include any relevant chemical equations in your answer. 3 marks

b. **i.** Compare the design of implantable glucose fuel cells with the design of external glucose fuel cells. 2 marks

ii. Identify **one** design challenge, based on the chemistry that occurs in an alkaline glucose fuel cell, that is unique to implantable glucose fuel cells and suggest how this challenge could be overcome. 3 marks

END OF QUESTION AND ANSWER BOOK

VICTORIAN CURRICULUM
AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2021

CHEMISTRY

Written examination

DATA BOOK

Instructions

This data book is provided for your reference.
A question and answer book is provided with this data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Table of contents

1. Periodic table of the elements

atomic number relative atomic mass	**79** **Au** 197.0 gold	symbol of element name of element

1 **H** 1.0 hydrogen																	**2** **He** 4.0 helium
3 **Li** 6.9 lithium	**4** **Be** 9.0 beryllium											**5** **B** 10.8 boron	**6** **C** 12.0 carbon	**7** **N** 14.0 nitrogen	**8** **O** 16.0 oxygen	**9** **F** 19.0 fluorine	**10** **Ne** 20.2 neon
11 **Na** 23.0 sodium	**12** **Mg** 24.3 magnesium											**13** **Al** 27.0 aluminium	**14** **Si** 28.1 silicon	**15** **P** 31.0 phosphorus	**16** **S** 32.1 sulfur	**17** **Cl** 35.5 chlorine	**18** **Ar** 39.9 argon
19 **K** 39.1 potassium	**20** **Ca** 40.1 calcium	**21** **Sc** 45.0 scandium	**22** **Ti** 47.9 titanium	**23** **V** 50.9 vanadium	**24** **Cr** 52.0 chromium	**25** **Mn** 54.9 manganese	**26** **Fe** 55.8 iron	**27** **Co** 58.9 cobalt	**28** **Ni** 58.7 nickel	**29** **Cu** 63.5 copper	**30** **Zn** 65.4 zinc	**31** **Ga** 69.7 gallium	**32** **Ge** 72.6 germanium	**33** **As** 74.9 arsenic	**34** **Se** 79.0 selenium	**35** **Br** 79.9 bromine	**36** **Kr** 83.8 krypton
37 **Rb** 85.5 rubidium	**38** **Sr** 87.6 strontium	**39** **Y** 88.9 yttrium	**40** **Zr** 91.2 zirconium	**41** **Nb** 92.9 niobium	**42** **Mo** 96.0 molybdenum	**43** **Tc** (98) technetium	**44** **Ru** 101.1 ruthenium	**45** **Rh** 102.9 rhodium	**46** **Pd** 106.4 palladium	**47** **Ag** 107.9 silver	**48** **Cd** 112.4 cadmium	**49** **In** 114.8 indium	**50** **Sn** 118.7 tin	**51** **Sb** 121.8 antimony	**52** **Te** 127.6 tellurium	**53** **I** 126.9 iodine	**54** **Xe** 131.3 xenon
55 **Cs** 132.9 caesium	**56** **Ba** 137.3 barium	**57–71** lanthanoids	**72** **Hf** 178.5 hafnium	**73** **Ta** 180.9 tantalum	**74** **W** 183.8 tungsten	**75** **Re** 186.2 rhenium	**76** **Os** 190.2 osmium	**77** **Ir** 192.2 iridium	**78** **Pt** 195.1 platinum	**79** **Au** 197.0 gold	**80** **Hg** 200.6 mercury	**81** **Tl** 204.4 thallium	**82** **Pb** 207.2 lead	**83** **Bi** 209.0 bismuth	**84** **Po** (210) polonium	**85** **At** (210) astatine	**86** **Rn** (222) radon
87 **Fr** (223) francium	**88** **Ra** (226) radium	**89–103** actinoids	**104** **Rf** (261) rutherfordium	**105** **Db** (262) dubnium	**106** **Sg** (266) seaborgium	**107** **Bh** (264) bohrium	**108** **Hs** (267) hassium	**109** **Mt** (268) meitnerium	**110** **Ds** (271) darmstadtium	**111** **Rg** (272) roentgenium	**112** **Cn** (285) copernicium	**113** **Nh** (280) nihonium	**114** **Fl** (289) flerovium	**115** **Mc** (289) moscovium	**116** **Lv** (292) livermorium	**117** **Ts** (294) tennessine	**118** **Og** (294) oganesson

57 **La** 138.9 lanthanum	**58** **Ce** 140.1 cerium	**59** **Pr** 140.9 praseodymium	**60** **Nd** 144.2 neodymium	**61** **Pm** (145) promethium	**62** **Sm** 150.4 samarium	**63** **Eu** 152.0 europium	**64** **Gd** 157.3 gadolinium	**65** **Tb** 158.9 terbium	**66** **Dy** 162.5 dysprosium	**67** **Ho** 164.9 holmium	**68** **Er** 167.3 erbium	**69** **Tm** 168.9 thulium	**70** **Yb** 173.1 ytterbium	**71** **Lu** 175.0 lutetium

89 **Ac** (227) actinium	**90** **Th** 232.0 thorium	**91** **Pa** 231.0 protactinium	**92** **U** 238.0 uranium	**93** **Np** (237) neptunium	**94** **Pu** (244) plutonium	**95** **Am** (243) americium	**96** **Cm** (247) curium	**97** **Bk** (247) berkelium	**98** **Cf** (251) californium	**99** **Es** (252) einsteinium	**100** **Fm** (257) fermium	**101** **Md** (258) mendelevium	**102** **No** (259) nobelium	**103** **Lr** (262) lawrencium

The value in brackets indicates the mass number of the longest-lived isotope.

2. Electrochemical series

Reaction	Standard electrode potential (E^0) in volts at 25 °C
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(1)$	+1.23
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$	+0.68
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	–0.25
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	–0.28
$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$	–0.40
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	–1.18
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	–1.66
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	–2.37
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$	–2.87
$K^+(aq) + e^- \rightleftharpoons K(s)$	–2.93
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	–3.04

3. Chemical relationships

Name	Formula
number of moles of a substance	$n = \dfrac{m}{M}$; $n = cV$; $n = \dfrac{V}{V_m}$
universal gas equation	$pV = nRT$
calibration factor (CF) for bomb calorimetry	$\mathrm{CF} = \dfrac{VIt}{\Delta T}$
heat energy released in the combustion of a fuel	$q = mc\Delta T$
enthalpy of combustion	$\Delta H = \dfrac{q}{n}$
electric charge	$Q = It$
number of moles of electrons	$n(e^-) = \dfrac{Q}{F}$
% atom economy	$\dfrac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times \dfrac{100}{1}$
% yield	$\dfrac{\text{actual yield}}{\text{theoretical yield}} \times \dfrac{100}{1}$

4. Physical constants and standard values

Name	Symbol	Value
Avogadro constant	N_A or L	6.02×10^{23} mol^{-1}
charge on one electron (elementary charge)	e	-1.60×10^{-19} C
Faraday constant	F	96 500 C mol^{-1}
molar gas constant	R	8.31 J mol^{-1} K^{-1}
molar volume of an ideal gas at SLC (25 °C and 100 kPa)	V_m	24.8 L mol^{-1}
specific heat capacity of water	c	4.18 kJ kg^{-1} K^{-1} or 4.18 J g^{-1} K^{-1}
density of water at 25 °C	d	997 kg m^{-3} or 0.997 g mL^{-1}

5. Unit conversions

Measured value	Conversion
0 °C	273 K
100 kPa	750 mm Hg or 0.987 atm
1 litre (L)	1 dm^3 or 1 × 10^{-3} m^3 or 1 × 10^3 cm^3 or 1 × 10^3 mL

6. Metric (including SI) prefixes

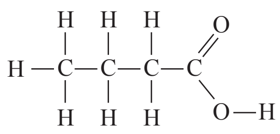
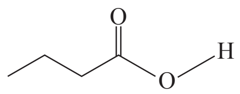
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

7. Acid-base indicators

Name	pH range	Colour change from lower pH to higher pH in range
thymol blue (1st change)	1.2–2.8	red → yellow
methyl orange	3.1–4.4	red → yellow
bromophenol blue	3.0–4.6	yellow → blue
methyl red	4.4–6.2	red → yellow
bromothymol blue	6.0–7.6	yellow → blue
phenol red	6.8–8.4	yellow → red
thymol blue (2nd change)	8.0–9.6	yellow → blue
phenolphthalein	8.3–10.0	colourless → pink

8. Representations of organic molecules

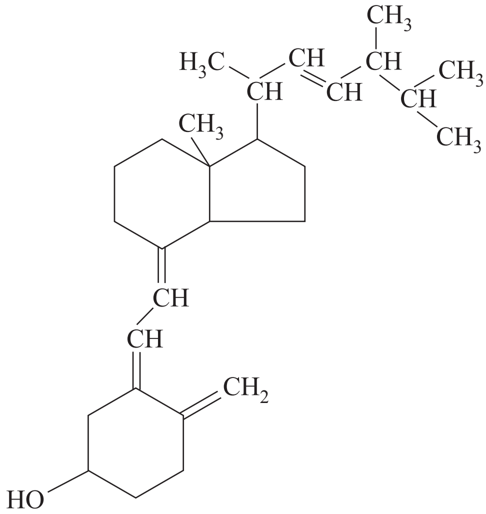
The following table shows different representations of organic molecules, using butanoic acid as an example.

Formula	Representation
molecular formula	$C_4H_8O_2$
structural formula	
semi-structural (condensed) formula	$CH_3CH_2CH_2COOH$ or $CH_3(CH_2)_2COOH$
skeletal structure	

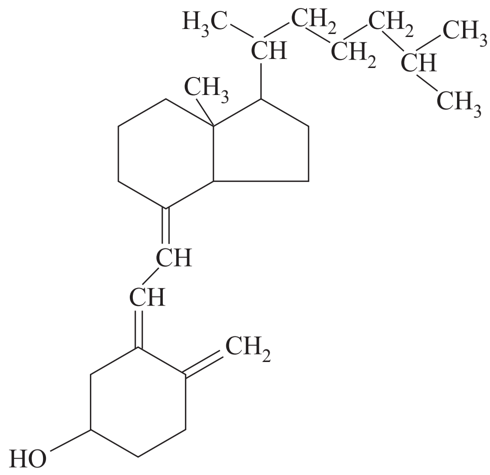
9. Formulas of some fatty acids

Name	Formula	Semi-structural formula
lauric	$C_{11}H_{23}COOH$	$CH_3(CH_2)_{10}COOH$
myristic	$C_{13}H_{27}COOH$	$CH_3(CH_2)_{12}COOH$
palmitic	$C_{15}H_{31}COOH$	$CH_3(CH_2)_{14}COOH$
palmitoleic	$C_{15}H_{29}COOH$	$CH_3(CH_2)_4CH_2CH{=}CHCH_2\ (CH_2)_5CH_2COOH$
stearic	$C_{17}H_{35}COOH$	$CH_3(CH_2)_{16}COOH$
oleic	$C_{17}H_{33}COOH$	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
linoleic	$C_{17}H_{31}COOH$	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$
linolenic	$C_{17}H_{29}COOH$	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$
arachidic	$C_{19}H_{39}COOH$	$CH_3(CH_2)_{17}CH_2COOH$
arachidonic	$C_{19}H_{31}COOH$	$CH_3(CH_2)_4(CH{=}CHCH_2)_3CH{=}CH(CH_2)_3COOH$

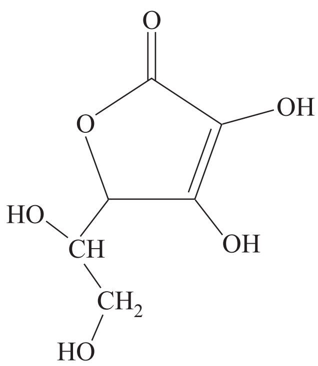
10. Formulas of some biomolecules



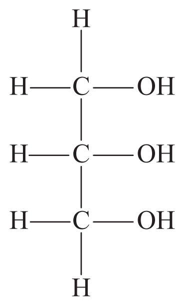
vitamin D_2 (ergocalciferol)



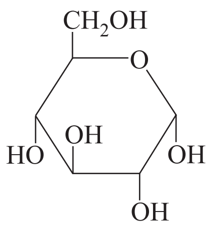
vitamin D_3 (cholecalciferol)



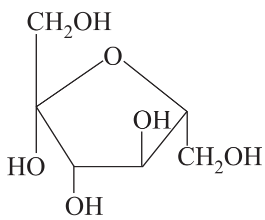
vitamin C (ascorbic acid)



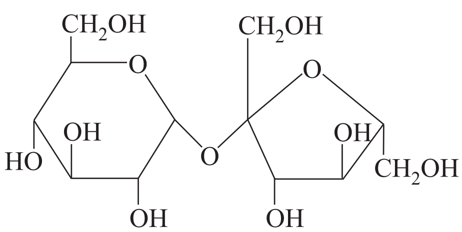
glycerol



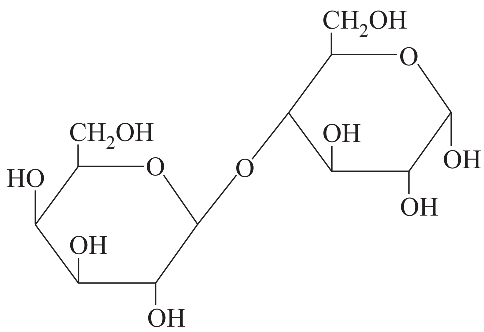
α-glucose



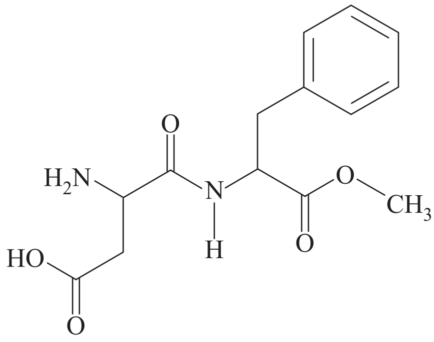
β-fructose



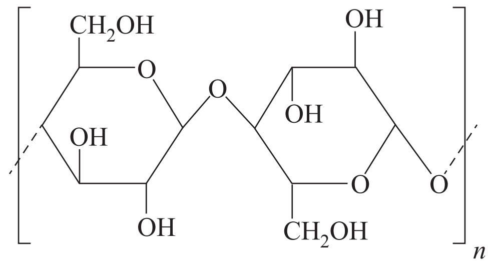
sucrose



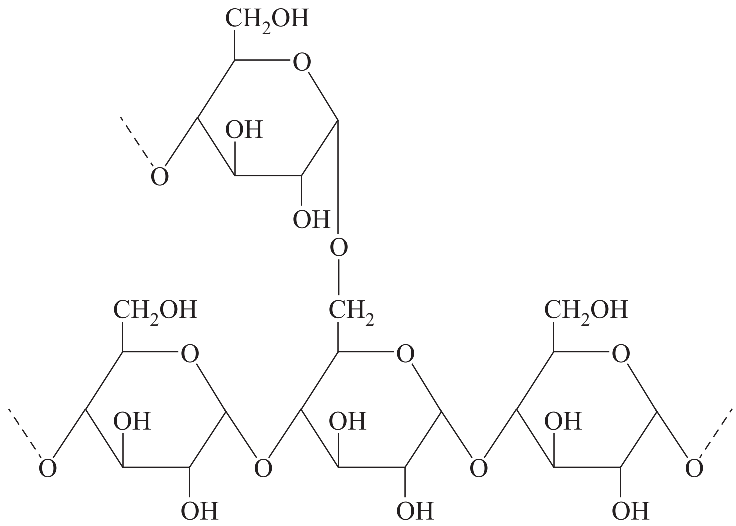
α-lactose



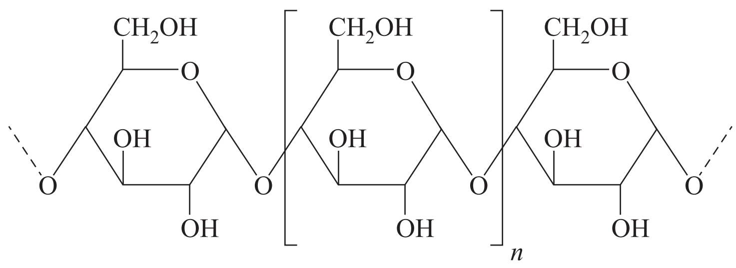
aspartame



cellulose



amylopectin (starch)



amylose (starch)

11. Heats of combustion of common fuels

The heats of combustion in the following table are calculated at SLC (25 °C and 100 kPa) with combustion products being CO_2 and H_2O. Heat of combustion may be defined as the heat energy released when a specified amount of a substance burns completely in oxygen and is, therefore, reported as a positive value, indicating a magnitude. Enthalpy of combustion, ΔH, for the substances in this table would be reported as negative values, indicating the exothermic nature of the combustion reaction.

Fuel	Formula	State	Heat of combustion (kJ g^{-1})	Molar heat of combustion (kJ mol^{-1})
hydrogen	H_2	gas	141	282
methane	CH_4	gas	55.6	890
ethane	C_2H_6	gas	51.9	1560
propane	C_3H_8	gas	50.5	2220
butane	C_4H_{10}	gas	49.7	2880
octane	C_8H_{18}	liquid	47.9	5460
ethyne (acetylene)	C_2H_2	gas	49.9	1300
methanol	CH_3OH	liquid	22.7	726
ethanol	C_2H_5OH	liquid	29.6	1360

12. Heats of combustion of common blended fuels

Blended fuels are mixtures of compounds with different mixture ratios and, hence, determination of a generic molar enthalpy of combustion is not realistic. The values provided in the following table are typical values for heats of combustion at SLC (25 °C and 100 kPa) with combustion products being CO_2 and H_2O. Values for heats of combustion will vary depending on the source and composition of the fuel.

Fuel	State	Heat of combustion (kJ g^{-1})
kerosene	liquid	46.2
diesel	liquid	45.0
natural gas	gas	54.0

13. Energy content of food groups

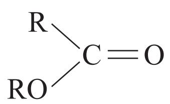
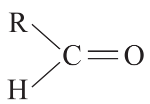
Food	Heat of combustion (kJ g^{-1})
fats and oils	37
protein	17
carbohydrate	16

14. Characteristic ranges for infra-red absorption

Bond	Wave number (cm^{-1})	Bond	Wave number (cm^{-1})
C–Cl (chloroalkanes)	600–800	C=O (ketones)	1680–1850
C–O (alcohols, esters, ethers)	1050–1410	C=O (esters)	1720–1840
C=C (alkenes)	1620–1680	C–H (alkanes, alkenes, arenes)	2850–3090
C=O (amides)	1630–1680	O–H (acids)	2500–3500
C=O (aldehydes)	1660–1745	O–H (alcohols)	3200–3600
C=O (acids)	1680–1740	N–H (amines and amides)	3300–3500

15. ^{13}C NMR data

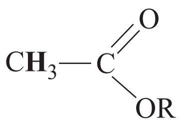
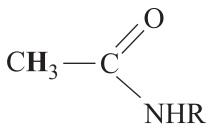
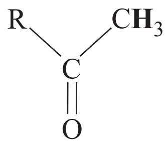
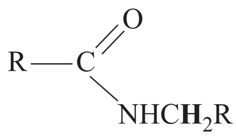
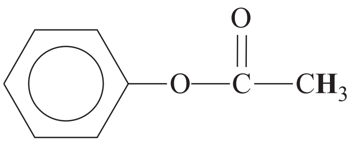
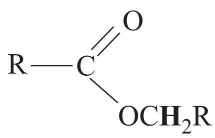
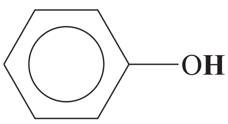
Typical ^{13}C shift values relative to TMS = 0
These can differ slightly in different solvents.

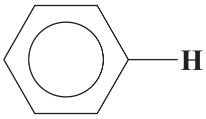
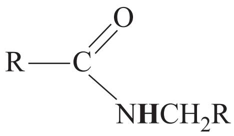
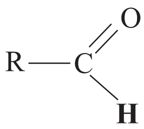
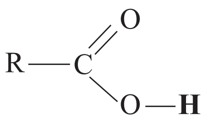
Type of carbon	Chemical shift (ppm)
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$, $R_3C–NR$	35–70
$R–CH_2–OH$	50–90
$RC{\equiv}CR$	75–95
$R_2C{=}CR_2$	110–150
RCOOH	160–185
	165–175
	190–200
$R_2C{=}O$	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

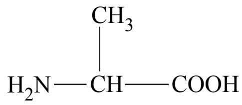
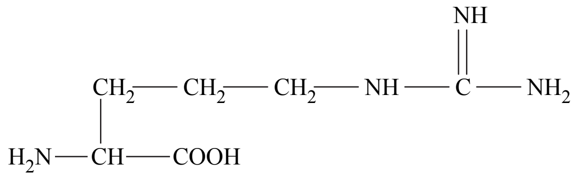
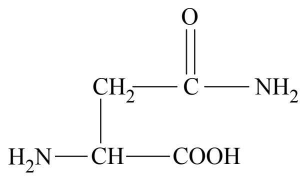
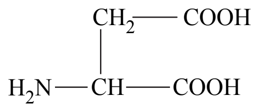
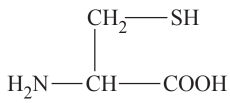
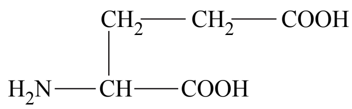
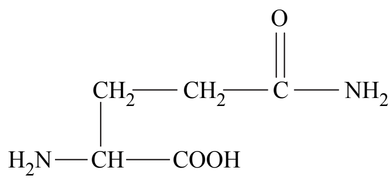
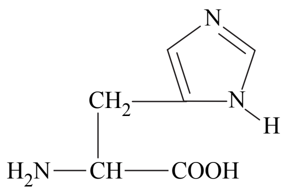
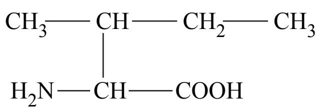
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

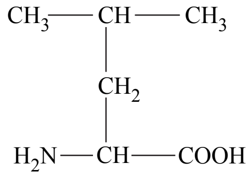
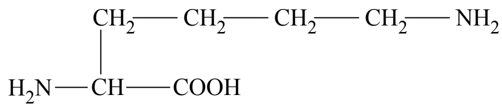
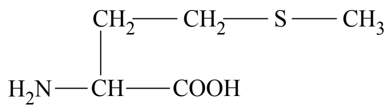
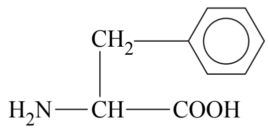
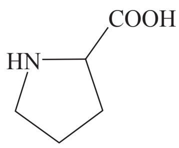
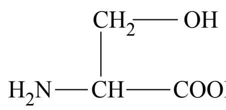
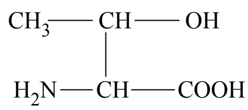
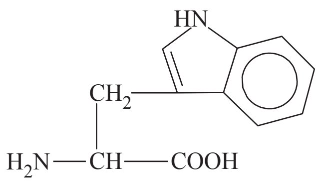
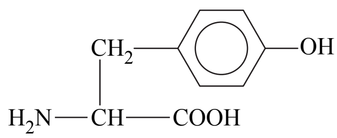
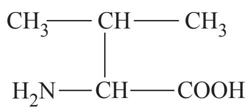
Type of proton	Chemical shift (ppm)
$R{-}C\mathbf{H}_3$	0.9–1.0
$R{-}C\mathbf{H}_2{-}R$	1.3–1.4
$RCH{=}CH{-}C\mathbf{H}_3$	1.6–1.9
$R_3{-}C\mathbf{H}$	1.5
 or 	2.0
	2.1–2.7
$R{-}C\mathbf{H}_2{-}X$ (X = F, Cl, Br or I)	3.0–4.5
$R{-}C\mathbf{H}_2{-}OH$, $R_2{-}C\mathbf{H}{-}OH$	3.3–4.5
	3.2
$R{-}O{-}C\mathbf{H}_3$ or $R{-}O{-}C\mathbf{H}_2R$	3.3–3.7
	2.3
	3.7–4.8
$R{-}O{-}\mathbf{H}$	1–6 (varies considerably under different conditions)
$R{-}N\mathbf{H}_2$	1–5
$RHC{=}C\mathbf{H}R$	4.5–7.0
	4.0–12.0

Type of proton	Chemical shift (ppm)
	6.9–9.0
	8.1
	9.4–10.0
	9.0–13.0

17. 2-amino acids (*α*-amino acids)

The table below provides simplified structures to enable the drawing of zwitterions, the identification of products of protein hydrolysis and the drawing of structures involving condensation polymerisation of amino acid monomers.

Name	Symbol	Structure
alanine	Ala	
arginine	Arg	
asparagine	Asn	
aspartic acid	Asp	
cysteine	Cys	
glutamic acid	Glu	
glutamine	Gln	
glycine	Gly	H_2N-CH_2-COOH
histidine	His	
isoleucine	Ile	

Name	Symbol	Structure
leucine	Leu	
lysine	Lys	
methionine	Met	
phenylalanine	Phe	
proline	Pro	
serine	Ser	
threonine	Thr	
tryptophan	Trp	
tyrosine	Tyr	
valine	Val	

END OF DATA BOOK