VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2022

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

Letter

STUDENT NUMBER

CHEMISTRY

Written examination

Tuesday 8 November 2022

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 11.45 am (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	9	9	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 37 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
Scientific posters communicate the findings of scientific investigations.
Which section of a scientific poster should explain the reason for undertaking an investigation?
A. discussion
B. conclusion
C. introduction
D. methodology

Question 2
A fuel undergoes combustion to heat water.
Which of the following descriptions of the energy and enthalpy of combustion, ΔH, of the reaction is correct?

	Energy	ΔH
A.	absorbed by the water	negative
B.	released by the water	negative
C.	absorbed by the water	positive
D.	released by the water	positive

Question 3
The correct equation for the incomplete combustion of ethanol is

A. $C_2H_5OH(l) + \frac{1}{2}O_2(g) \rightarrow 2CO(g) + 3H_2(g)$

B. $C_2H_5OH(l) + \frac{3}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2(g)$

C. $C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO(g) + 3H_2O(l)$

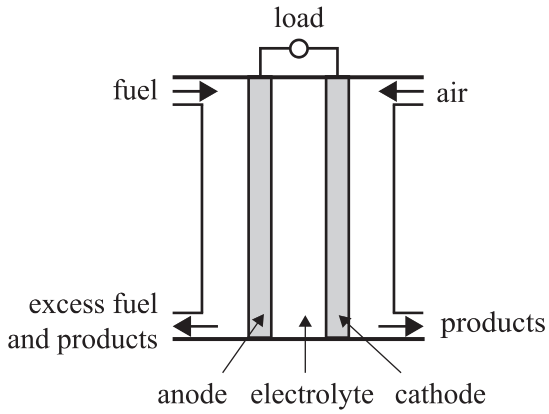
D. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

DO NOT WRITE IN THIS AREA

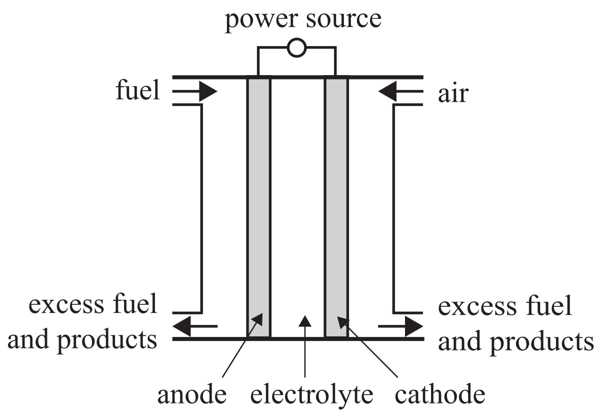
Question 4

Which one of the following diagrams shows the common design features of a fuel cell?

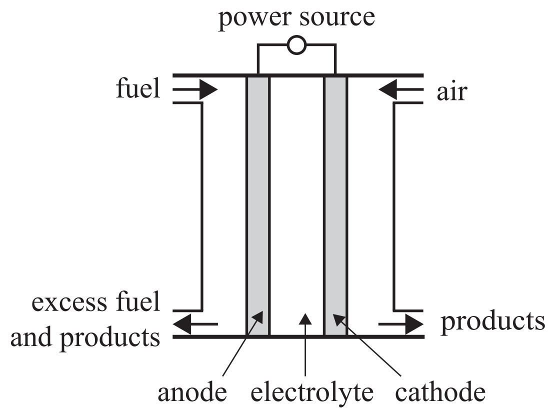
A.



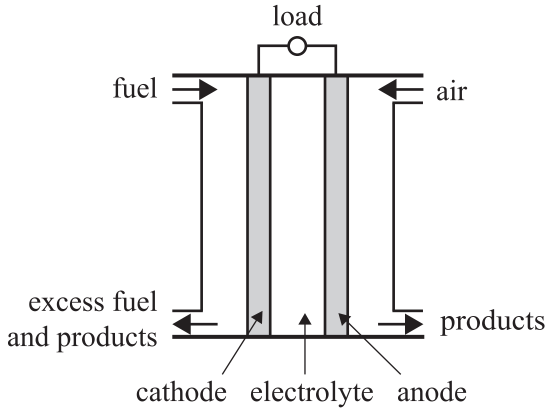
B.



C.



D.



Question 5

Scientists often repeat trials of an experiment using the same experimental method and the same equipment.

Which one attribute of experimental data will be improved when there is an increase in the number of times that a trial is repeated?

A. bias
B. validity
C. accuracy
D. reliability

Question 6

Galvanic cells and fuel cells have

A. the same energy transformations and both are reversible.
B. the same energy transformations and both produce heat.
C. different energy transformations but galvanic cells produce electricity.
D. different energy transformations but fuel cells use porous electrodes.

Question 7

In a protein, hydrogen bonding takes place during the formation of the

A. secondary, tertiary and quaternary structures only.

B. primary, secondary and tertiary structures only.

C. tertiary and quaternary structures only.

D. primary and tertiary structures only.

Question 8

Unlike direct combustion of fuel, fuel cells

A. can be recharged.

B. do not produce greenhouse gases.

C. require electrical energy to overcome the activation energy barrier.

D. do not have direct contact between the oxidising and reducing agents.

Question 9

Consider the following four fatty acids: arachidonic, linoleic, linolenic and stearic.

Which one of the following statements related to these four fatty acids is correct?

A. Both linoleic acid and stearic acid are omega-3 fatty acids.

B. Linolenic acid is an omega-3 fatty acid and contains three C=C double bonds.

C. Arachidonic acid is an omega-6 fatty acid and contains three C=C double bonds.

D. Both linoleic acid and arachidonic acid are omega-6 fatty acids and contain one C=C double bond.

Question 10

The molar mass of glycerol, $C_3H_8O_3$, is 92.0 g mol^{-1}.

The production of 65.0 g of $C_3H_8O_3$ from tripalmitin, $C_{51}H_{98}O_6$, which is a triglyceride

A. requires 12.7 g of water.

B. requires 38.2 g of water.

C. produces 12.7 g of water.

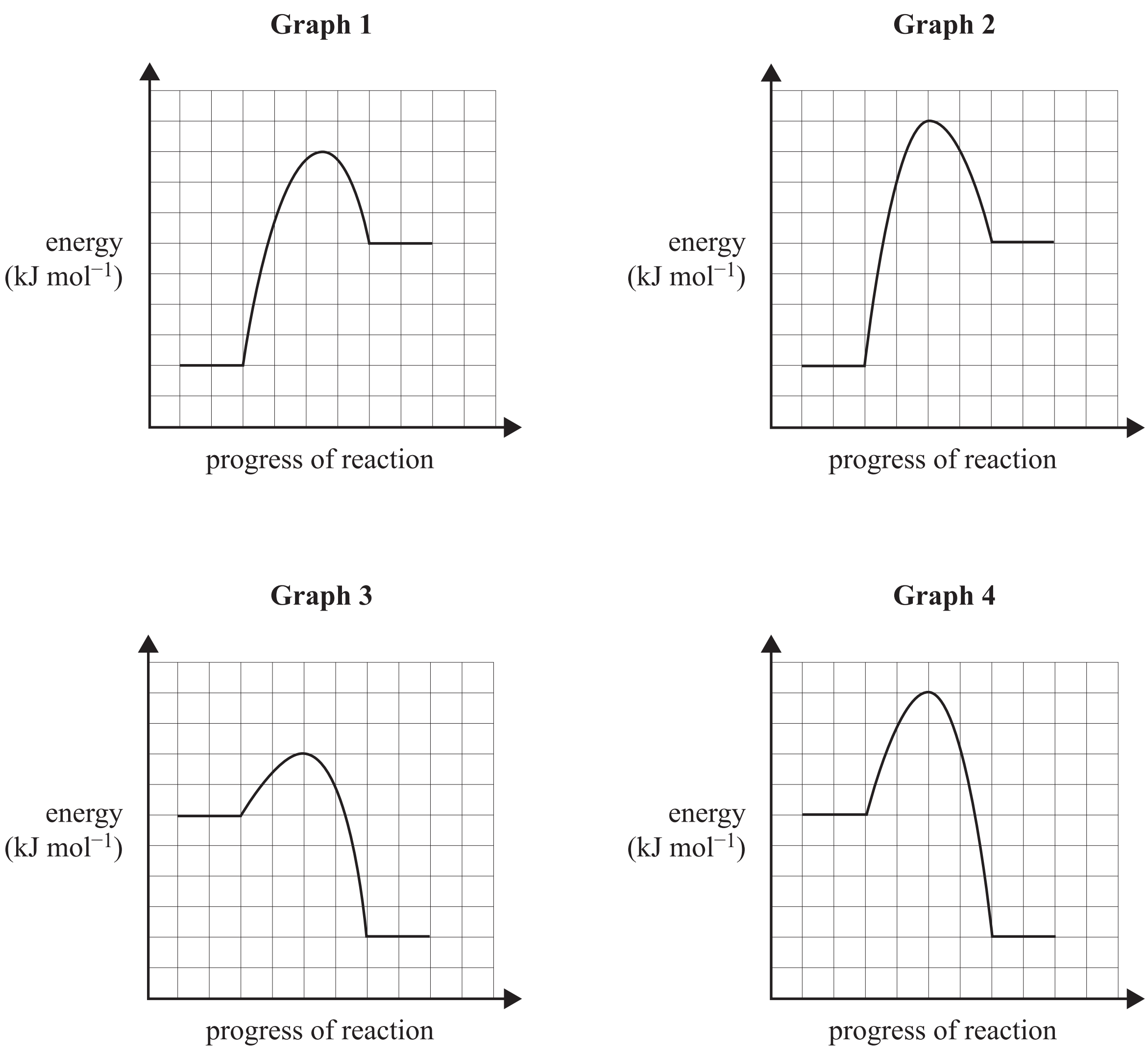
D. produces 38.2 g of water.

Question 11

The graphs shown below are energy profiles for the following reaction.

$$A + B \rightleftharpoons C \qquad \Delta H < 0$$

The graphs represent the forward reaction, with and without a catalyst, and the reverse reaction, with and without a catalyst. All graphs are drawn to the same scale.



Which energy profile represents the reverse reaction without a catalyst?

A. Graph 1

B. Graph 2

C. Graph 3

D. Graph 4

DO NOT WRITE IN THIS AREA

Question 12

Enzymes are commonly not effective in acidic conditions because acids

A. change the charges on the enzymes.

B. react with the enzymes to form zwitterions.

C. esterify the enzymes into smaller molecules.

D. react with the carboxyl groups on the enzymes' amino acid residues.

Question 13

An electrolysis cell is set up with inert platinum, Pt, electrodes.

Which one of the following will produce a gas at the cathode when undergoing electrolysis in the cell?

A. potassium iodide, $KI(aq)$

B. sodium chloride, $NaCl(l)$

C. lead bromide, $PbBr_2(l)$

D. copper sulfate, $CuSO_4(aq)$

Question 14

The discharge reaction in a vanadium redox battery is represented by the following equation.

$$VO_2^+(aq) + 2H^+(aq) + V^{2+}(aq) \rightarrow V^{3+}(aq) + VO^{2+}(aq) + H_2O(l)$$

When the vanadium redox battery is recharging

A. H^+ is the reducing agent.

B. H_2O is the oxidising agent.

C. VO^{2+} is the reducing agent.

D. VO_2^+ is the oxidising agent.

Question 15

The molar heat of combustion of glucose, $C_6H_{12}O_6$, in the cellular respiration equation is 2805 kJ mol^{-1} at standard laboratory conditions (SLC).

Which one of the following statements about cellular respiration is correct?

A. Cellular respiration is an endothermic reaction.

B. The products of cellular respiration are carbon and carbon dioxide.

C. Cellular respiration is a redox reaction because $C_6H_{12}O_6$ accepts electrons from oxygen.

D. When one mole of oxygen is consumed in the reaction, 467.5 kJ of energy is released.

Question 16

The correct IUPAC name for $CH_3CH_2CHClCHOHCH_3$ is

A. 3-chloropentan-4-ol

B. 3-chloropentan-2-ol

C. 2,3-chloro-pentanol

D. 3,2-chloro-pentanol

Question 17

Which one of the following statements about sweeteners is correct?

A. Glucose and fructose are optical isomers.

B. Glucose reacts as a monomer in the body.

C. 2 mol of glucose has the same energy content as 1 mol of sucrose.

D. Sucrose has an energy output almost 200 times the energy output of aspartame.

Question 18

A student wants to investigate a galvanic cell consisting of Sn^{4+}/Sn^{2+} and Ag^{+}/Ag half-cells.

Which one of the following combinations of electrodes and solutions will produce an operational galvanic cell?

	Sn^{4+}/Sn^{2+} half-cell		Ag^{+}/Ag half-cell	
	Electrode	**Solution(s)**	**Electrode**	**Solution**
A.	Sn	1 M $Sn(NO_3)_2$	graphite	1 M $AgNO_3$
B.	Sn	1 M $Sn(NO_3)_4$, 1 M $Sn(NO_3)_2$	graphite	1 M $AgNO_3$
C.	graphite	1 M $Sn(NO_3)_4$, 1 M $Sn(NO_3)_2$	Ag	1 M $AgNO_3$
D.	graphite	1 M $Sn(NO_3)_4$	Ag	1 M $AgNO_3$

Question 19

Which one of the following chemical compounds contains a chiral carbon centre?

A. glycine

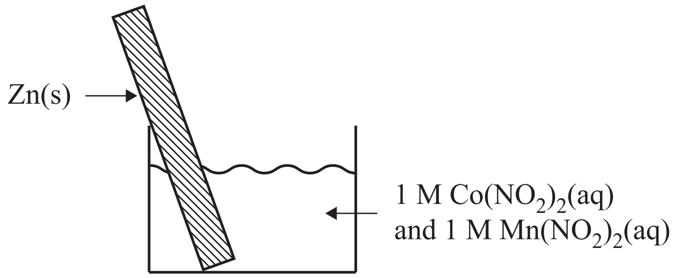
B. glycerol

C. butan-2-o1

D. 1,1-dichloropropane

Question 20

The equipment below was set up by a student.



Which one of the following is correct?

A. In the beaker, the reaction between Zn(s) and Co^{2+}(aq) produces 0.48 V.

B. In the beaker, chemical energy stored in the reactants is converted to heat energy.

C. In the beaker, the concentration of ions increases because Zn(s) loses $2e^-$.

D. In the beaker, a voltage of greater than 0.42 V must be applied to Zn(s) so that it reacts with Mn^{2+}(aq).

Question 21

Consider the following statements about enzymes and coenzymes:

I Enzymes and coenzymes are not changed during the catalytic reaction.

II All catalytic reactions require a coenzyme to proceed.

III Coenzymes can lose or gain electrons during a catalytic reaction.

IV Coenzymes are inorganic molecules derived from vitamins.

V Coenzymes can change the binding properties of an enzyme to allow a reaction to occur.

Which of the statements above are correct?

A. I, IV and V only

B. II and IV only

C. I, II and III only

D. III and V only

Use the following information to answer Questions 22 and 23.

Lithium ion batteries are used in a range of electronic devices, including mobile phones. The discharge reaction for this type of battery is

$$LiC_6(s) + CoO_2(s) \rightarrow C_6(s) + LiCoO_2(s)$$

Question 22

Which of the following is correct about lithium ion batteries?

	During discharge, reduction occurs at the	During recharge, reduction occurs at the
A.	anode	cathode
B.	cathode	anode
C.	anode	anode
D.	cathode	cathode

Question 23

Which one of the following statements about lithium ion batteries is correct?

A. During recharge, $LiCoO_2$ is formed at the negative electrode.

B. During discharge, Li^+ ions move towards the positive electrode.

C. Raising the battery temperature increases the rate of reaction, thereby increasing the battery life.

D. The battery operates as an electrolytic cell during discharge and as a galvanic cell during recharge.

Question 24

A high-performance liquid chromatography (HPLC) instrument is set up with a polar mobile phase and a non-polar stationary phase. Three amino acids – leucine, Leu, alanine, Ala, and asparagine, Asn – are added to the mobile phase and are run through the HPLC.

The order of the retention times, from shortest to longest, for these three amino acids is

A. Leu, Ala, Asn

B. Leu, Asn, Ala

C. Ala, Asn, Leu

D. Asn, Ala, Leu

DO NOT WRITE IN THIS AREA

Question 25

Consider the following statements regarding biodiesel and petrodiesel:

I Petrodiesel is more hygroscopic than biodiesel.

II Biodiesel forms crystals at a higher temperature than petrodiesel.

III Biodiesel and petrodiesel are derived from plants and animals.

IV The combustion of biodiesel releases less sulfur dioxide than petrodiesel.

Which of the statements above are correct?

A. I and IV only

B. III and IV only

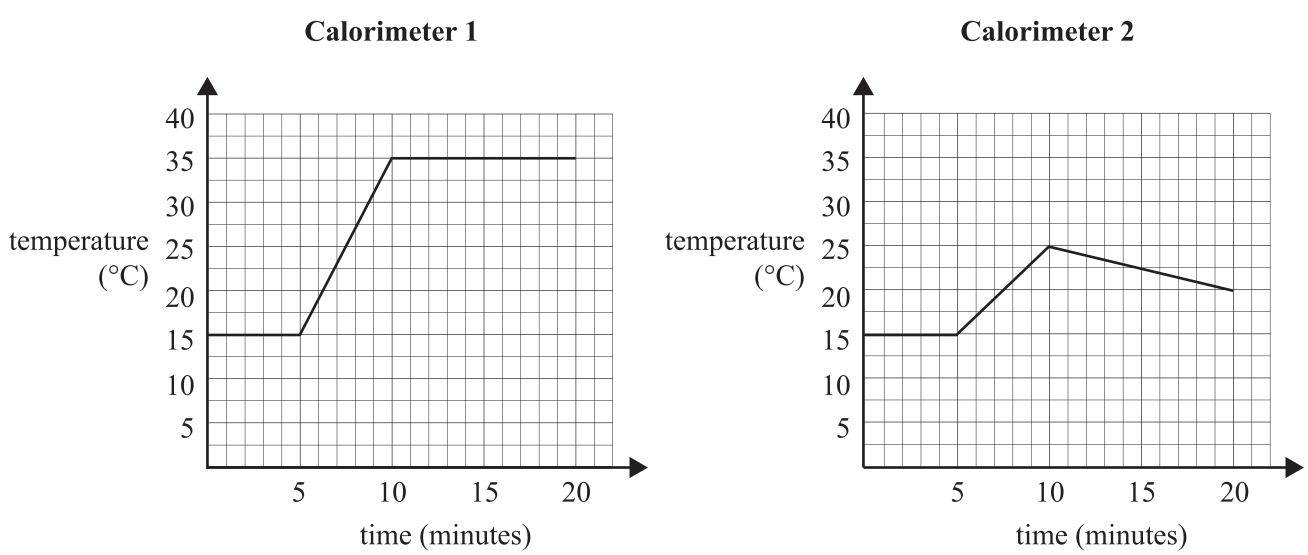
C. I, II and III only

D. II, III and IV only

Question 26

Calorimeter 1 and Calorimeter 2 were each electrically calibrated. The same current, voltage and time were used to calibrate each calorimeter.

A reaction was undertaken in Calorimeter 1 and Calorimeter 2. The same amount and type of each reactant was used in both calorimeters. The following temperature versus time graphs were produced for the reaction in each calorimeter.



Which one of the following statements is correct?

A. Only Calorimeter 1 can be used to calculate ΔH.

B. Calorimeter 2 has better insulation than Calorimeter 1.

C. The calibration factor for Calorimeter 2 is higher than the calibration factor for Calorimeter 1.

D. During the calibration, the temperature increase of Calorimeter 2 was greater than the temperature increase of Calorimeter 1.

DO NOT WRITE IN THIS AREA

Question 27

Which one of the following reactions has the highest atom economy in the production of an organic molecule?

A. complete combustion of propyne, C_3H_4

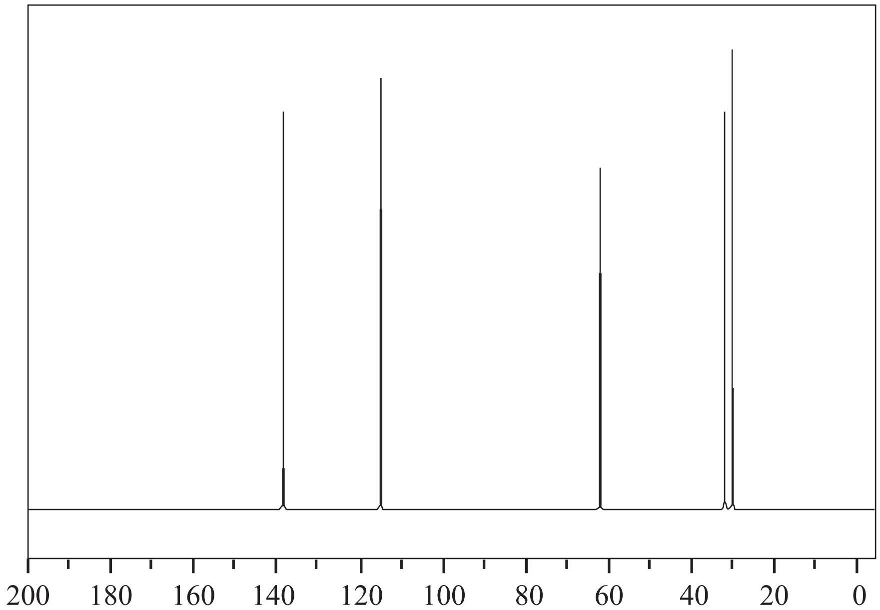
B. reaction of iodine, I_2, with propane, C_3H_8

C. reaction of bromine, Br_2, and propene, C_3H_6

D. formation of a dipeptide from alanine, $C_3H_7NO_2$

Question 28

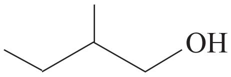
The ^{13}C NMR spectrum of an organic compound is shown below.



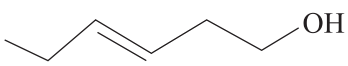
Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

The organic compound could be

A.

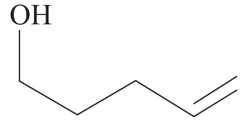


B.



C.

D.



Question 29

One mole of methane, CH_4, reacts with one mole of halogen, X_2. X can be fluorine, F, chlorine, Cl, or bromine, Br. The general equation for the reaction is given below.

$$CH_4(g) + X_2(g) \xrightarrow{\text{catalyst}} CH_3X(g) + HX(g) \qquad \Delta H < 0$$

Which one of the following statements is true?

A. The strength of the bonds from weakest to strongest is C–Br < C–Cl < C–F.

B. Since hydrogen has the smallest atomic radius, the C–H bond is the weakest bond.

C. The C–Br bond is stronger than the C–H bond because of the size of the bromine atom.

D. The C–Br, C–Cl and C–F bonds are equal in strength because Br, Cl and F are halogens.

DO NOT WRITE IN THIS AREA

Question 30

Consider the following half-equations, which are not in standard electrode potential order.

$$HCrO_4^-(aq) + 7H^+(aq) + 3e^- \rightleftharpoons Cr^{3+}(aq) + 4H_2O(l)$$

$$HBrO(aq) + H^+(aq) + e^- \rightleftharpoons \frac{1}{2}Br_2(aq) + H_2O(l)$$

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

$$BrO_3^-(aq) + 6H^+(aq) + 6e^- \rightleftharpoons Br^-(aq) + 3H_2O(l)$$

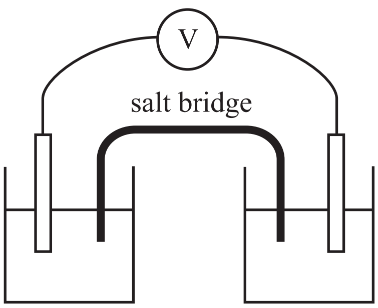
The following is also known:

- I_2 reacts with BrO_3^- and HBrO but not with $HCrO_4^-$.
- Br^- reacts with HBrO but not with IO_3^-.

Platinum electrodes were used in each half-cell.

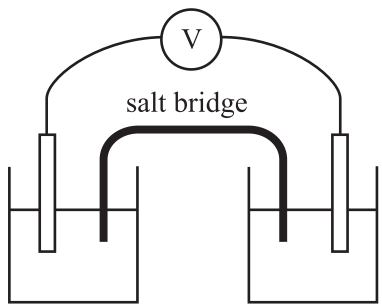
Which one of the following galvanic cells will produce the highest potential difference?

A.



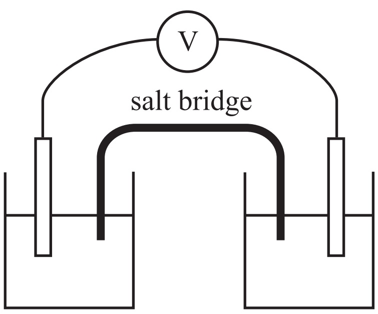
$HBrO(aq)/Br_2(aq)$ $HCrO_4^-(aq)/Cr^{3+}(aq)$

B.



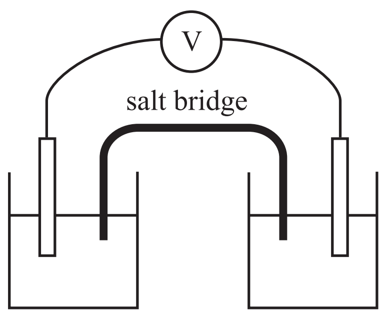
$HCrO_4^-(aq)/Cr^{3+}(aq)$ $BrO_3^-(aq)/Br^-(aq)$

C.



$BrO_3^-(aq)/Br^-(aq)$ $IO_3^-(aq)/I_2(aq)$

D.



$HBrO(aq)/Br_2(aq)$ $IO_3^-(aq)/I_2(aq)$

END OF SECTION A
TURN OVER

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.

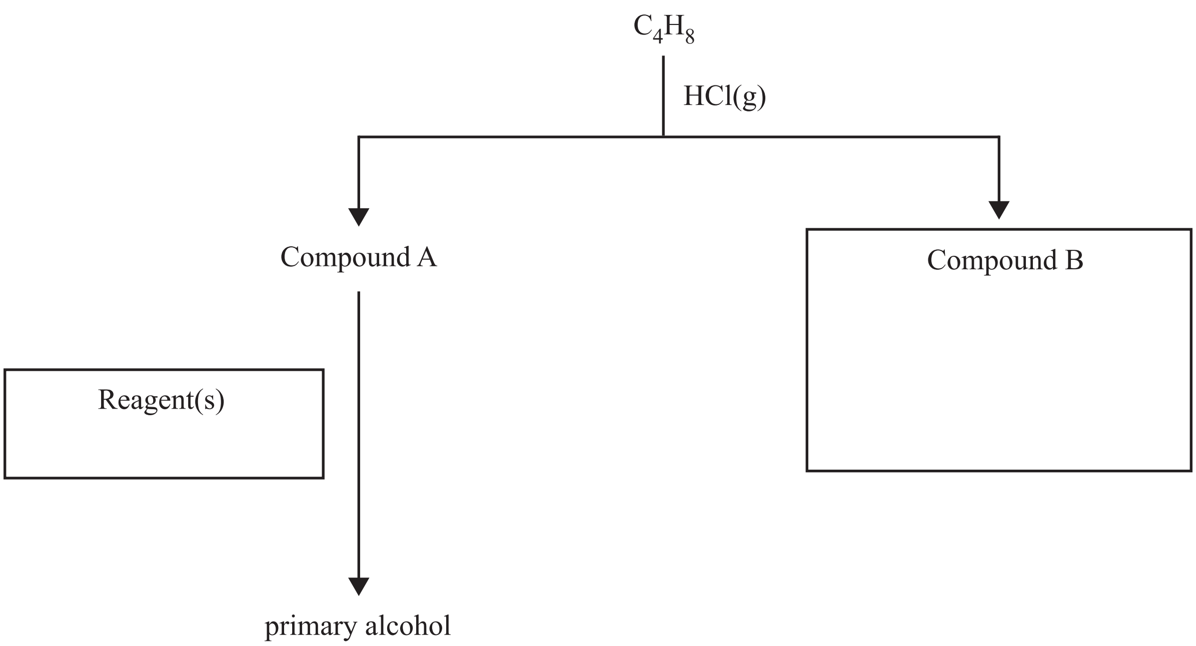
Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

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 (7 marks)

A reaction pathway to produce a primary alcohol is shown below.



C_4H_8 reacts with HCl(g) to form two unbranched isomers – Compound A and Compound B. Only Compound A can react to produce a primary alcohol.

a. Identify the type of reaction that converts C_4H_8 into Compound A. 1 mark

b. Write the semi-structural formula for Compound B in the box provided. 1 mark

c. State the reagent(s) required to convert Compound A into a primary alcohol in the box provided. 1 mark

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

d. Propan-1-ol can react with methanoic acid to produce an organic molecule.

i. Identify the catalyst for this reaction. 1 mark

___

ii. Write a balanced chemical equation for the reaction. 2 marks

___

___

iii. Write the systematic IUPAC name for the organic molecule produced. 1 mark

___

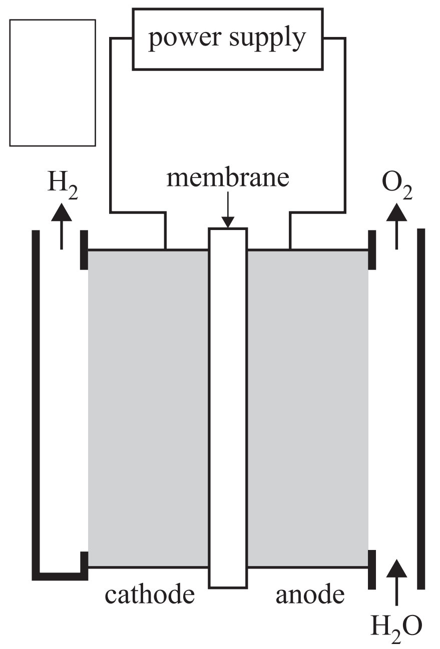
Question 2 (10 marks)

A coal-fired power station is used to generate electricity. Carbon dioxide, CO_2, gas is produced as part of the process.

a. Carbon capture and storage is one option being considered to reduce the amount of CO_2 released into the atmosphere. 5.17×10^4 mol of CO_2 is captured, cooled to 28.0 °C and stored in a sealed 20 000.0 L tank prior to transportation.

Calculate the pressure, in kilopascals, in the tank when it contains 5.17×10^4 mol of CO_2. 2 marks

b. Hydrogen, H_2, can be produced using electricity generated by renewable sources. A simplified diagram of an acidic electrolyser used to produce hydrogen is shown below.



DO NOT WRITE IN THIS AREA

i. Draw an arrow in the box provided on the diagram on page 16 to show the direction of flow of electrons through the wire. Justify your answer. 2 marks

ii. State **two** functions of the membrane. 2 marks

c. i. Write the overall equation for the reaction that takes place in the acidic electrolyser shown in the diagram on page 16 when it is operating at 80 °C. 1 mark

ii. How many moles of H_2 could be produced by the acidic electrolyser using 1625.0 A in 1.25 hours, assuming 100% efficiency? 3 marks

Question 3 (10 marks)

The following equation represents a gaseous reaction that takes place in a sealed container.

$$4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g) \qquad \Delta H < 0$$

a. **i.** Write the equilibrium expression for this reaction. 1 mark

ii. State the units for this equilibrium expression. 1 mark

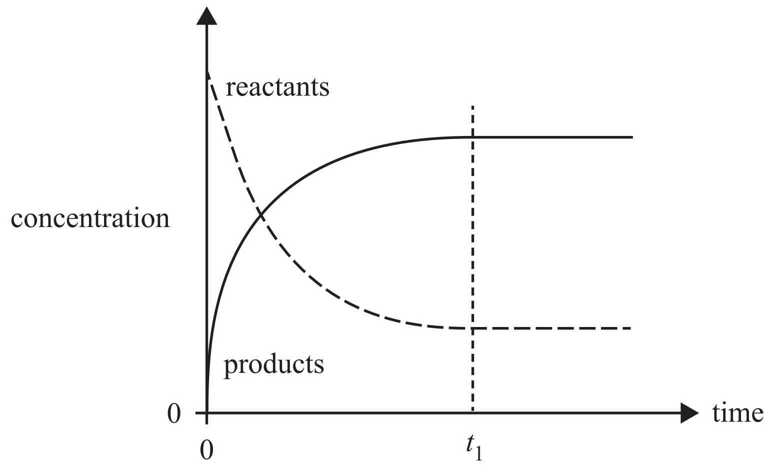
b. The temperature of the reaction system is increased and a new equilibrium is established.

i. How does the increase in the temperature affect the value of the equilibrium constant? Justify your answer. 4 marks

ii. Compare the rate of the forward reaction at the original equilibrium with the rate of the forward reaction at the new equilibrium after the increase in temperature. Explain the difference using collision theory. 3 marks

DO NOT WRITE IN THIS AREA

c. The concentration versus time graph for a different reaction is shown below. This reaction takes place with a catalyst. Equilibrium is reached at time t_1 .



The reaction is repeated without a catalyst.

On the concentration versus time graph above, sketch the expected curve for the products when the reaction is performed without a catalyst. 1 mark

Question 4 (12 marks)

a. Collagen is found in muscles, joints and skin. It is the most abundant protein in the body. Gelatin can be made by boiling animal collagen in water for many hours. Collagen and gelatin are made from the same 18 amino acids. Gelatin is more easily metabolised by the body than collagen.

i. Gelatin is produced when collagen is broken into smaller molecules.

Name the chemical reaction that produces gelatin from collagen. 1 mark

---

ii. Explain how consuming gelatin can be useful in increasing collagen levels in the body. In your answer, identify any chemical processes involved. 3 marks

---

---

b. i. Vitamin C is required for the production of collagen in the body.

What is the source of the vitamin C present in the body? Justify your answer. 2 marks

---

---

ii. Vitamin C is added to some foods to help prevent spoilage.

State how vitamin C can slow the rate of oxidative rancidity in some foods. 1 mark

---

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

c. Researchers have identified pathways that will enable production of the biofuel 2-methylpropan-1-ol from proteins. 2-methylpropan-1-ol can be used in petrol engines. 2-methylpropan-1-ol has a heat of combustion of 36.1 kJ g^{-1}.

i. Compare the energy content of octane and 2-methylpropan-1-ol. Explain the difference. 2 marks

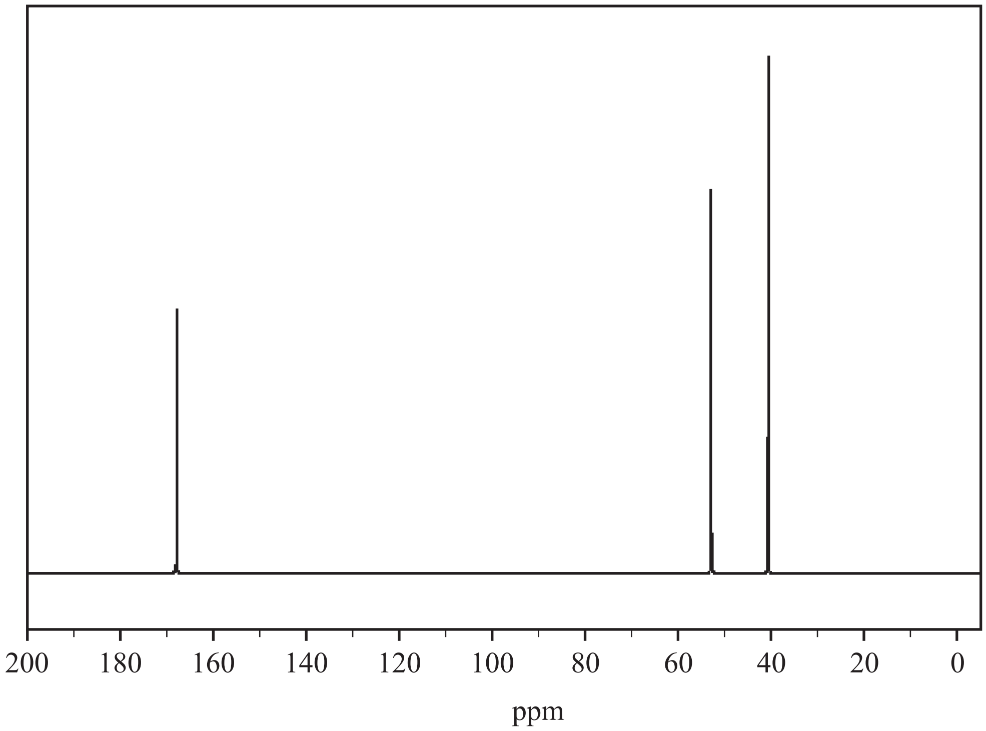
ii. A small fuel burner containing 2.36 g of 2-methylpropan-1-ol was placed directly underneath a beaker containing 500.0 g of water at standard laboratory conditions (SLC).

Calculate the maximum temperature that the water could reach if the contents of the fuel burner underwent complete combustion. 3 marks

Question 5 (10 marks)

A chemist uses spectroscopy to identify an unknown organic molecule, Molecule J, that contains chlorine.

The ^{13}C NMR spectrum of Molecule J is shown below.



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

a. There are two possible carbon environments that can produce the peak at 168 ppm.

Identify **one** of the two possible carbon environments that can produce the peak at 168 ppm. 1 mark

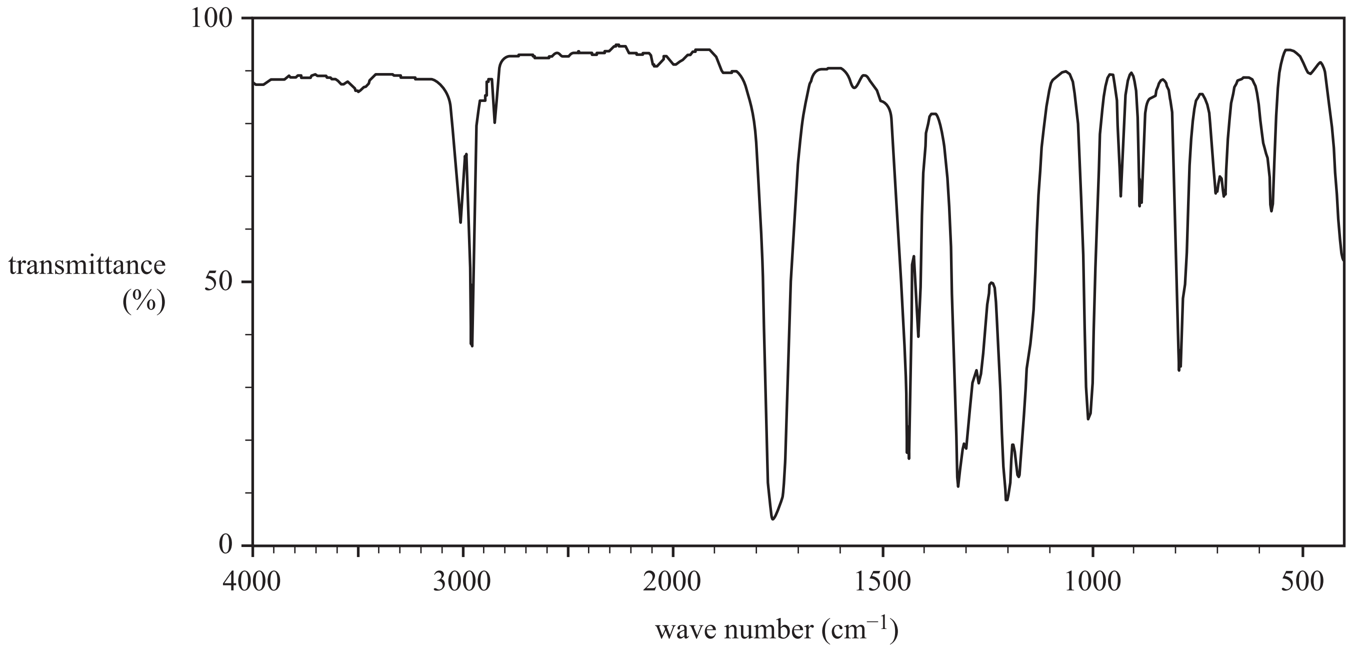
___

___

___

DO NOT WRITE IN THIS AREA

The infra-red (IR) spectrum of Molecule J is shown below.



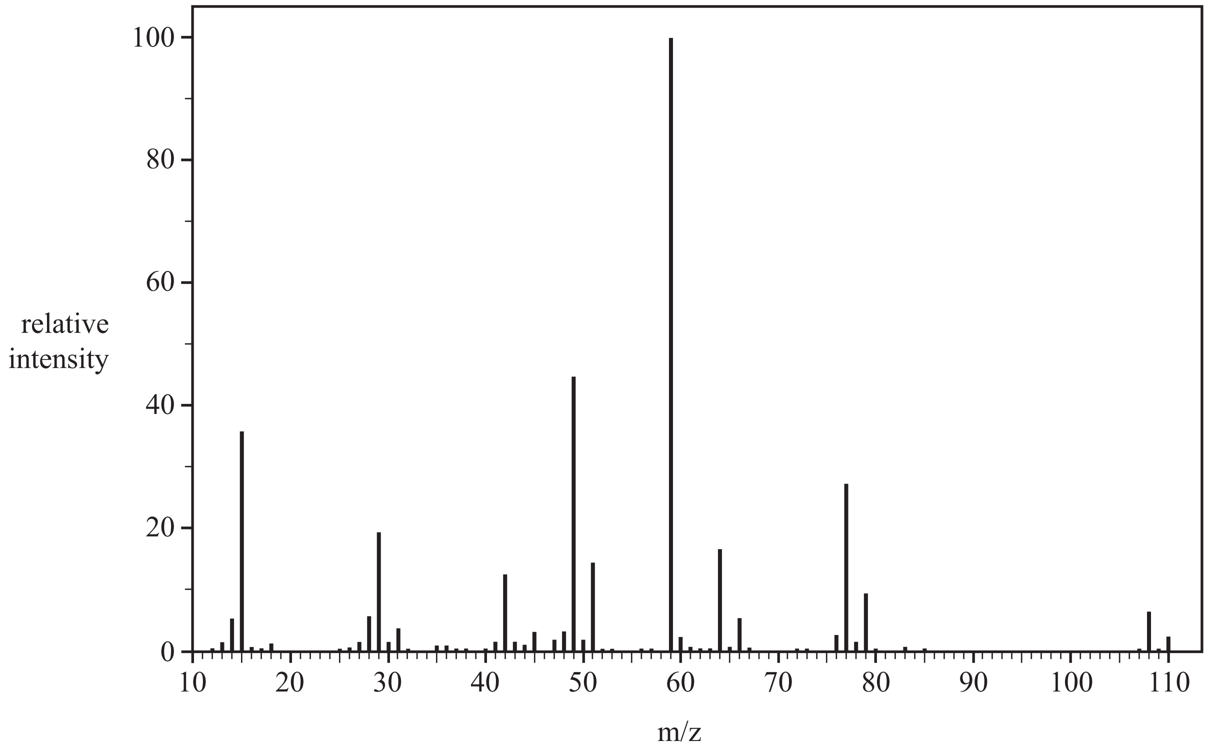
Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

b. Name the functional group that produces the peak at 168 ppm in the ^{13}C NMR spectrum on page 22, which is consistent with the IR spectrum shown above. Justify your answer with reference to the IR spectrum. 2 marks

____

____

The mass spectrum of Molecule J is shown below.



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

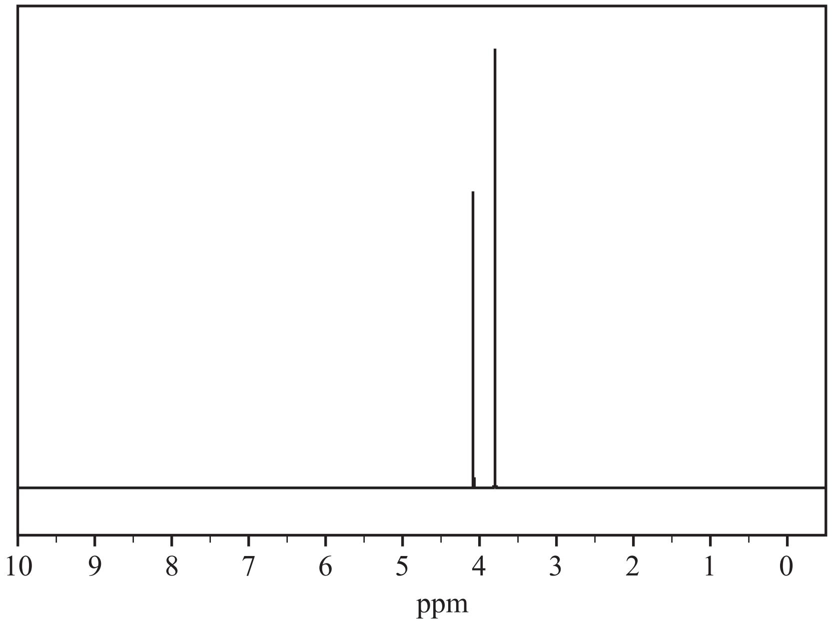
c. The molecular mass of Molecule J is 108.5

i. Explain the presence of the peak at 110 m/z. 1 mark

ii. Explain how the peaks in the mass spectrum relate to the molecular mass of Molecule J. 2 marks

DO NOT WRITE IN THIS AREA

The ^1H NMR spectrum of Molecule J is shown below.



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

d. The ^1H NMR spectrum consists of two singlet peaks.

What information does this give about the molecule? 2 marks

e. Draw a structural formula for Molecule J that is consistent with the information provided in **parts a.–d.** 2 marks

Question 6 (14 marks)

Corn makes up a large proportion of people's diet in some parts of the world.

Air-popped popcorn is made from whole corn kernels. The nutrition content of a particular type of air-popped popcorn is provided in Table 1.

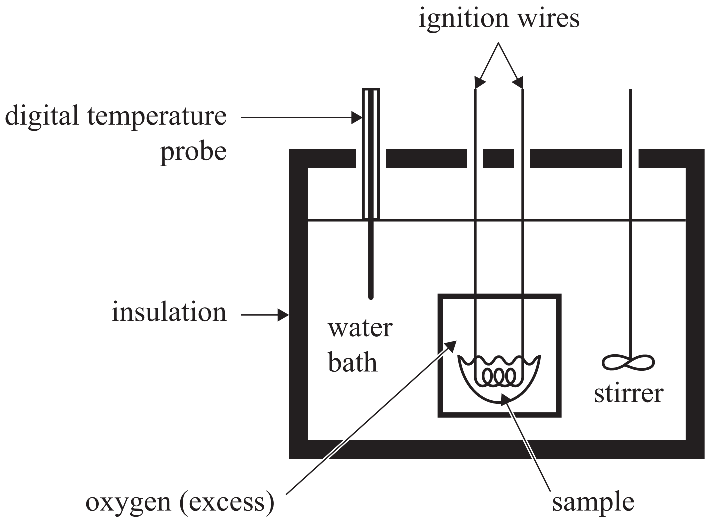
Table 1

	Average quantity per 100 g
Protein	10.7 g
Fat	5.0 g
Carbohydrates	78.7 g

a. Using the information provided in Table 1, calculate the energy content of air-popped popcorn in kilojoules per gram. 2 marks

DO NOT WRITE IN THIS AREA

The energy content of food can be determined experimentally using a bomb calorimeter similar to the one shown in the diagram below.



A 1.50 g sample of air-popped popcorn is placed in the bomb calorimeter. The initial temperature of the water is 22.2 °C and the final temperature is 25.7 °C. Assume that the air-popped popcorn is fully combusted. The calibration factor for the bomb calorimeter is 6.54 kJ $°C^{-1}$.

b. Using the calibration factor provided, calculate the energy released by the air-popped popcorn in kilojoules per gram. 2 marks

c. Assume that the calorimeter was accurately calibrated so that heat loss from the calorimeter was accounted for in the calibration factor.

State **two** factors that may contribute to a difference in the energy content that was calculated using the methods in **part a.** and **part b.** 2 marks

d. Carbohydrates are the main source of energy in corn. Chemical analysis shows that the carbohydrates in corn include amylose, amylopectin and cellulose.

Complete the table below by ranking these three carbohydrates from lowest to highest on the basis of their glycaemic index (GI). Explain your ranking for each. 3 marks

	Carbohydrate	Explanation
Lowest GI		
↓		
Highest GI		

e. When corn is picked it tastes sweet. Farmers recommend eating corn soon after picking. Once picked, the sweetness of the corn begins to decrease as glucose reacts to form starch. One way to help keep the sweetness for longer is to boil the corn for about two minutes and then freeze it.

Identify how boiling and then freezing corn helps to keep it sweet for longer. 2 marks

DO NOT WRITE IN THIS AREA

f. Corn oil is produced from corn and it is commonly used to deep-fry food. Table 2 shows the percentage fatty acid composition of a corn oil sample.

Table 2

Fatty acid	% composition
linolenic	1
stearic	3
palmitic	13
oleic	31
linoleic	52

Explain, with reference to its fatty acid composition, why corn oil is a liquid at SLC. 3 marks

Question 7 (8 marks)

Liquefied petroleum gas (LPG) is a type of fuel currently used in some cars.

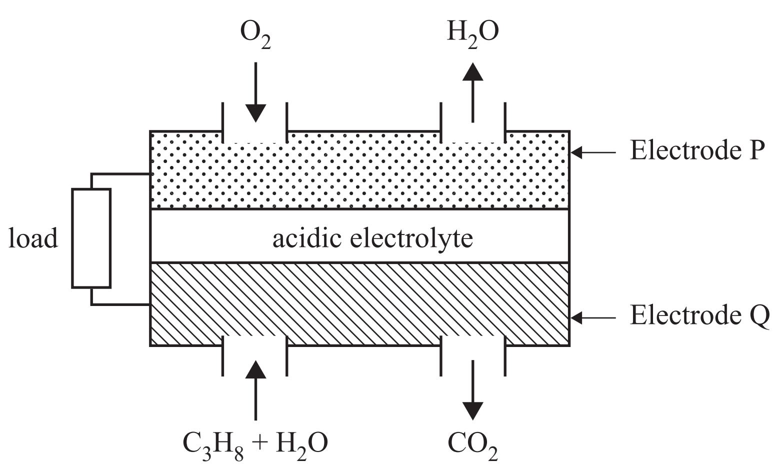
a. The main component of LPG is propane, C_3H_8, gas.

Write a thermochemical equation for the complete combustion of propane gas. 2 marks

b. An LPG-powered car uses 33.7 L of C_3H_8 to travel 270 km.

Calculate the amount of energy released when 33.7 L of C_3H_8 undergoes complete combustion. The density of C_3H_8 is 0.510 kg L^{-1}. 2 marks

A diagram of an acidic LPG fuel cell is shown below.



c. State the polarity of Electrode P. 1 mark

d. Write a balanced half-equation for the reaction at Electrode Q. 2 marks

DO NOT WRITE IN THIS AREA

e. Identify **one** difference between an acidic LPG fuel cell and a secondary cell during discharge. 1 mark

Question 8 (11 marks)

A student wrote the following partial experimental report.

Experimental report

Introduction

Wine is made from grapes containing sugars that are fermented by bacteria to produce ethanol. If a bottle of wine is left open, the ethanol will oxidise.

Aim

To investigate how the oxidation rate of ethanol in white wine from a freshly opened bottle is affected by the concentration of ethanol in the wine

Method

Open a bottle of white wine and prepare samples in four beakers according to Part I below. Then, determine the acidity of the samples in each beaker after two weeks using the method described in Part II.

Part I – Beaker preparation

Prepare four different beakers.

1. Put a clean and dry 250 mL beaker on a balance.
2. Zero the balance and add 250.00 g of wine to the beaker.
3. Remove the first beaker from the balance and put a second 250 mL beaker on the balance.
4. Zero the balance and add 245.00 g of wine to the beaker.
5. Zero the balance and add 5.00 g of pure ethanol to the beaker.
6. Repeat steps 4 and 5 with different amounts of wine and ethanol for Beaker 3 and Beaker 4, as shown in Table 1.

Table 1

	Mass of wine added to beaker (g)	Mass of pure ethanol added to beaker (g)	Total mass of contents (g)
Beaker 1	250.00	0.00	250.00
Beaker 2	245.00	5.00	250.00
Beaker 3	240.00	10.00	250.00
Beaker 4	235.00	15.00	250.00

7. Cover each of the four beakers with a watch glass and leave the covered beakers on a bench in an unused corner of the laboratory for two weeks.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Experimental report – continued

Part II – Acid-base titration

1. Rinse a clean and dry burette with a freshly standardised solution of 0.0100 M sodium hydroxide, NaOH.
2. Fill the burette with more of the freshly standardised solution of NaOH.
3. Flush about 5 mL of the NaOH through the burette and into a waste beaker to remove any air bubbles.
4. Rinse a clean conical flask with distilled water.
5. Rinse a 25.00 mL pipette using a small amount of the contents of Beaker 1.
6. Use the rinsed pipette to transfer 25.00 mL of the contents of Beaker 1 to the rinsed conical flask.
7. Add two drops of phenolphthalein indicator to the conical flask.
8. Note the initial volume reading on the burette.
9. Slowly add the NaOH from the burette to the conical flask, swirling to mix. As soon as the colour permanently changes, stop adding NaOH and note the final volume reading on the burette.
10. Calculate the titre.
11. Repeat steps 4 to 10 to obtain three concordant titres for Beaker 1. Refill the burette as necessary.
12. Repeat steps 2 to 11 for Beaker 2, Beaker 3 and Beaker 4.

a. State how the precision of the experimental data will be affected by the acid-base titration method specified in Part II. 1 mark

Immediately after the bottle was opened, an experienced and qualified laboratory technician analysed a sample of the wine and found that:

- the wine contained 8.12% m/m ethanol
- the concentration of acid in the sample was 9.45×10^{-4} M (assuming a monoprotic acid).

b. Use the laboratory technician's results and the information given in Table 1 on page 32 to calculate the initial ethanol concentration of the ethanol–wine mixture in Beaker 2 in % m/m. 3 marks

c. What is the independent variable in the student's investigation? 1 mark

d. At Step 5 of Part II on page 33, the student mistakenly rinsed the pipette with distilled water instead of a small amount of the contents of the beaker.

Explain how this change would affect the student's calculated value for the concentration of a monoprotic acid in the sample. 2 marks

e. State why analysing the acidity of the wine in beakers 1, 2, 3 and 4 can be related to the oxidation of ethanol in the wine in each beaker. 1 mark

The student obtained the following results.

Table 2

	Titre 1 (mL)	Titre 2 (mL)	Titre 3 (mL)	Titre 4 (mL)	Titre 5 (mL)	Titre 6 (mL)
Beaker 1	23.65	24.54	24.64	24.59		
Beaker 2	21.32	24.55	22.25	21.25	21.30	
Beaker 3	3.55	2.60	4.45	2.65	2.58	
Beaker 4	1.80	2.45	2.75	2.65	2.85	2.72

f. **i.** Write a conclusion relating to the oxidation rate of ethanol, which is consistent with the student's results in Table 2. 1 mark

____

____

ii. Discuss your conclusion in relation to the white wine tested in this experiment. In your answer, make **two** points relating to **one or both** of the following:

- the limitations of your conclusion
- an explanation for the student's findings

2 marks

____

____

____

____

____

Question 9 (8 marks)

> Flashpoint measurements of various types are used as one measure of the flammability of liquid materials … Many manufacturing processes involve flammable chemicals; therefore, flashpoints and flammability limits are essential to maximise safety in process design and operational procedures.

Source: M Vidal, WJ Rogers, JC Holste and MS Mannan, 'A review of estimation methods for flash points and flammability limits', American Institute of Chemical Engineers (AIChE), 30 March 2004, <https://doi.org/10.1002/prs.10004>

a. Describe and explain the variation in flashpoint between organic molecules. In your answer:

- define 'flashpoint'
- refer to the influence of structure and bonding on flashpoint.

References to specific values of flashpoints and to safety are **not** required. 4 marks

b. In 1859, the Scottish physicist James Clerk Maxwell developed a kinetic theory of gases. He determined the distribution of the velocities of gas molecules, which were later, in 1871, generalised to a distribution of the energies of gas molecules by the Austrian physicist Ludwig Boltzmann.

The reaction between ethene and hydrogen gas is very slow at SLC. When the same reaction is performed at SLC in the presence of a platinum catalyst, the reaction occurs more quickly.

Use the Maxwell-Boltzmann distribution curve to explain the difference between the rate of reaction of ethene and hydrogen gas with and without the platinum catalyst. In your answer:

- explain the Maxwell-Boltzmann distribution curve
- refer to activation energy.

A graph may assist your answer but is **not** essential. 4 marks

END OF QUESTION AND ANSWER BOOK

VICTORIA
State
Government

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2022

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

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

Key:

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

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

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

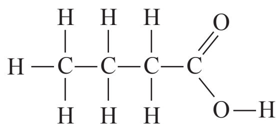
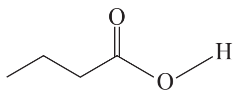
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

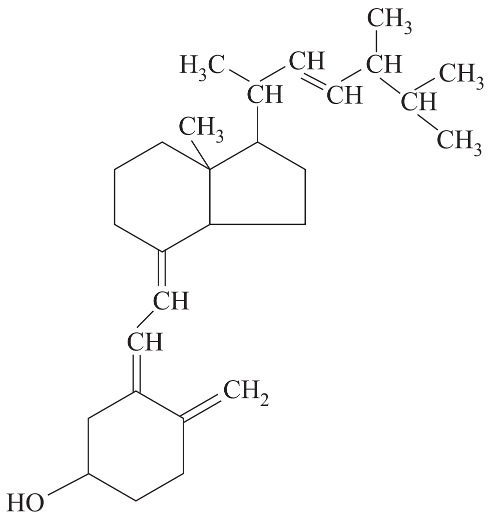
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

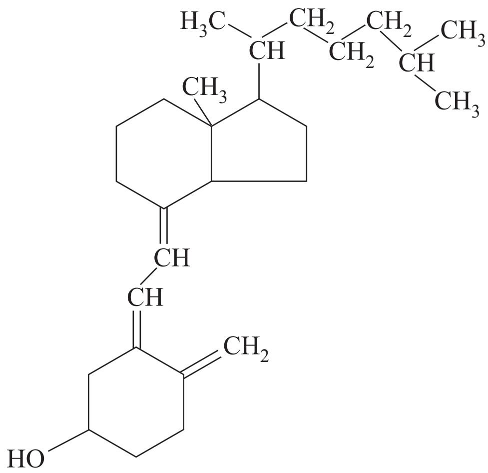
9. Formulas of some fatty acids

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	$C_{19}H_{31}COOH$	$CH_3(CH_2)_4(CH{=}CHCH_2)_3CH{=}CH(CH_2)_3COOH$

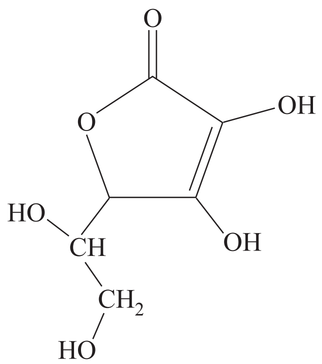
10. Formulas of some biomolecules



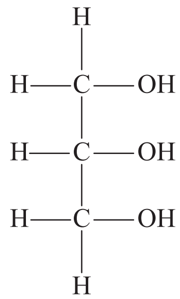
vitamin D_2 (ergocalciferol)



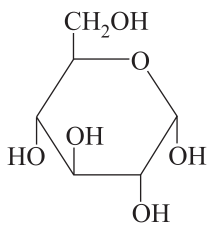
vitamin D_3 (cholecalciferol)



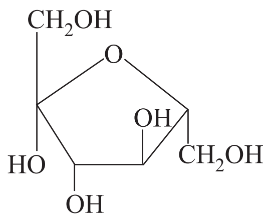
vitamin C (ascorbic acid)



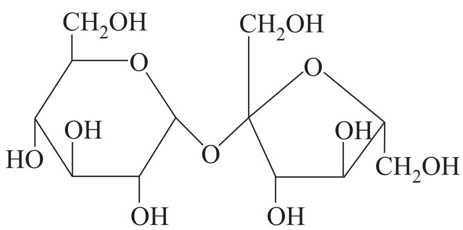
glycerol



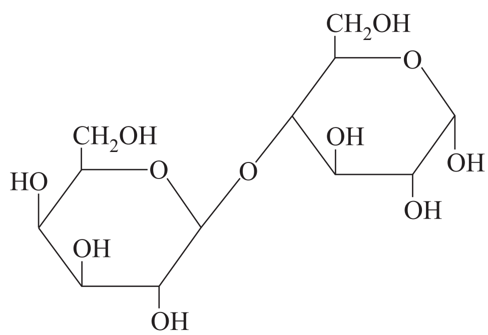
α-glucose



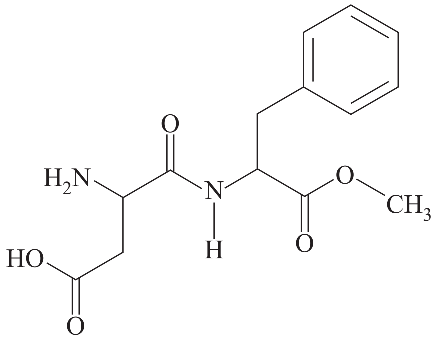
β-fructose



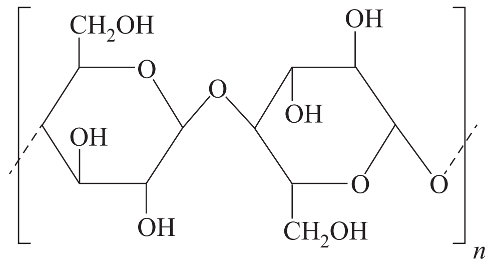
sucrose



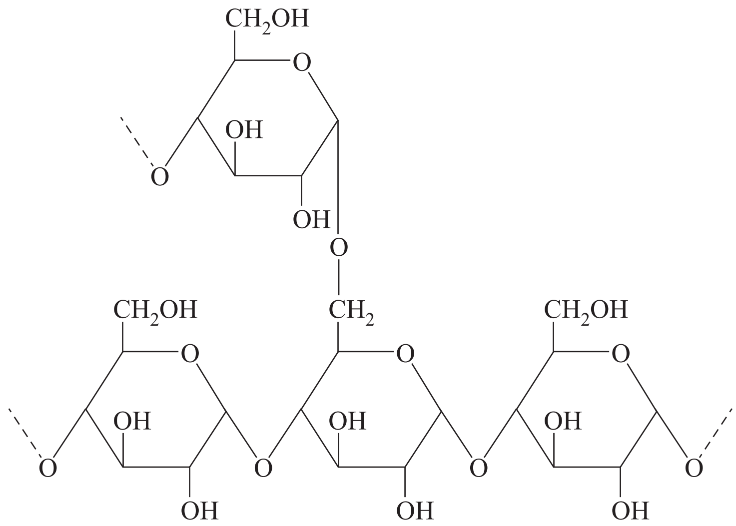
α-lactose



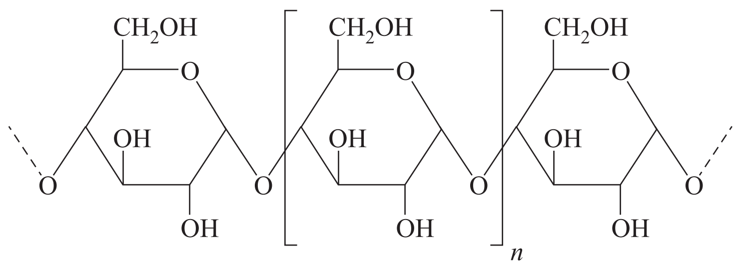
aspartame



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

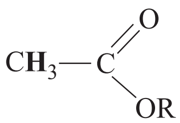
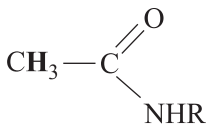
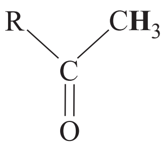
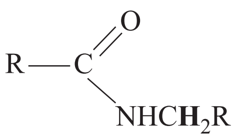
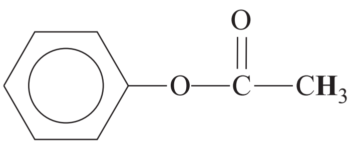
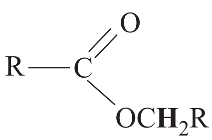
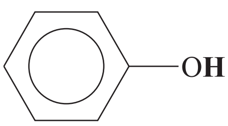
Typical ^{13}C shift values relative to TMS = 0
These can differ slightly in different solvents.

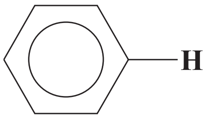
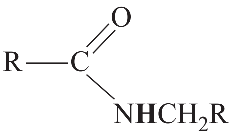
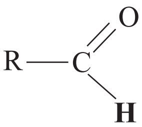
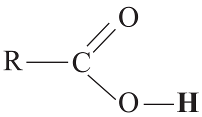
Type of carbon	Chemical shift (ppm)
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$, $R_3C–NR$	35–70
$R–CH_2–OH$	50–90
RC≡CR	75–95
$R_2C=CR_2$	110–150
RCOOH	160–185
R(RO)C=O	165–175
R(H)C=O	190–200
$R_2C=O$	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

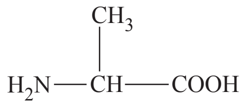
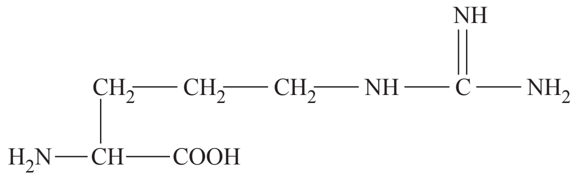
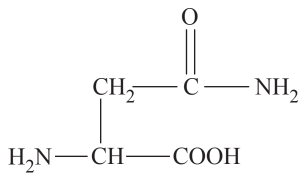
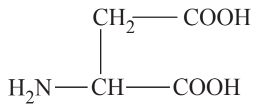
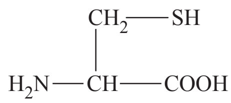
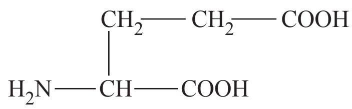
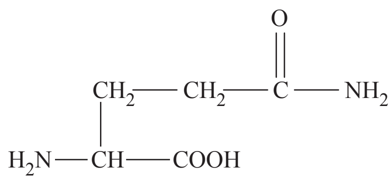
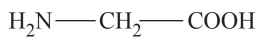
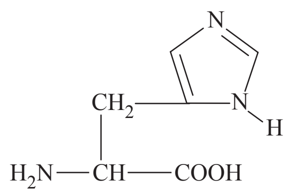
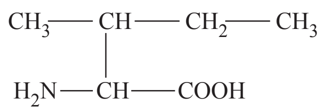
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

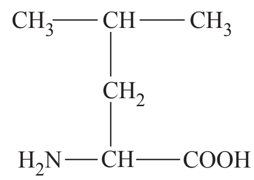
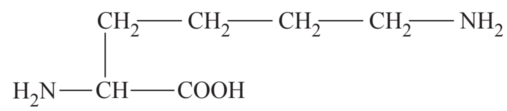
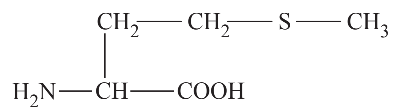
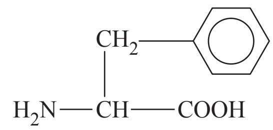
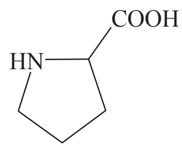
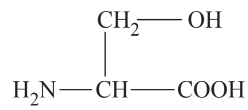
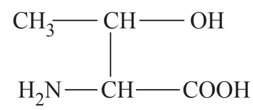
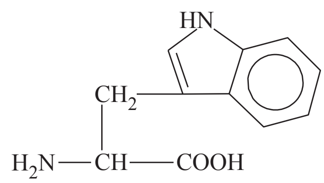
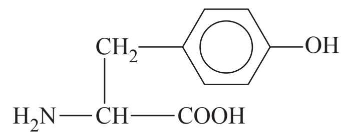
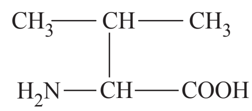
Type of proton	Chemical shift (ppm)
R–C**H**$_3$	0.9–1.0
R–C**H**$_2$–R	1.3–1.4
RCH=CH–C**H**$_3$	1.6–1.9
R$_3$–C**H**	1.5
 or 	2.0
	2.1–2.7
R–C**H**$_2$–X (X = F, Cl, Br or I)	3.0–4.5
R–C**H**$_2$–OH, R$_2$–C**H**–OH	3.3–4.5
	3.2
R—O—C**H**$_3$ or R—O—C**H**$_2$R	3.3–3.7
	2.3
	3.7–4.8
R–O–**H**	1–6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

VICTORIA
State
Government