VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2018

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER Letter

CHEMISTRY

Written examination

Monday 4 June 2018

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	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 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

All fuel cells

A. are rechargeable and have electrodes that are separated.
B. are galvanic cells and the required reactants are stored in the cells.
C. are rechargeable and the reactants are stored externally and continually supplied.
D. convert chemical energy into electrical energy and the reactants are continually supplied.

Question 2

$$HCOOH(l) + CH_3OH(l) \xrightarrow{H^+} HCOOCH_3(l) + H_2O(l)$$

The equation above is an example of what type of reaction?

A. condensation
B. denaturation
C. hydrolysis
D. addition

Question 3

Consider the following reaction.

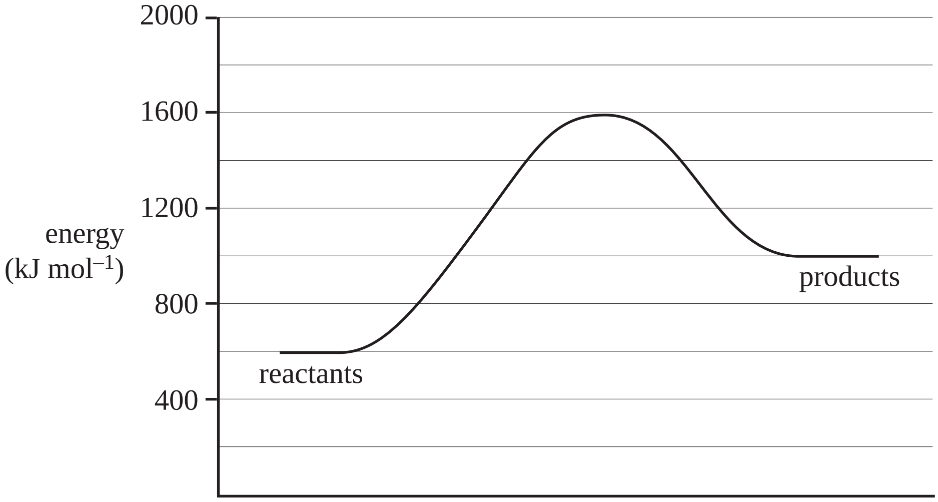
$$O_2(g) + 2NO(g) \rightleftharpoons 2NO_2(g) \qquad K_c = 9.1 \times 10^6 \text{ M}^{-1} \text{ at } 450 \text{ °C}$$

Which one of the following statements is correct?

A. K_c is very large; the reaction is reversible.
B. Changing the pressure will affect the value of K_c.
C. K_c is very large; the reaction is effectively irreversible.
D. Changing the temperature will not affect the value of K_c.

Question 4

The following diagram shows the energy profile for a reaction.



A catalyst reduces the activation energy by 250 kJ mol^{-1}.

The value of the enthalpy change, in kJ mol^{-1}, of the catalysed reaction is

A. –600

B. 400

C. 750

D. 1000

Question 5

Pentane, hexane, heptane and octane are non-branched alkanes.

Which one of the following statements gives a valid comparison?

A. Octane has a greater viscosity and a higher boiling point than hexane.

B. Pentane has a greater viscosity and a lower boiling point than octane.

C. Heptane has a lower viscosity and a higher boiling point than octane.

D. Heptane has a lower viscosity and a lower boiling point than pentane.

Question 6

Some strips of the metals, iron, Fe, zinc, Zn, and silver, Ag, were placed in separate beakers, each containing 1.0 M nickel(II) sulfate, $NiSO_4$, solution in water at 25 °C.

What is expected to occur over time?

A. Ni will be deposited in all of the beakers.

B. Ni will not be deposited in any of the beakers.

C. A reaction will occur only in the beaker containing Ag.

D. A reaction will occur only in the beakers containing Fe and Zn.

Question 7

Linoleic acid is a

A. polyunsaturated omega-6 essential fatty acid.

B. monounsaturated omega-3 essential fatty acid.

C. polyunsaturated omega-3 non-essential fatty acid.

D. monounsaturated omega-6 non-essential fatty acid.

Question 8

Coenzyme A is involved in the synthesis of fatty acids.

Coenzyme A is

A. a vitamin that is a precursor of an enzyme.

B. the substrate in the synthesis of fatty acids.

C. required by all enzymes to catalyse a reaction.

D. a small organic molecule that forms a complex with an enzyme.

Question 9

Before water treatment authorities release water into the environment, the water is tested to ensure it is safe and meets environmental standards.

The concentration of organic carbon is one indicator of water quality. In an experiment, a student determines the concentration of organic carbon by conducting a redox titration between the organic carbon in a water sample and standard acidified potassium permanganate solution, $KMnO_4$.

To accurately determine the concentration of organic carbon, an action the student should take is to

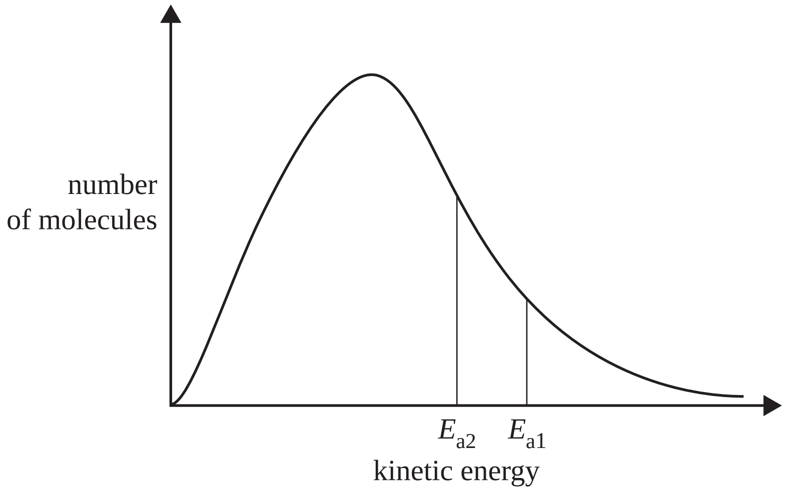
A. collect samples before and after a storm.

B. repeat the titration using a different standard solution.

C. use a measuring cylinder to measure the volumes of water samples.

D. rinse the burette with deionised water before filling it with the standard acidified $KMnO_4$ solution.

Question 10



The diagram above represents the distribution of kinetic energy in a sample of gaseous reactant molecules. Activation energy E_{a1} can be changed to activation energy E_{a2}. This change increases the reaction rate.

Which of the following gives the most likely cause of the change from E_{a1} to E_{a2} and explains why the reaction rate would increase?

	Cause	Why the reaction rate increases
A.	catalyst added	molecules move faster, resulting in more successful collisions
B.	catalyst added	greater proportion of reactants collide with sufficient energy to react
C.	temperature increased	greater proportion of reactants collide with the correct orientation to react
D.	concentration of reactants increased	greater frequency of collisions, resulting in more successful collisions

Question 11

An aqueous solution of ethanol, CH_3CH_2OH, left exposed to the air, will undergo a redox reaction with oxygen, O_2, to form ethanoic acid, CH_3COOH.

The half-equation for the oxidation reaction is

A. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

B. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

C. $CH_3CH_2OH(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 4e^-$

D. $CH_3CH_2OH(aq) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH(aq) + 2H^+(aq) + 2e^-$

Question 12

The semi-structural formula for an isomer of $C_5H_{13}NO$ is

$$NH_2CH_2CH_2CH(CH_3)CH_2OH$$

The correct systematic name for this molecule is

A. 4-amino-pentan-1-ol

B. 4-amino-2-methyl-butan-1-ol

C. 4-hydroxy-3-methyl-butan-1-amine

D. 1-hydroxy-2-methyl-4-amino-butane

Question 13

Which one of the following reactions has the lowest percentage atom economy for the production of ethanol, C_2H_5OH?

A. $C_2H_4(aq) + H_2O(l) \rightarrow C_2H_5OH(aq)$

B. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$

C. $C_2H_5Cl(aq) + NaOH(aq) \rightarrow C_2H_5OH(aq) + NaCl(aq)$

D. $C_2H_5NH_2(aq) + HNO_2(aq) \rightarrow C_2H_5OH(aq) + H_2O(l) + N_2(g)$

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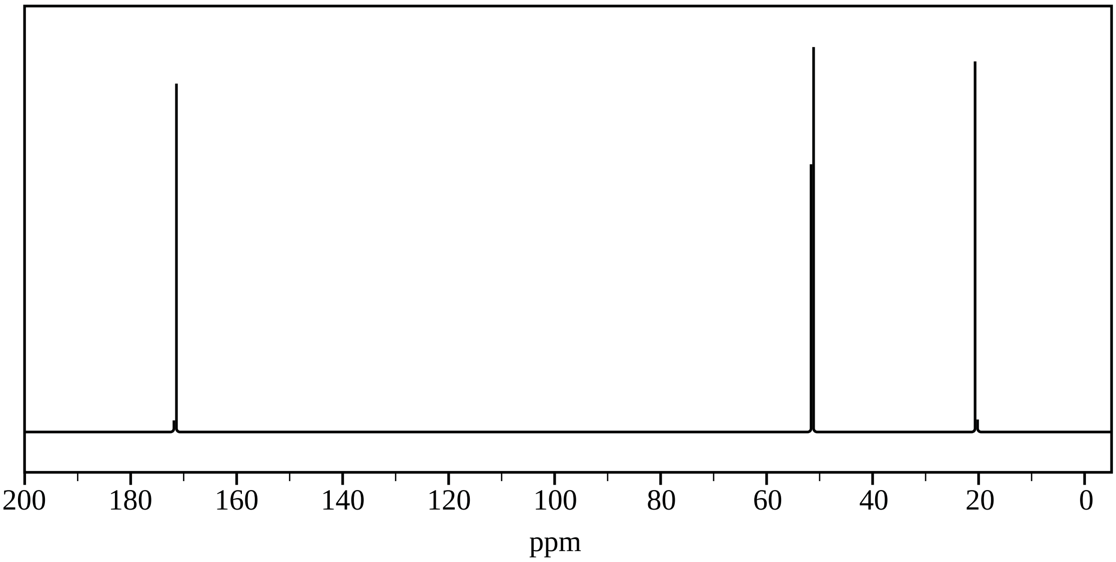
Question 14

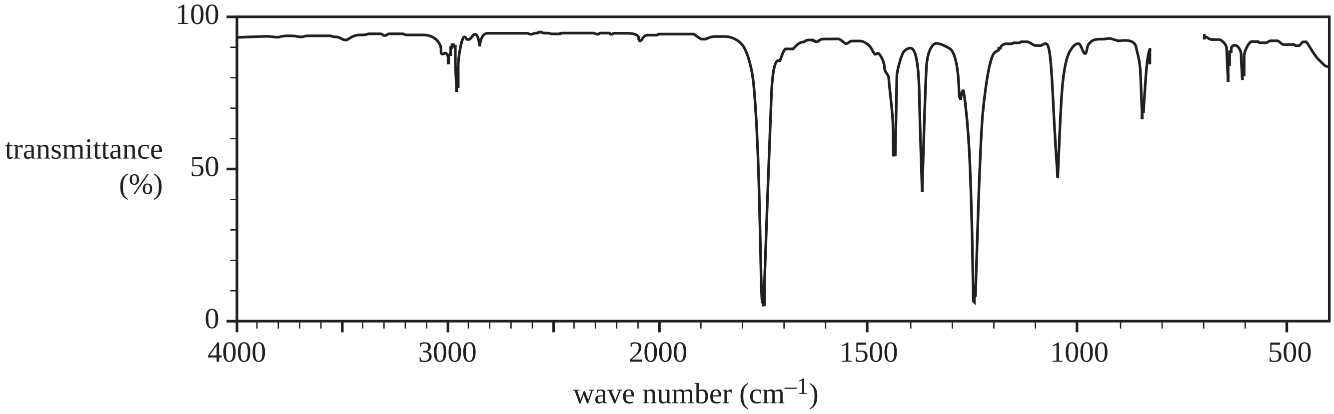
The following two spectra were obtained for a pure organic substance, Compound W.

^{13}C NMR spectrum



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

Infra-red spectrum



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

The formula of Compound W that is consistent with the spectra above is

A. $CH_2(OH)CH_2CH_2OH$

B. CH_3CH_2COOH

C. CH_3COOCH_3

D. CH_3COCH_3

Question 15

A zinc-carbon dry cell battery has a potential of +1.50 V measured at standard conditions.

The two half-reactions that occur in this battery are shown in the following equations.

Equation 1 $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

Equation 2 $MnO_2(s) + H_2O(l) + e^- \rightarrow MnO(OH)(s) + OH^-(aq)$

Assuming standard conditions, the electrode potential of Equation 2 is

A. +2.26 V

B. +0.74 V

C. –0.74 V

D. –2.26 V

Question 16

Which one of the following compounds can exist as cis- and trans- isomers?

A. CH_2CH_2

B. CH_2CHCH_3

C. $CH_3CHCHCH_3$

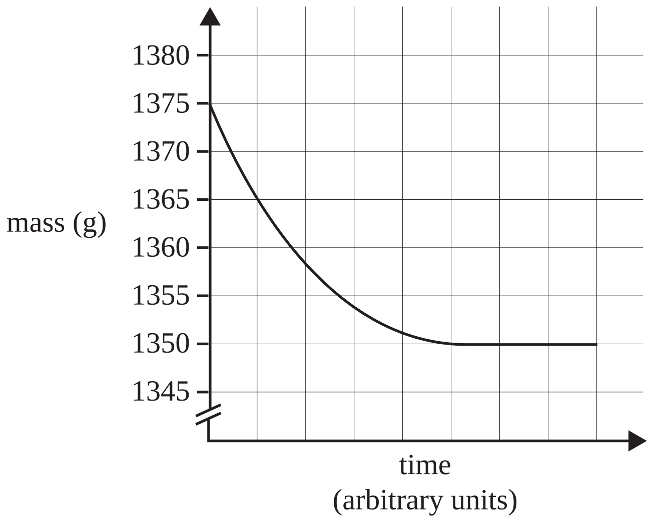
D. $CH_3(CH_2)_{16}COOH$

Question 17

Soda water is made by dissolving pressurised carbon dioxide, CO_2, in water.

A bottle of soda water was placed on an electronic balance. The cap was removed and placed next to the bottle on the electronic balance.

The graph below shows the change in mass as the CO_2 escapes. The experiment was conducted at standard laboratory conditions (SLC).



Assuming CO_2 was the only gas given off, the volume of CO_2 that was released is closest to

A. 14 L

B. 25 L

C. 36 L

D. 44 L

Question 18

The equation for cellular respiration is as follows.

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \qquad \Delta H < 0 \qquad M(C_6H_{12}O_6) = 180.0 \text{ g mol}^{-1}$$

When 72.0 g of glucose, $C_6H_{12}O_6$, is metabolised in cellular respiration, the total energy released is 1.126×10^3 kJ.

The value of ΔH, in kJ mol^{-1}, for the equation above is

A. -1.56×10^1

B. -4.50×10^2

C. -2.82×10^3

D. -8.11×10^4

Question 19

The following reaction, in which dinitrogen tetroxide, N_2O_4, is converted to nitrogen dioxide, NO_2, forms an equilibrium.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

At a given temperature, the equilibrium constant for this reaction is 3.15 M and the molar concentration of N_2O_4 at equilibrium is 0.350 M.

At this temperature, the molar concentration of NO_2 at equilibrium is

A. 0.550 M

B. 1.05 M

C. 1.10 M

D. 3.00 M

Question 20

A meal containing a mixture of carbohydrates, fats and protein is eaten. The biomolecules in this meal are broken down into smaller molecules in the body before they can be absorbed.

Which of the following summarises the chemical reactions that would occur prior to the smaller molecules being absorbed by the body?

	Type of reaction	H_2O is a reactant	Possible product
A.	hydrolysis	yes	glycine
B.	condensation	yes	glycogen
C.	hydrolysis	no	glucose
D.	condensation	no	glycerol

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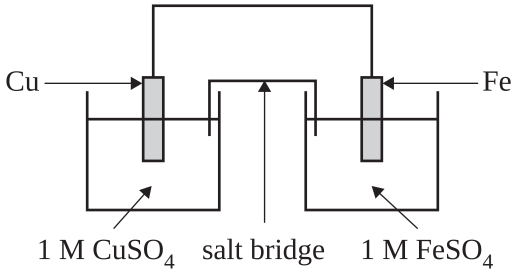
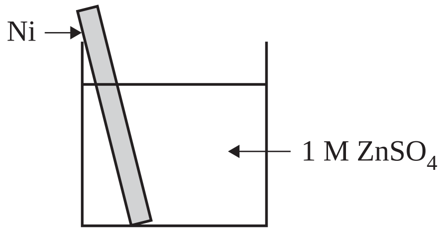
Question 21

Which one of the following produces heat energy as its main energy output?

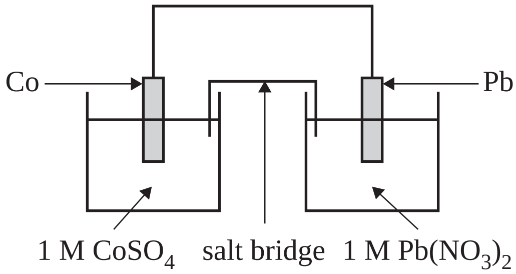
A.



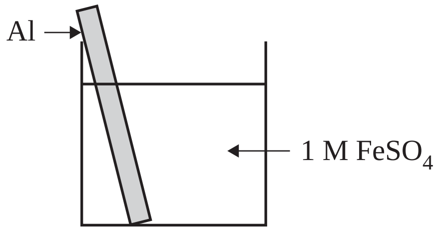
B.



C.



D.



Question 22

A 12 g sample of a vegetable is estimated to have a vitamin C concentration of 30 mg/100 g. The high-performance liquid chromatography (HPLC) instrument used for the analysis produces a linear calibration curve for vitamin C concentrations between 0.020 mg mL^{-1} and 0.10 mg mL^{-1}.

Which one of the following volumetric flasks, made up to the mark, would be appropriate for preparing the vegetable sample solution for analysis?

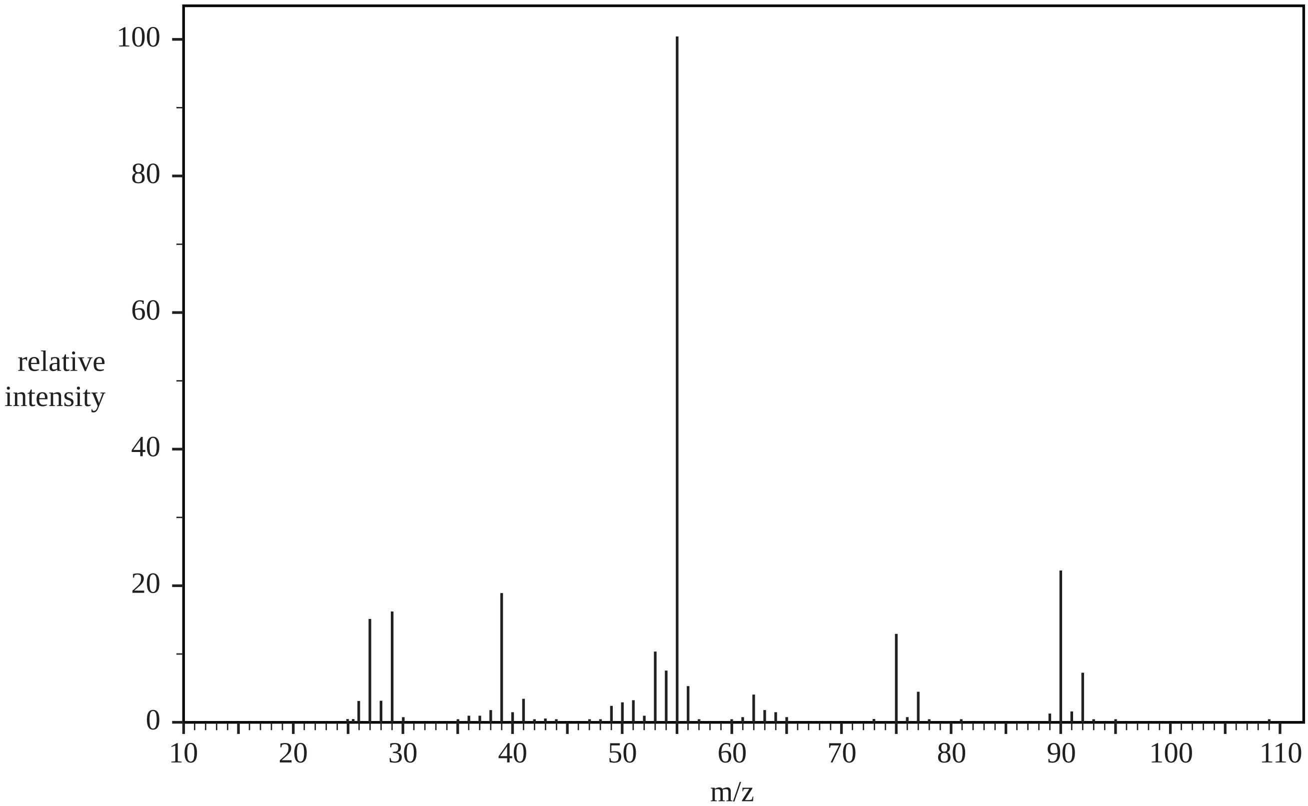
A. a 25.00 mL flask

B. a 100.00 mL flask

C. a 250.00 mL flask

D. a 500.00 mL flask

Question 23



Data: SDBSWeb, <http://sdbs.db.aist.go.jp>,
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The mass spectrum shown above is for a molecule with the molecular formula C_4H_7Cl.

Which species is responsible for the base peak?

A. $C_4H_7Cl^+$

B. $C_3H_4Cl^+$

C. $C_3H_5^+$

D. $C_4H_7^+$

Question 24

An electroplating cell containing two platinum electrodes and an electroplating solution is operated at 5.0 A for 600 s. After the cell is turned off, 0.54 g of metal is found to have been deposited on the cathode.

Which electroplating solution was used in this process?

A. 1 M $AgNO_3$

B. 1 M $Ni(NO_3)_2$

C. 1 M $Pb(NO_3)_2$

D. 1 M $Cr(NO_3)_3$

Question 25

A certain fuel contains 91% octane, C_8H_{18}, by mass with the remainder being ethanol, C_2H_5OH.

When 2.50 kg of this fuel is completely burnt at 25 °C and 100 kPa, the amount of energy produced, in megajoules, would be

A. 78

B. 114

C. 116

D. 121

Question 26

The concentration of a propanoic acid, C_2H_5COOH, solution was determined by titration with standardised 0.100 M sodium hydroxide, NaOH, solution at 25 °C. The reaction for this titration is shown below.

$$C_2H_5COOH(aq) + NaOH(aq) \rightarrow C_2H_5COONa(aq) + H_2O(l)$$

A 0.10 M solution of sodium propanoate, C_2H_5COONa, in water has a pH of 8.9 at 25 °C.

The most appropriate indicator to use for this titration would be

A. thymol blue.

B. methyl red.

C. phenol red.

D. bromothymol blue.

Question 27

Tristearin, a triglyceride, is the primary fat found in beef and it contains stearic acid as the only fatty acid.

10.0 g of a pure sample of tristearin is completely broken down into its component molecules – glycerol and stearic acid.

$$M(\text{tristearin}) = 890.0 \text{ g mol}^{-1} \qquad M(\text{glycerol}) = 92.0 \text{ g mol}^{-1}$$

This reaction would

A. produce 3.10 g of glycerol.

B. require 0.836 L of hydrogen gas.

C. require 0.0112 mol of water molecules.

D. produce 2.03×10^{22} molecules of stearic acid.

Question 28

Dissolved carbon dioxide, CO_2, can react with water, H_2O, to form carbonic acid, H_2CO_3.

H_2CO_3 can also react with H_2O to form bicarbonate ions, HCO_3^-, and hydronium ions, H_3O^+.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

A beaker that contains 2 L of deionised water is placed in a room and left overnight so that these two reactions reach equilibrium. In the morning one change is made to the system.

Which one of the following changes is most likely to result in an increase in the concentration of H_3O^+ ions?

A. Dilute the solution.

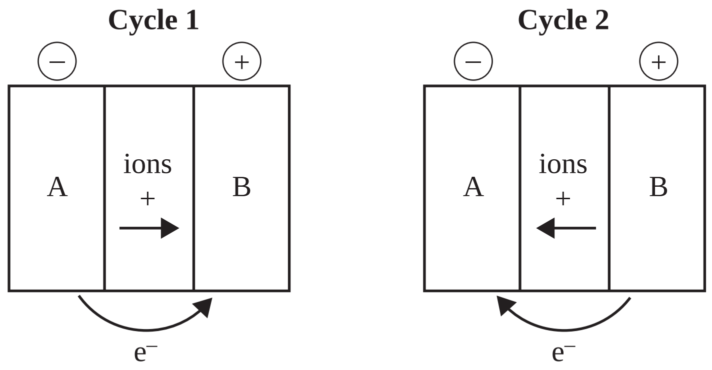
B. Bubble in more CO_2 gas.

C. Add a few drops of phenolphthalein indicator.

D. Add a few drops of 0.1 M sodium hydroxide, NaOH, solution.

Question 29

The following diagrams represent the operation of a secondary cell during recharge and discharge, in no particular order. The diagrams of the circuits are not complete.



Which of the options below correctly describes the cell and its operation?

	Cycle 1	Cycle 2
A.	energy produced	anode is positive
B.	spontaneous reaction	energy produced
C.	anode is positive	energy required
D.	spontaneous reaction	cathode is positive

Question 30

Cold weather can affect the performance of diesel fuels, such as petrodiesel and biodiesel. As the temperature is lowered, a point is reached at which the larger molecules in the fuel begin to solidify out of the liquid. When this point is reached, the fuel starts to become cloudy. The temperature at which this point is reached is known as the cloud point.

Which statement is correct?

A. A high cloud point indicates that the diesel fuel is a biodiesel and will produce more pollutants.

B. A low cloud point indicates that the diesel fuel is a biodiesel and has good hygroscopic properties.

C. A low cloud point indicates that the diesel fuel is a petrodiesel and will flow readily in cold temperatures.

D. A high cloud point indicates that the diesel fuel is a petrodiesel and contains only straight-chain carbon molecules.

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

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 (5 marks)

Alkenes can be used to manufacture a range of products. The reaction pathway diagram on page 15 represents one example of the use of an alkene.

In this reaction pathway, Compound P is used to produce Compound R and Compound S. Compound S can then be used to produce Compound T.

Complete the following in the appropriate boxes in the reaction pathway diagram provided.

a. Give the IUPAC systematic names for Compound P and Compound R. 2 marks

b. Write the formulas of the reagent and the catalyst required to produce Compound R and Compound S from Compound P. 1 mark

c. Write the semi-structural formula of Compound S. 1 mark

d. Draw the structural formula of Compound T. 1 mark

Compound P

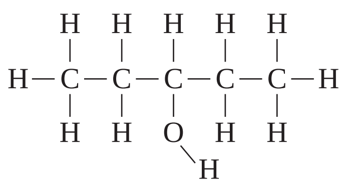
$CH_3CH_2CHCHCH_3$

Name ______________________

Reagent ______________

Catalyst ______________

Compound R



Name ______________________

Compound S

semi-structural formula

$Cr_2O_7^{2-}(aq)/H^+(aq)$

Compound T

structural formula

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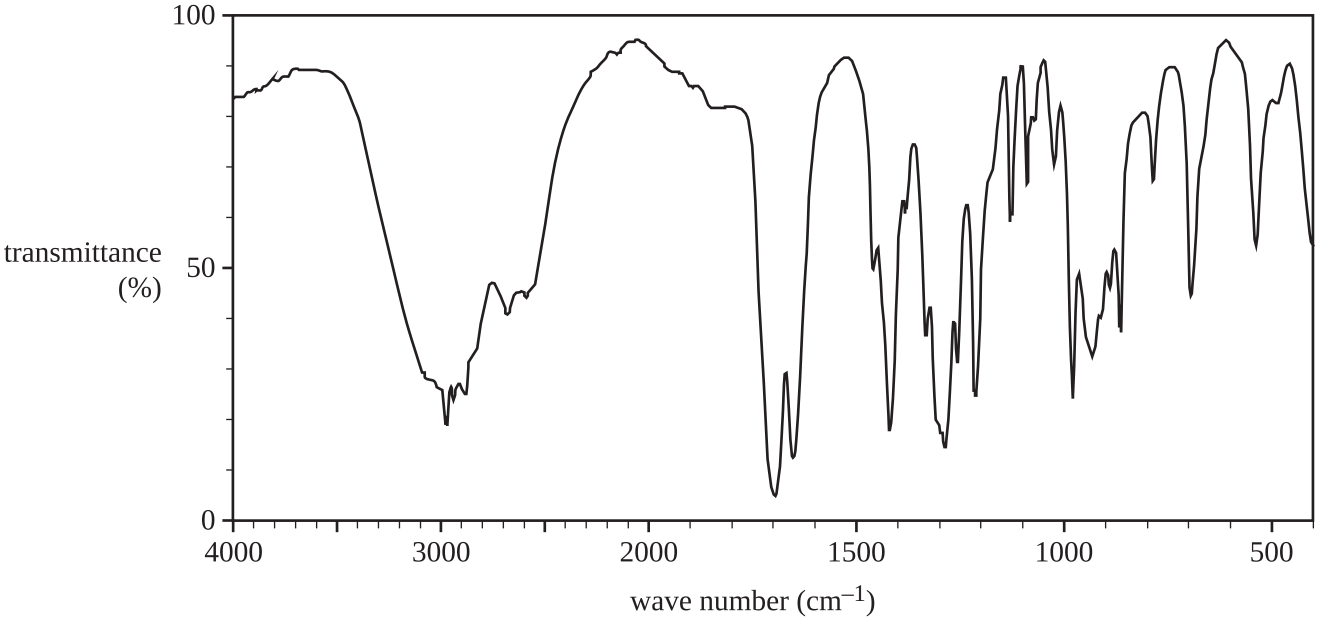
Question 2 (7 marks)

A student investigated an organic substance, Compound Y, with the molecular formula $C_5H_8O_2$.

Infra-red spectrum



Data: SDBSWeb, <http://sdbs.db.aist.go.jp>,
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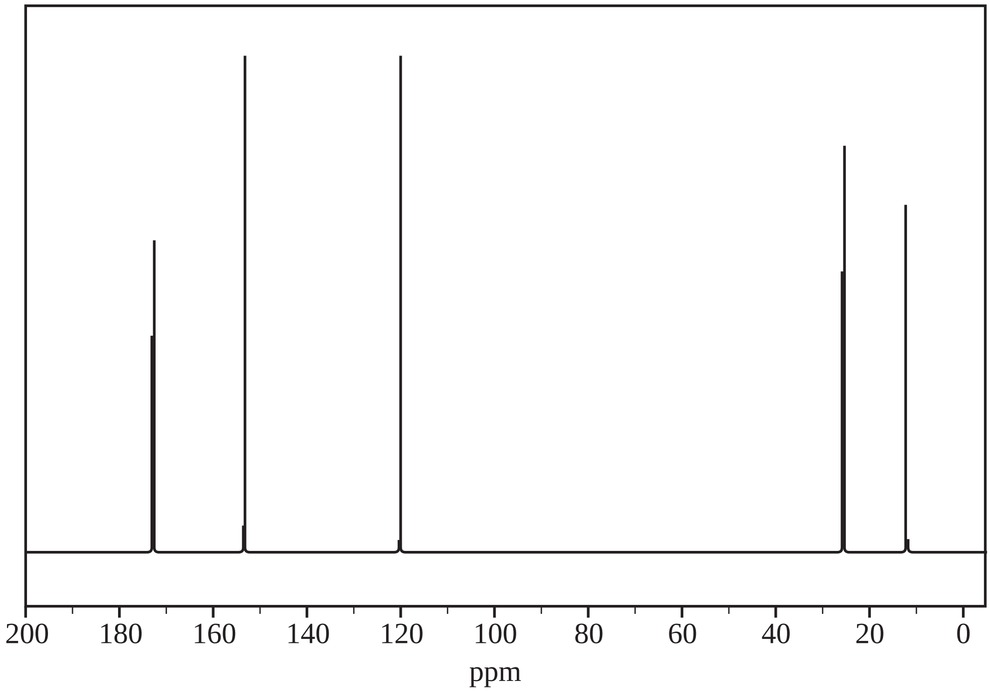
a. The infra-red spectrum of Compound Y is shown above.

On the spectrum, circle **two** peaks and identify the bond(s) responsible for each peak. 2 marks

A sample of Compound Y was further analysed using ^{13}C NMR and ^{1}H NMR. The spectra are shown below.

^{13}C NMR spectrum



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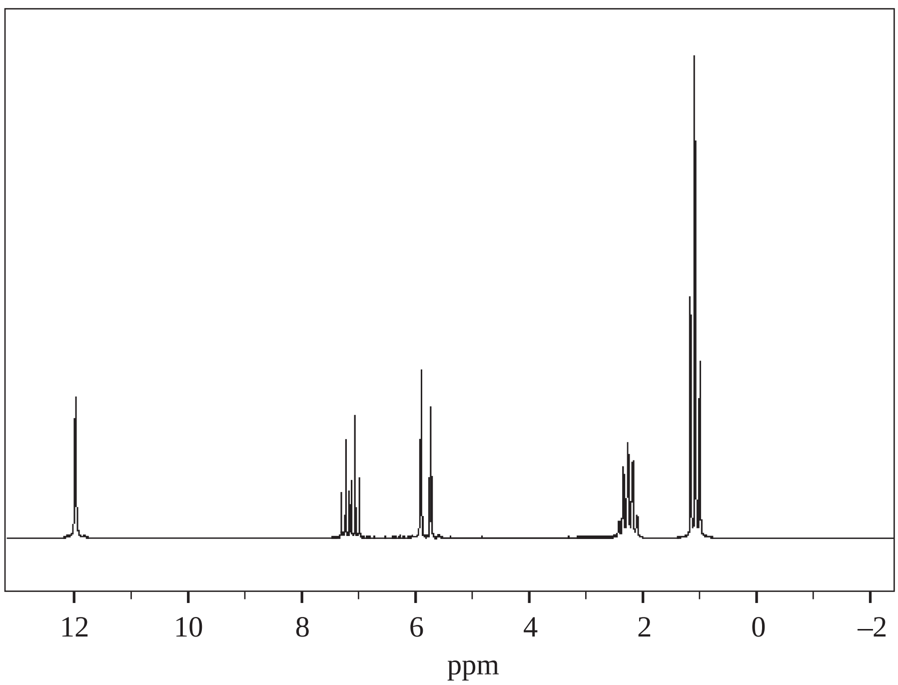
^{1}H NMR spectrum



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

^{1}H NMR data

Chemical shift (ppm)	Relative peak area	Peak splitting
1.1	3	triplet (3)
2.3	2	pentet (5)
5.8	1	doublet (2)
7.1	1	quartet (4)
12	1	singlet (1)

b. **i.** Use the information provided in the ^{13}C NMR spectrum to identify the number of different carbon environments for Compound Y. 1 mark

Number of different carbon environments	

ii. For the signal at 2.3 ppm in the ^{1}H NMR spectrum, identify what specific information is provided by 2 marks

- the relative peak area

____

____

- peak splitting.

____

____

c. Draw the structural formula of Compound Y. 2 marks

Question 3 (8 marks)

Nitrosyl chloride, NOCl, is a highly toxic gas used in the chemical industry as an oxidising agent. The formation reaction of NOCl from nitrogen monoxide, NO, and chlorine, Cl_2, is

$$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g) \qquad \Delta H > 0$$

This reaction forms an equilibrium above 100 °C.

A scientist conducted two experiments on the equilibrium reaction of NOCl. The initial experiments were conducted in evacuated and sealed 4 L containers at 150 °C.

Experiment 1 2 mol of NOCl was injected into a previously evacuated, sealed 4 L container.

Experiment 2 4 mol of NOCl was injected into another previously evacuated, sealed 4 L container.

a. **i.** Which experiment had the highest initial rate of production of Cl_2? Circle the correct response below. Justify your answer. 2 marks

Experiment 1 rates are equal Experiment 2

ii. If, for Experiment 1, the concentrations of NOCl and NO were equal at equilibrium, [NOCl] = [NO], then what conclusion could be made about the relative concentrations of NOCl and NO in Experiment 2 at equilibrium? Justify your answer. 2 marks

SECTION B – Question 3 – continued

b. 2 mol of an inert gas is injected into the container in Experiment 1. The temperature is kept at 150 °C.

What effect will this have on the rate of production of the Cl_2 in the container? Circle the correct response below. Justify your answer using collision theory. 2 marks

decreases no change increases

c. The temperature for Experiment 2 is increased to 200 °C.

Explain the effect on the equilibrium concentration of NOCl in the reaction. 2 marks

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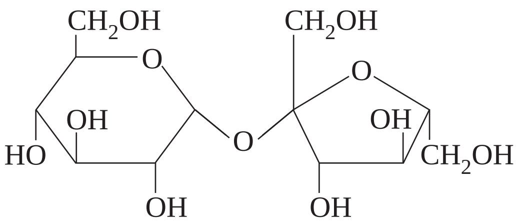
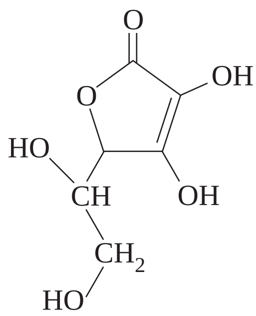
Question 4 (7 marks)

The structures or formulas of a number of important biomolecules are shown below.

A.

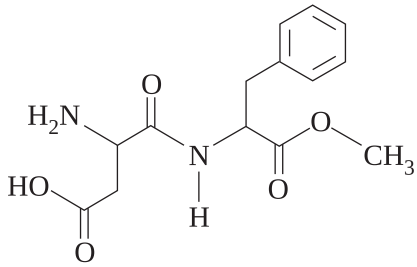


B.

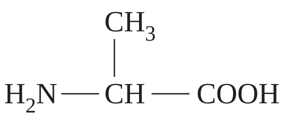


C. $CH_3(CH_2)_{14}COOCH_3$

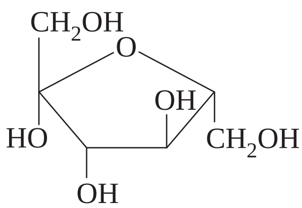
D.



E.

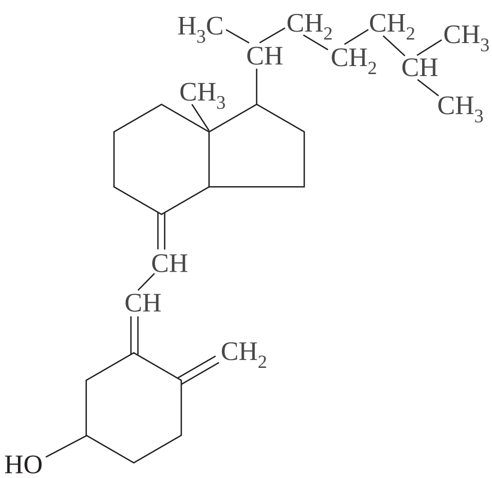


F.



G. $C_{17}H_{29}COOH$

H.



SECTION B – Question 4 – continued

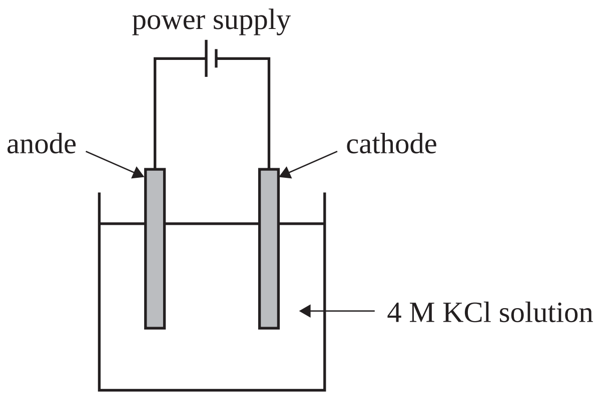
For each of the following characteristics of biomolecules, write the letter or letters in the space provided for the corresponding biomolecule or biomolecules shown on page 22. Each biomolecule may be used more than once or may not be used at all.

Characteristic	Biomolecule letter(s) (A.–H.)
contains a glycosidic linkage	
is an essential dietary component (give letters for **two** examples)	
is soluble in water (give letters for **two** examples)	
is able to form a zwitterion	
contains an ester linkage (give letters for **two** examples)	
can be a key constituent of biodiesel	
has phenylalanine as a component	

Question 5 (13 marks)

Potassium hydroxide, KOH, is made commercially by the electrolysis of concentrated potassium chloride, KCl, solution.

A chemist aims to make a solution of aqueous potassium hydroxide, KOH(aq), using electrolysis. The electrolysis cell is shown below. It is operated at standard laboratory conditions (SLC).



a. **i.** Explain why potassium bromide, KBr, or potassium iodide, KI, could not replace KCl as the electrolyte solution, using the cell shown above. 2 marks

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ii. When the power supply is turned on, the chemist observes bubbles forming at the anode.

Use the electrochemical series to predict the gas formed at the anode. 1 mark

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iii. A faint smell of chlorine was detected above the anode.

Explain this observation. 2 marks

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iv. Write a balanced equation for the overall reaction that occurs in the electrolysis cell that is consistent with the explanation given in **part a.iii.** 2 marks

v. Identify a safety issue with this cell and how the risk(s) can be minimised. 2 marks

b. In a commercial electrolysis cell that produces KOH, the two electrodes are separated by a membrane.

What is the purpose of this membrane? 1 mark

c. KOH is also used as part of a rechargeable nickel-cadmium, NiCd, battery. The chemical reactions that occur in an NiCd battery during discharge are

$$Cd(s) + 2OH^{-}(aq) \rightarrow Cd(OH)_2(s) + 2e^{-}$$
$$2NiO(OH)(s) + 2H_2O(l) + 2e^{-} \rightarrow 2Ni(OH)_2(s) + 2OH^{-}(aq)$$

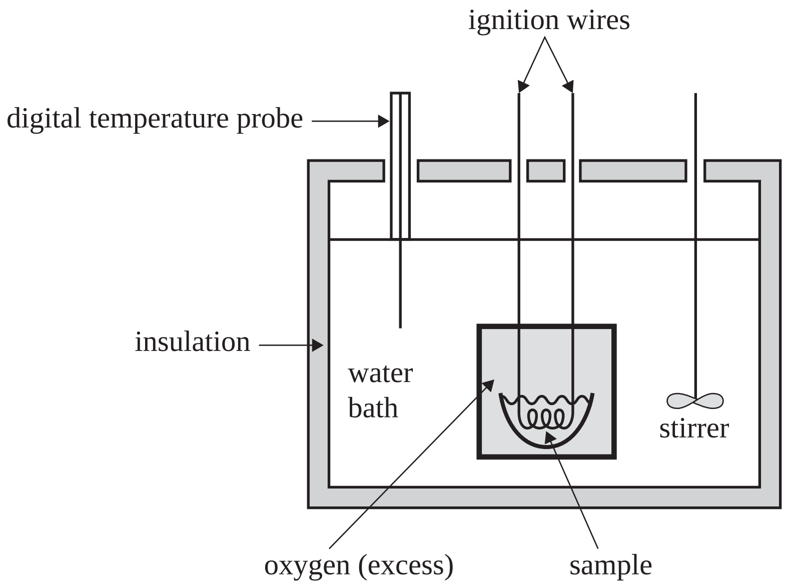
i. Identify the reducing agent in these reactions during discharge. 1 mark

ii. Identify the oxidising agent in these reactions during recharge. 1 mark

iii. What is the purpose of the KOH in the NiCd battery? 1 mark

Question 6 (14 marks)

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



The calibration factor for the bomb calorimeter is initially determined by burning a known amount of naphthalene, $C_{10}H_8$.

The combustion reaction for $C_{10}H_8$ is shown below.

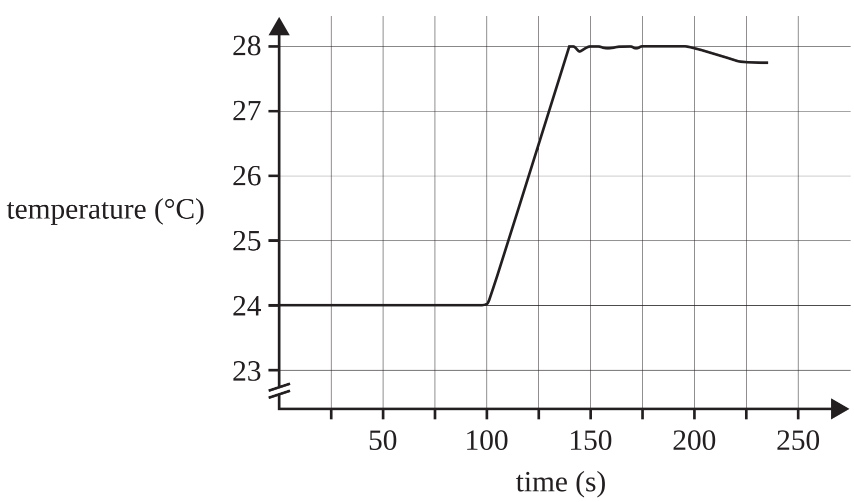
$$C_{10}H_8(s) + 12O_2(g) \rightarrow 10CO_2(g) + 4H_2O(l) \qquad \Delta H = -5133 \text{ kJ mol}^{-1}$$

Data for the calibration of the bomb calorimeter

mass of $C_{10}H_8$	0.212 g
mass of water	300 g

The graph produced by the digital temperature probe in the bomb calorimeter is shown below.

Naphthalene combustion



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DO NOT WRITE IN THIS AREA

a. **i.** Use the data in the graph on page 26 to calculate the calibration factor for the bomb calorimeter. 3 marks

ii. Comment on the reliability of the data collected using this bomb calorimeter. 2 marks

b. 2.70 g of a cereal is burnt in a different bomb calorimeter. Below is an extract from the nutrition label on the cereal package.

serving size	27 g
protein	1.9 g
fat	8.9 g
carbohydrate	14.0 g

i. Calculate the total amount of energy released from the complete combustion of the 2.70 g sample of cereal. 2 marks

ii. The bomb calorimeter used has a calibration factor of 3.3 kJ $°C^{-1}$.

Calculate the maximum expected temperature change in this bomb calorimeter. 1 mark

The carbohydrate in the cereal is mainly cellulose with a small amount of starch.

c. i. Name the monosaccharide unit that makes up both cellulose and starch molecules in the cereal. 1 mark

ii. The starch in the cereal is composed of approximately 27% amylose and has a glycaemic index (GI) of approximately 70.

Give an explanation for the high GI of the starch. 2 marks

d. When eaten, the cellulose component of the cereal is not digested in the human body, yet starch is readily digested.

A person ate 2.70 g of the cereal.

How would the energy released in the body compare to the value calculated in **part b.i.**? Justify your answer. 3 marks

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Question 7 (14 marks)

Motor vehicles, such as cars, are a standard means of transport around the world. The majority of cars use a battery to start the engine and then use the combustion of a fuel in the engine to power the car.

The standard battery used to start a car is a rechargeable lead-acid battery. The components of a simplified lead-acid battery are shown below.

lead Pb(s)	sulfuric acid solution $H_2SO_4(aq)$	lead(IV) oxide $PbO_2(s)$

When the battery is fully charged, it has a lead, Pb, anode, a lead(IV) oxide, PbO_2, cathode and a sulfuric acid, H_2SO_4, electrolyte. When fully discharged, the two electrodes are both coated in lead(II) sulfate, $PbSO_4$.

a. **i.** Write the oxidation reaction, including states, that occurs during discharge. 1 mark

ii. Write the reduction reaction, including states, that occurs during discharge. 1 mark

DO NOT WRITE IN THIS AREA

The car is powered by the combustion of a fuel in the engine and, historically, the fuel has been petrol. Ethanol, C_2H_5OH, and hydrogen, H_2, are now being used as alternative fuels in cars.

b. A significant component of petrol is 2,2,4-trimethylpentane, C_8H_{18}, which has the same molar heat of combustion as octane, C_8H_{18}.

i. Write the balanced thermochemical equation for the combustion of C_8H_{18} in excess oxygen, O_2. 2 marks

ii. Calculate the mass of carbon dioxide, CO_2, in kilograms, released during the complete combustion of 1.00 kg of C_8H_{18}.
$M(C_8H_{18})$ = 114 g mol^{-1} 1 mark

iii. Calculate the mass of CO_2, in kilograms, released during the combustion of 1.00 kg of C_2H_5OH.
$M(C_2H_5OH)$ = 46 g mol^{-1} 2 marks

iv. Both petrol and ethanol produce about 15.50 MJ of energy for each kilogram of CO_2 produced.

Use the information in **parts b.i.–iv.** to describe **one** advantage of using petrol as a fuel. 1 mark

DO NOT WRITE IN THIS AREA

c. An alternative means of providing power to cars is the combustion of H_2 in fuel cells.

i. If 582 L of H_2 (measured at 100 kPa and 18 °C) were combusted, what amount of energy, in megajoules, would be released? 2 marks

ii. H_2 can be produced by several methods. Two of these methods are given below.

Method 1 Reacting methane with water at a high temperature

$$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$$

Method 2 The electrolysis of water

$$2H_2O(l) \rightarrow O_2(g) + 2H_2(g)$$

Evaluate the environmental impacts of each of these methods of producing H_2. 4 marks

DO NOT WRITE IN THIS AREA

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Question 8 (15 marks)

For an extended experimental investigation, a group of students designed and carried out experiments to investigate various aspects of electroplating.

Some extracts from the scientific poster produced by one of these students is shown below.

Introduction

Electroplating is generally carried out to improve the appearance or corrosion resistance of the surface of an object by depositing a thin layer of metal on it.

In this experiment, two copper electrodes were used in a solution of copper sulfate, $CuSO_4$.

Copper was plated out onto the copper strip at the cathode.

The anode was connected to the positive terminal of the power supply.

cathode half-reaction $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

anode half-reaction $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

The copper strip was dipped in propanone, $(CH_3)_2CO$, before being weighed to determine the mass of copper plated on the electrode. Care needs to be taken when using $(CH_3)_2CO$.

$(CH_3)_2CO$ is harmful if inhaled and is highly flammable. Vapour may travel a considerable distance to the source of ignition.

The number of coulombs passed during the plating can be calculated by using the following.

$Q = It$

In this equation:

- Q is the charge, in coulombs
- I is the average current, in amperes
- t is the time, in seconds.

a. Considering the properties of $(CH_3)_2CO$ stated in the introduction, outline the safety precautions the student would take when

i. using $(CH_3)_2CO$ 1 mark

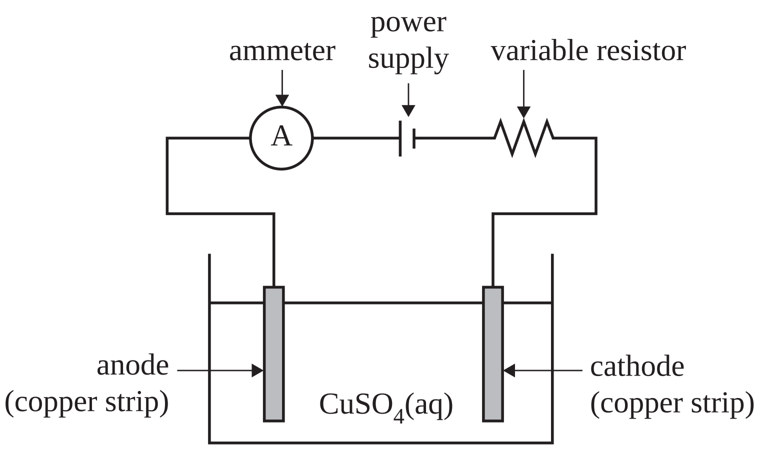
ii. disposing of $(CH_3)_2CO$. 1 mark

Aim

To find the amount of copper gained or lost on the electrodes using different amounts of current each time during electrolysis, and how changing the current affects the electroplating of copper

Procedure

1. Cut identical strips of copper.
2. Clean the copper strips.
3. Weigh the copper strips.
4. Connect the copper strips to the electrodes.
5. Place them in the beaker of $CuSO_4$ solution.
6. Pass a current of 1.0 A through the cell for 10.0 minutes. Use 8.0 V.
7. Maintain the current by using a variable resistor.
8. Carefully remove the copper-plated electrode.
9. Dip this into the beaker of water.
10. Now dip it into the beaker of $(CH_3)_2CO$.
11. Allow it to dry and then weigh.
12. Repeat using different currents.



b. **i.** Name the independent variable in this experiment. 1 mark

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ii. Name a controlled variable in this experiment and state why it is important for this variable to be controlled. 2 marks

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iii. The aim and the procedure stated by the student do not match.

Rewrite the aim so that it better matches the stated procedure. 2 marks

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Results

Trial number	Current (A)	Mass of copper strip (g) before electroplating	Mass of copper strip (g) after electroplating	Mass of copper (g) plated
1	0.6	2.21	2.29	0.08
2	0.8	2.19	2.31	0.12
3	1.0	2.09	2.25	0.16
4	1.2	1.99	2.19	0.20
5	1.4	1.93	2.16	0.23

c. Suggest another way of displaying the results given in the table above. 1 mark

d. Describe how the class data could be used to determine the reliability of the experiment. 2 marks

e. Write a suitable conclusion for the results given in the table above. 2 marks

f. As part of a peer assessment process, a group of students reviewed the investigation and suggested a number of changes. One of these suggested changes is shown below.

Measure the mass of both the anode and the cathode before and after electroplating.

Comment on how implementing this suggested change would affect the experiment with respect to:

- the validity of the experiment
- the sources of error (random and systematic).

3 marks

Question 9 (7 marks)

Enzymes are crucial for the reactions involved in the metabolism of food in the human body. Even when conditions vary in the human body, there are enzymes that function to ensure the chemical reactions needed to sustain life take place.

In the digestive tract, there is a variation in pH. The stomach can have a pH in the range of 1 to 4, while in the intestines, the pH can vary from 5 to 7.

a. Describe the tertiary structure of enzymes and explain the chemistry that enables enzymes to function in different parts of the digestive tract. Your response should:

- describe the chemical bonding that enables the tertiary structure to be maintained
- comment on the significance of chemical bonding to the correct functioning of the enzyme
- explain how the enzyme chemically interacts with the substrate.

Diagrams may be used to support your answer. 4 marks

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b. State **one** factor, other than pH, that would affect the activity of an enzyme. Outline the effect this factor would have on the rate of reaction of the enzyme and explain why. 3 marks

END OF QUESTION AND ANSWER BOOK

VICTORIAN CURRICULUM
AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2018

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	79	symbol of element
relative atomic mass	Au 197.0 gold	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	$n = \frac{m}{M}$; $n = cV$; $n = \frac{V}{V_m}$
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

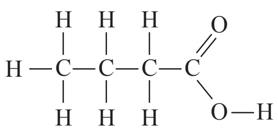
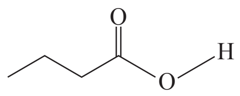
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

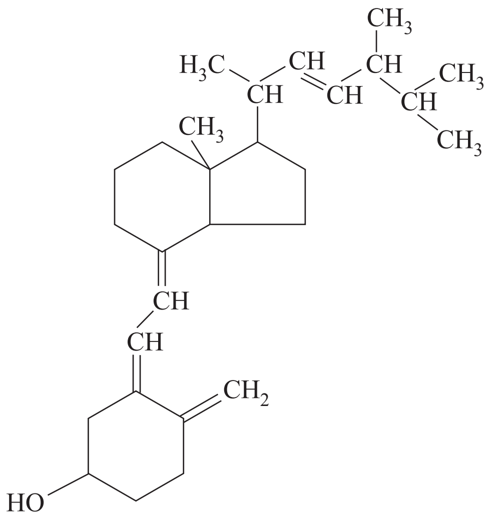
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

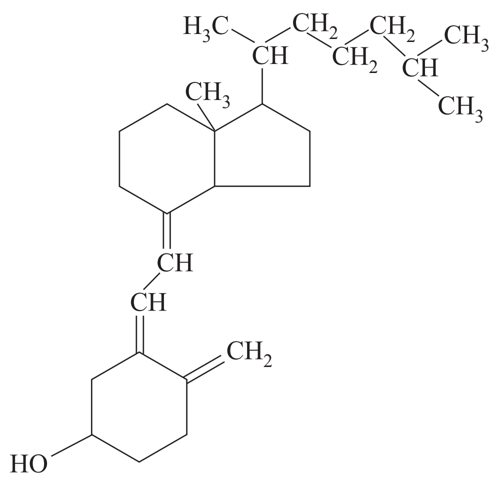
9. Formulas of some fatty acids

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

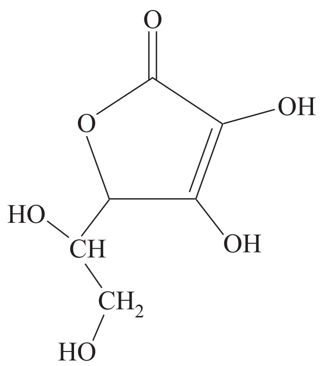
10. Formulas of some biomolecules



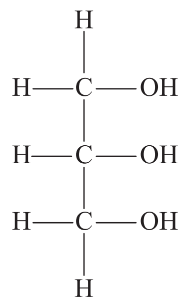
vitamin D_2 (ergocalciferol)



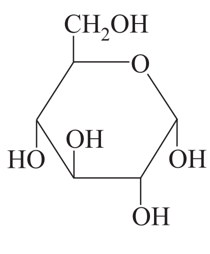
vitamin D_3 (cholecalciferol)



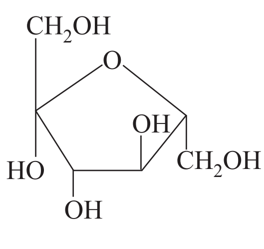
vitamin C (ascorbic acid)



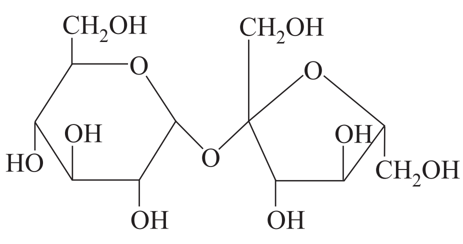
glycerol



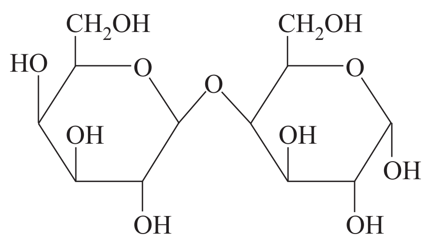
α-glucose



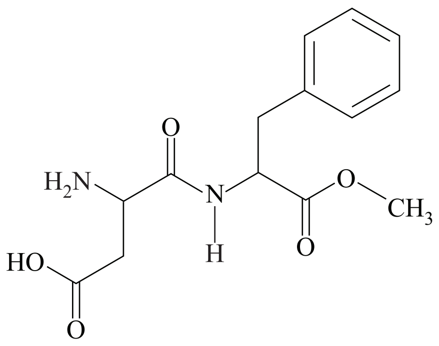
β-fructose



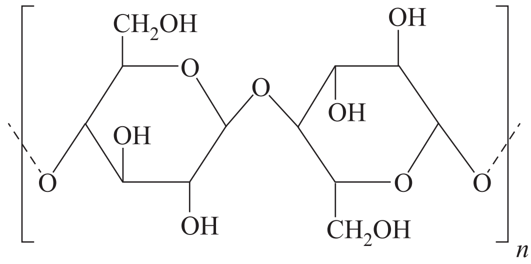
sucrose



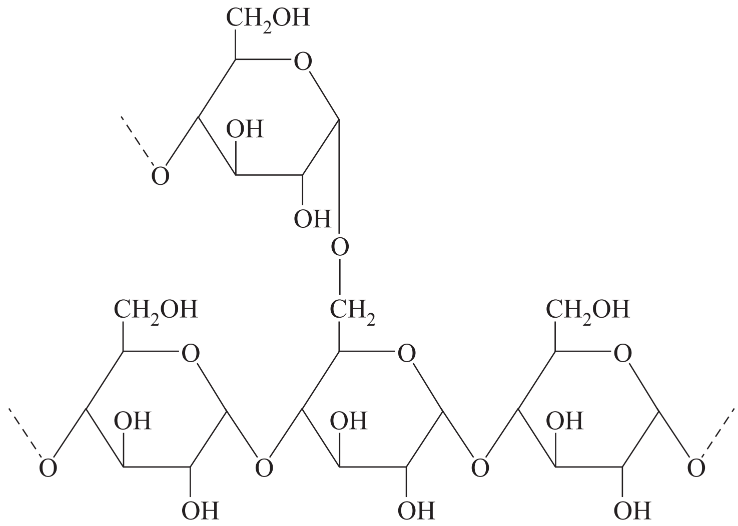
lactose



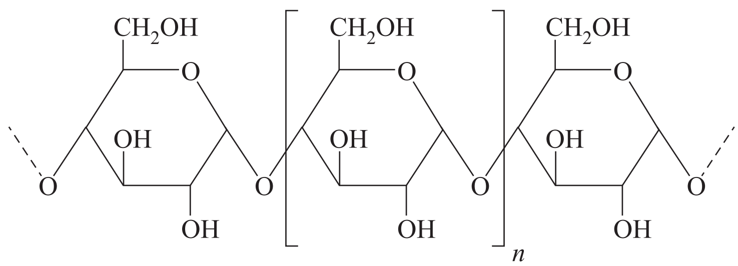
aspartame



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

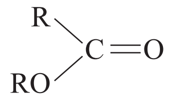
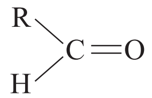
14. Characteristic ranges for infra-red absorption

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

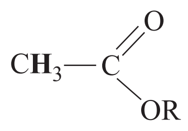
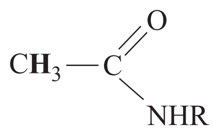
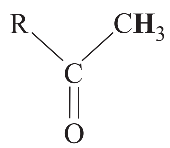
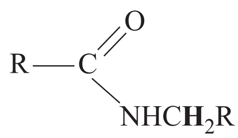
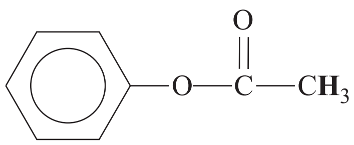
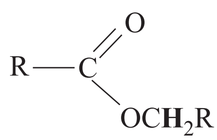
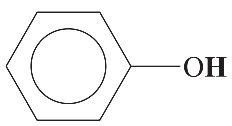
These can differ slightly in different solvents.

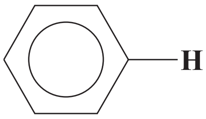
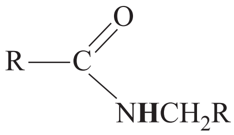
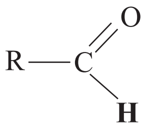
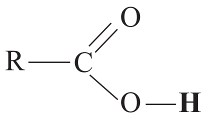
Type of carbon	Chemical shift (ppm)
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$, $R_3C–NR$	35–70
$R–CH_2–OH$	50–90
RC≡CR	75–95
$R_2C=CR_2$	110–150
RCOOH	160–185
	165–175
	190–200
$R_2C=O$	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

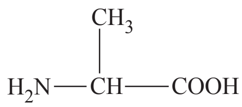
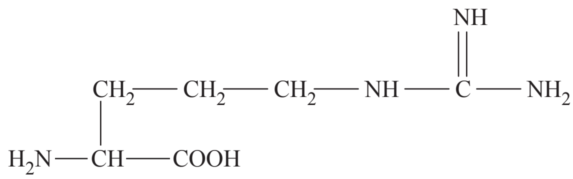
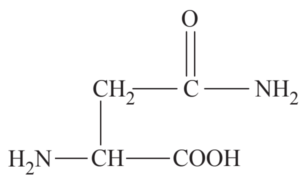
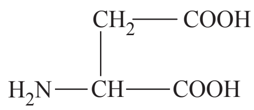
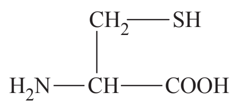
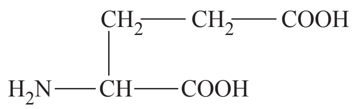
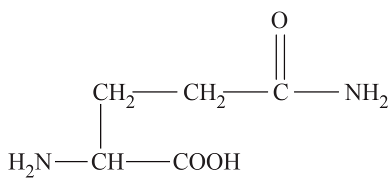
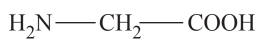
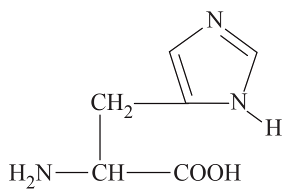
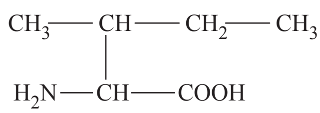
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

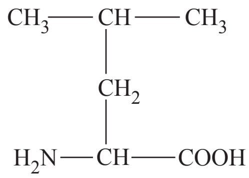
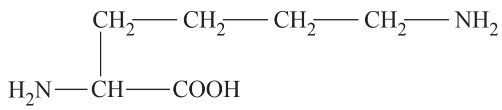
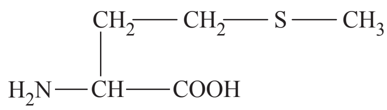
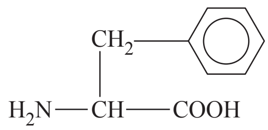
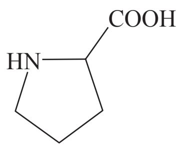
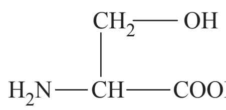
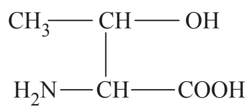
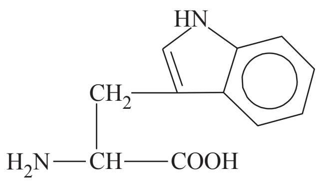
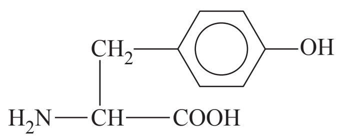
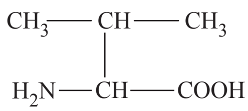
Type of proton	Chemical shift (ppm)
R–C**H**$_3$	0.9–1.0
R–C**H**$_2$–R	1.3–1.4
RCH=CH–C**H**$_3$	1.6–1.9
R$_3$–C**H**	1.5
 or 	2.0
	2.1–2.7
R–C**H**$_2$–X (X = F, Cl, Br or I)	3.0–4.5
R–C**H**$_2$–OH, R$_2$–C**H**–OH	3.3–4.5
	3.2
R—O—C**H**$_3$ or R—O—C**H**$_2$R	3.3–3.7
	2.3
	3.7–4.8
R–O–**H**	1–6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