Neap

Trial Examination 2022

VCE Chemistry Unit 3

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	6	6	55
			Total 75

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 booklet of 18 pages

Data booklet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet 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 booklet.

You may keep the data booklet.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2022 VCE Chemistry Units 3&4 Written Examination.

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 booklet are **not** drawn to scale.

Question 1

Which one of the following statements is correct when comparing a galvanic cell with an electrolytic cell?

A. The anode is positive in a galvanic cell only.

B. Oxidation occurs at the negative electrode in both types of cell.

C. Reduction occurs at the cathode in an electrolytic cell only.

D. Only an electrolytic cell uses a non-spontaneous redox reaction.

Use the following information to answer Questions 2 and 3.

The following reaction is used in a secondary cell at high temperature to produce electrical energy.

$$2Na(l) + S(l) \rightarrow Na_2S(l)$$

Question 2

Which one of the following energy transformations does **not** occur at any time in the operation of the cell?

A. chemical energy to electrical energy

B. chemical energy to heat energy

C. electrical energy to chemical energy

D. heat energy to chemical energy

Question 3

Which one of the following features enables the cell to be recharged?

A. Two electrodes made from an inert material are used.

B. The molten electrolyte allows ions to flow easily through the cell.

C. The products of the reaction remain in contact with the electrodes.

D. Electrical energy is produced using a spontaneous redox reaction.

Use the following information to answer Questions 4–6.

Information relating to a particular chemical reaction is shown in the following table.

Activation energy	Enthalpy change
250 kJ mol^{-1}	+206 kJ mol^{-1}

Question 4

The following statements refer to this chemical reaction.

I The reaction is exothermic or heat-consuming.

II The reaction is not likely to be spontaneous at room temperature.

III The energy of the products is greater than the energy of the reactants.

IV Heating the reaction will lower the activation energy.

Which of the statements are correct?

A. I and II only

B. II and III only

C. I, II and III only

D. II, III and IV only

Question 5

Which of the values in the table would change if a catalyst were introduced into the reaction?

A. activation energy only

B. enthalpy change only

C. both activation energy and enthalpy change

D. neither activation energy nor enthalpy change

Question 6

What is the activation energy of the uncatalysed reverse reaction?

A. –250 kJ mol^{-1}

B. 44 kJ mol^{-1}

C. 250 kJ mol^{-1}

D. 456 kJ mol^{-1}

Use the following information to answer Questions 7–9.

Carbon monoxide gas, CO, can be used as a fuel but is highly dangerous to humans if not used with great care.

Question 7

CO gas is classified as a fuel because all fuels are chemicals that

A. react with oxygen to produce energy in an exothermic reaction.

B. contain carbon and will burn to produce heat energy.

C. are comprised of carbon and oxygen and will burn in air.

D. contain energy that can be released relatively easily.

Question 8

CO gas can be produced during several reactions.

Which one of the following pairs of reactants from balanced equations is most likely to produce CO gas as a product?

A. $C + O_2 \rightarrow$

B. $2CH_4 + 3O_2 \rightarrow$

C. $C_3H_8 + 5O_2 \rightarrow$

D. $2C_8H_{18} + 25O_2 \rightarrow$

Question 9

When carbon monoxide poisoning occurs in humans, a substance known as carboxyhaemoglobin ($Hb_4(CO)_4$) is formed in an equilibrium reaction.

Which one of the following best explains why treating a victim of carbon monoxide poisoning with pure oxygen gas, O_2, is effective?

A. O_2 gas has a greater affinity for haemoglobin (Hb) than CO gas does.

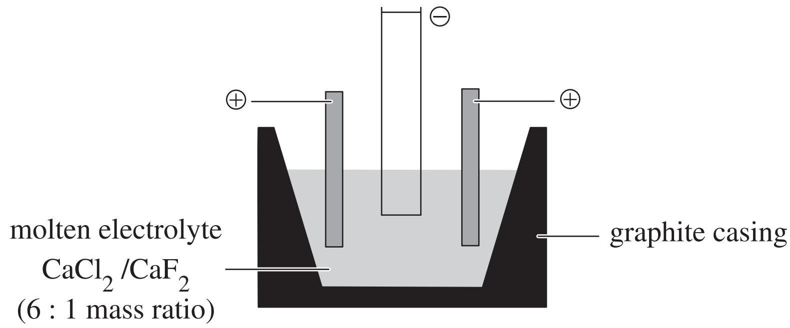
B. Any CO gas in the body reacts with O_2 to form CO_2 gas, which is exhaled.

C. The equilibrium reaction that forms $Hb_4(CO)_4$ moves towards the reactants when O_2 levels are high.

D. O_2 decreases the value of the equilibrium constant (K_c) of the reaction that forms $Hb_4(CO)_4$.

Use the following information to answer Questions 10 and 11.

The set-up for the industrial production of the metal calcium is shown in the following simplified diagram.



Question 10

The set-up uses a graphite casing. Some of the properties of graphite are as follows.

I electrical conductivity

II high melting point and boiling point

III unreactive under normal conditions

Which of the properties of the graphite casing are used in the production of calcium?

A. I and II only

B. II and III only

C. I and III only

D. I, II and III

Question 11

A molten electrolyte is used in this electrolysis because

A. aqueous solutions are too bulky and expensive to transport.

B. melting ionic substances allows ions to be present in the electrolyte.

C. electrolysis of aqueous solutions of calcium ions would not produce calcium.

D. water is a stronger reductant than calcium and so calcium would not be formed.

Question 12

25.0 mL of ethyne, C_2H_2, at standard laboratory conditions (SLC) is burnt in excess oxygen.

What is the maximum number of kilojoules of energy that could be released?

A. 1.31

B. 1.57

C. 806

D. 967

Use the following information to answer Questions 13 and 14.

At a particular temperature, T_1°C, the equilibrium constant (K_c) for the following exothermic reaction is 0.95 M^{-1}.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

Question 13

A sample of nitric oxide gas, NO, and oxygen gas, O_2, was placed in a sealed container and allowed to reach equilibrium at T_1°C. When the volume of the container was then doubled but the temperature was not changed, the concentration of the gases in the mixture instantly halved.

Which of the following statements is correct?

A. When the gas mixture reaches equilibrium again, the K_c will be 0.48 M^{-1}.

B. When the gas mixture reaches equilibrium again, the K_c will be 0.95 M^{-1}.

C. When the gas mixture reaches equilibrium again, the K_c will be 1.9 M^{-1}.

D. The value of the K_c can only be determined if the concentration of each gas is known.

Question 14

What is the magnitude of the K_c for the reaction $NO_2(g) \rightleftharpoons NO(g) + \frac{1}{2}O_2(g)$ at T_1°C?

A. 0.48

B. 0.95

C. 1.03

D. 1.05

Question 15

Which one of the following descriptions applies to biodiesel and not to petrodiesel?

A. is classified as a transport fuel, which is not renewable

B. absorbs almost no moisture from the surrounding air

C. exhibits a decrease in viscosity when temperatures are lowered

D. may have problems with flow along fuel lines in cold weather

Use the following information to answer Questions 16 and 17.

Hydrogen gas, H_2, can be produced using different methods, including the following.

I electrolysis of sea water: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

II steam reforming of methane: $CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$

Question 16

Which one of the following statements about these methods of production is correct?

A. Method I has no environmental impact because sea water is regenerated.

B. Method I is unsustainable as electricity for electrolysis can only be produced from fossil fuels.

C. Method II could be sustainable if the methane were produced from biogas.

D. Method II damages the environment as it produces a greenhouse gas.

Question 17

Petrol engines in cars can be modified so that H_2 gas can be used as fuel. H_2 gas can also be used in fuel cells fitted into specially designed cars.

Which one of the following is a significant issue associated with the use of H_2 gas in cars?

A. safety concerns due to mixtures of H_2 gas and air being explosive

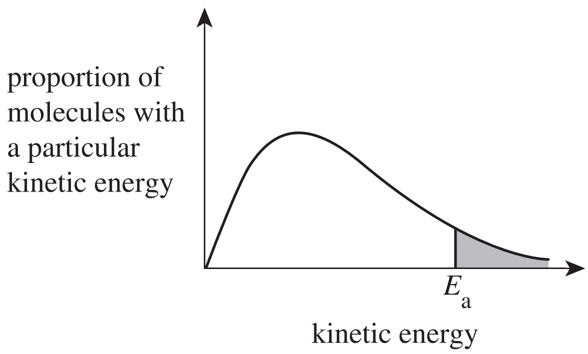
B. the low heat of combustion of H_2 gas compared to other fuels

C. the requirement of very high temperature or low pressure to store a useful amount of fuel

D. the inability to ever produce H_2 gas on a large scale for transport purposes

Question 18

The Maxwell-Boltzmann distribution curve for the reactant gas particles at a set temperature for a particular reaction is shown below.



If the temperature of the gas particles were lowered, the height of the curve would

A. not change, but the shaded area would increase.

B. decrease and the shaded area would increase.

C. not change, but the shaded area would decrease.

D. increase and the shaded area would decrease.

Use the following information to answer Questions 19 and 20.

The following reaction was used in an investigation into the factors affecting the rate of reaction.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Four numbered test tubes were used in the investigation. Their contents are shown in the table below.

Test tube	1	2	3	4
Contents	5 mL of 2 M HCl(aq) + 5 mL of water + 1 g zinc granules	10 mL of 2 M HCl(aq) + 1 g zinc granules	10 mL of 2 M HCl(aq) + 1 g zinc powder	10 mL of 2 M HCl(aq) + 1 g zinc powder
Initial temperature of contents	20°C	20°C	30°C	20°C

Question 19

Which one of the following shows the test tubes in order of decreasing rate of reaction of zinc, Zn, with hydrochloric acid, HCl?

A. 3, 4, 2, 1

B. 1, 2, 4, 3

C. 3, 1, 2, 4

D. 1, 2, 3, 4

Question 20

Various factors in the investigation could be measured over time.

Which one of the following measured factors could **not** be used to determine the rate of reaction?

A. volume of the liquid contents

B. temperature of the liquid contents

C. volume of the hydrogen gas, H_2, evolved

D. mass of the test tube and contents

END OF SECTION A

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SECTION B

Instructions for Section B

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

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

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

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

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

Question 1 (9 marks)

An important step in the industrial production of sulfuric acid is the oxidation of sulfur dioxide gas, SO_2, which occurs according to the following equation.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

a. Using collision theory, outline the conditions of pressure that would produce the fastest rate of reaction. 2 marks

b. Using Le Chatelier's principle, explain the conditions of pressure that would produce the highest yield. 2 marks

c. Discuss the reasons why the condition of pressure used for the economical industrial manufacture of sulfuric acid is atmospheric pressure. 2 marks

d. The table below shows three features of the industrial process that is used for the oxidation of sulfur dioxide.

Explain why each feature is used. 3 marks

Feature	**Explanation**
The catalyst $V_2O_5(s)$ is spread out over a number of shallow trays.	
Reactant gases are passed progressively over each catalyst tray.	
Reactant gases are cooled after being passed over each catalyst tray before being passed over the next catalyst tray.	

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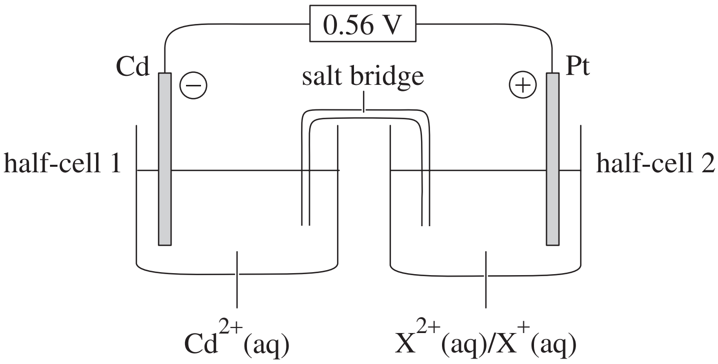
Question 2 (9 marks)

a. The following galvanic cell was constructed under standard laboratory conditions (SLC).



i. Write the half-cell equation for the reaction that occurs at the cathode. 1 mark

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ii. Write the balanced ionic equation for the overall reaction of the cell. 2 marks

____

____

iii. Determine the standard electrode potential for the following half-cell reaction. 1 mark

$$X^{2+}(aq) + e^{-} \rightarrow X^{+}(aq)$$

____

____

iv. Do the positive ions in the salt bridge move towards half-cell 1 or half-cell 2 when the cell is operating? 1 mark

____

b. Some half-reactions from an electrochemical series are shown in the following table in no particular order.

A	$MnO_2(s) + 4H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$
B	$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
C	$PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$
D	$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$

Under SLC, a series of cells was made by connecting different half-cells that use reactions A–D. The observations were recorded in the following table.

Cell	Half-cells	Observations
1	A and C	Half-cell C contained the anode.
2	A and D	The pH of the electrolyte in half-cell A decreased.
3	B and C	The concentration of chromium ions increased.

i. Identify the weaker reductant in cell 1. 1 mark

____

ii. Identify the stronger oxidant in cell 2. 1 mark

____

iii. Using the letters A, B, C and D, list the half-reactions in order of decreasing standard electrode potential (E^0 value). 2 marks

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Question 3 (10 marks)

An experiment was conducted to determine the value of Faraday's constant (F). An aqueous solution of iron(III) nitrate, $Fe(NO_3)_3$, was electrolysed using inert electrodes in a single beaker. During the electrolysis, a steady current of 3.216 A was passed for 15.0 minutes and 0.567 g of iron was deposited on one of the electrodes.

a. Explain why the electrolysis could be completed in a single beaker whereas a galvanic cell uses electrodes in two separate half-cells. 2 marks

b. **i.** Is the polarity of the electrode on which the iron was deposited positive or negative? 1 mark

ii. Write the balanced half-equation for the deposition of iron. 1 mark

c. **i.** Calculate the amount of iron, in moles, deposited and, hence, determine the amount of electrons, in moles, passing through the cell. 2 marks

ii. Calculate the amount of charge, in coulombs, that passed through the cell. 1 mark

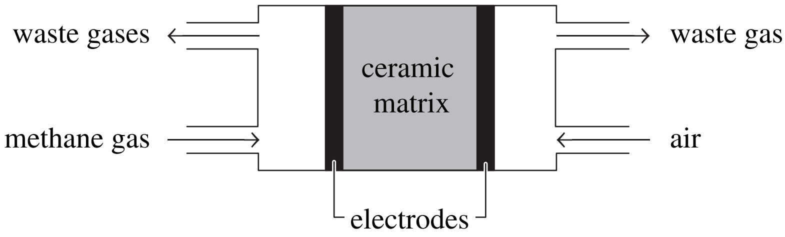
iii. Using the values calculated in **parts c.i.** and **c.ii.**, determine a value for Faraday's constant (the charge carried by one mole of electrons). 1 mark

d. The value for Faraday's constant obtained in **part c.iii.** is lower than the expected value.

Identify and explain **one** possible source of error in the experiment that could account for the lower-than-expected value. 2 marks

Question 4 (7 marks)

The simplified diagram below shows the design of a solid ceramic fuel cell that uses methane gas as the energy source. The electrodes used are metallic with embedded catalytic particles.



a. At the cathode, oxygen gas in air is converted to oxide ions.

i. Write a half-equation for this reaction in the gaseous state. 1 mark

____

ii. Explain why the cathode is both metallic and catalytic. 2 marks

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iii. Gaseous oxide ions travel through the ceramic matrix from the cathode to the anode. At the anode, oxide ions react with methane.

Write a half-equation for this reaction in the gaseous state. 2 marks

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b. The fuel cell is designed to be used for the domestic generation of electricity.

Why is the cell more efficient at generating electricity compared to using methane in a power generation facility? 2 marks

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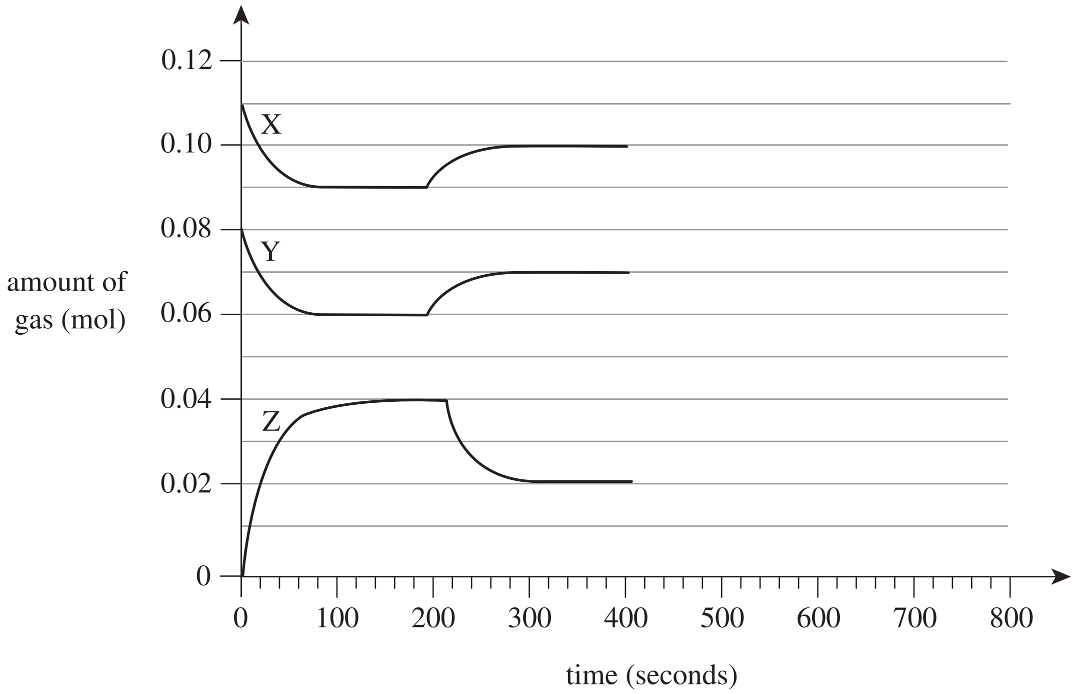
Question 5 (9 marks)

An experiment involving gases X, Y and Z was conducted to investigate homogeneous equilibria. Initially, two reactant gases were injected into an empty, sealed 2.00 L vessel. The results are displayed in the following graph.



a. The reaction that occurred is represented by the following balanced chemical equation.

$$X(g) + Y(g) \rightleftharpoons 2Z(g)$$

Explain how this equation could be deduced from the information shown in the graph. 2 marks

b. Calculate the value of the equilibrium constant (K_c) at 150 seconds. 3 marks

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c. The equilibrium mixture was cooled at 200 seconds.

Explain how it can be deduced that the forward reaction is endothermic. 2 marks

d. **i.** At 400 seconds, 0.02 mol of gas Z was injected instantaneously into the vessel.

Draw this change on the graph on page 16. 1 mark

ii. By 600 seconds, the system reached equilibrium again.

On the graph on page 16, draw the expected changes for gas Y between 400 and 600 seconds. 1 mark

Question 6 (11 marks)

When 6.154 g of the hydrocarbon benzene, C_6H_6, is burnt in excess oxygen, O_2, 258.0 kJ of energy is released.

a. Write the thermochemical equation for the complete combustion of liquid C_6H_6.
In your answer, give the enthalpy change (ΔH) in kJ mol^{-1}. 4 marks

b. Calculate the volume of carbon dioxide (CO_2) gas produced at 15.0°C and 1.15 atm when 3.98 mol of benzene is burnt completely in O_2. 3 marks

c. Calculate the mass of liquid C_6H_6 that must be completely burnt to heat 500 g of water from 18.1°C to 87.6°C if the heating process is only 67% efficient. 4 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2022

VCE Chemistry Unit 3

Written Examination

Data Booklet

Instructions

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

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1. Periodic table of the elements

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

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** 30.1 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 homium	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 the 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
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+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	$n\left(e^-\right) = \frac{Q}{F}$
% 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

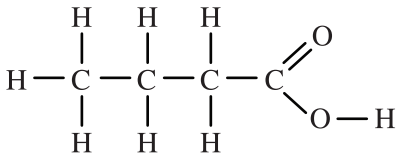
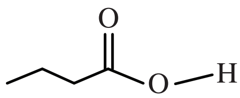
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

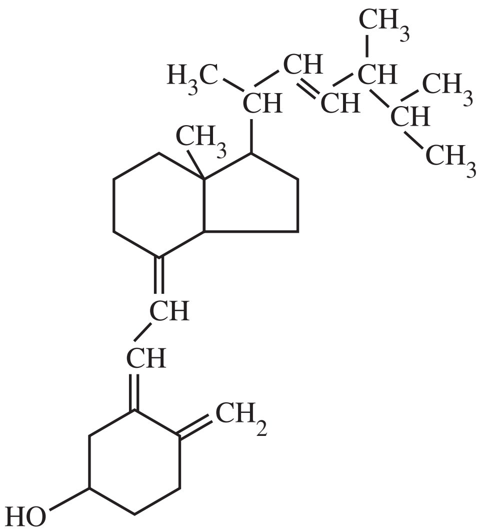
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

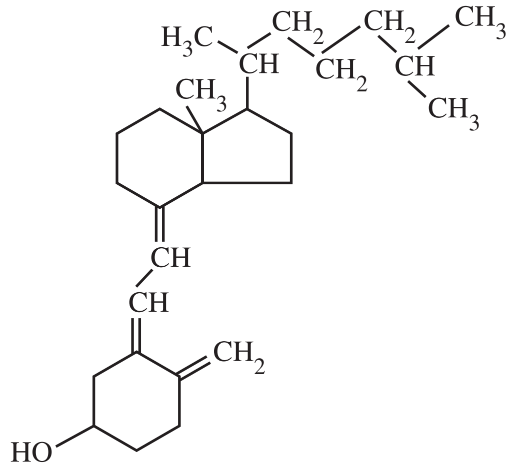
9. Formulas of some fatty acids

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

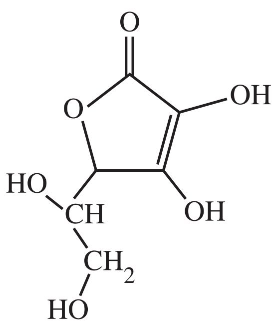
10. Formulas of some biomolecules



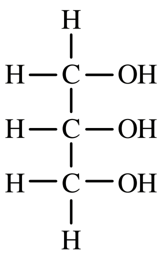
vitamin D_2 (ergocalciferol)



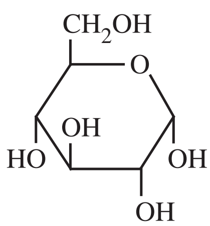
vitamin D_3 (cholecalciferol)



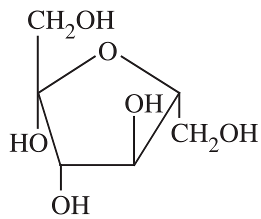
vitamin C (ascorbic acid)



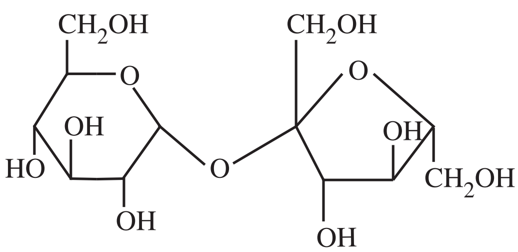
glycerol



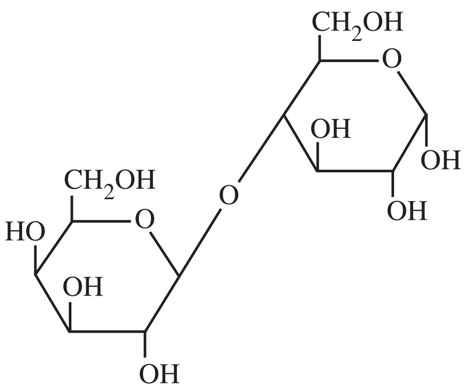
α-glucose



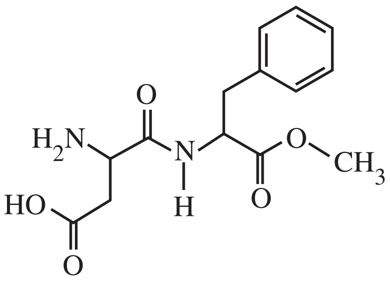
β-fructose



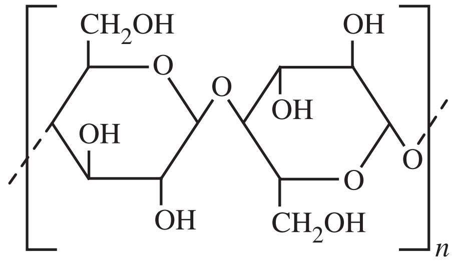
sucrose



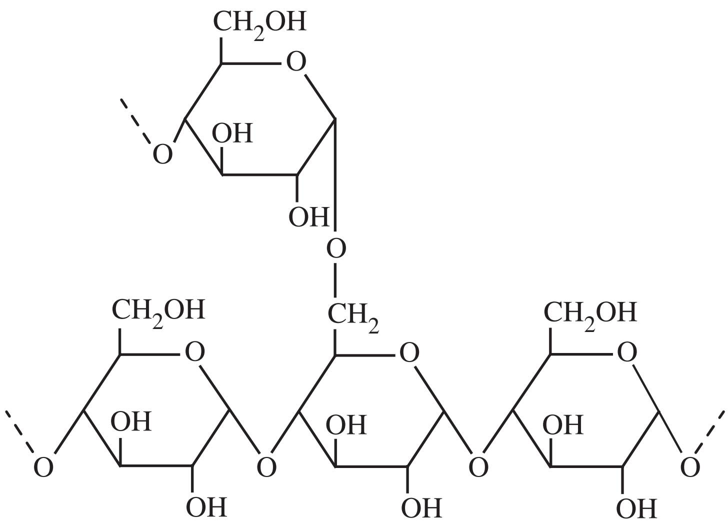
α-lactose



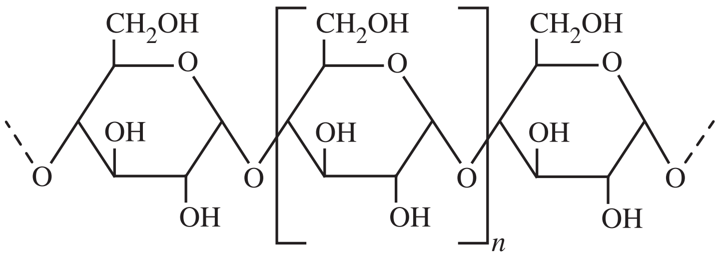
aspartame



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

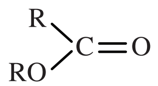
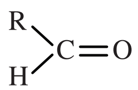
14. Characteristic ranges for infra-red absorption

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

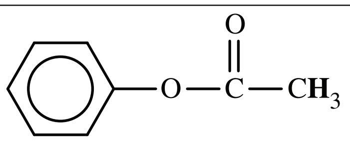
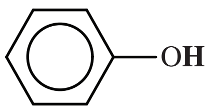
These can differ slightly in different solvents.

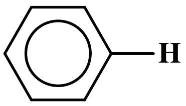
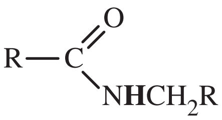
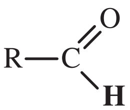
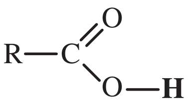
Type of carbon	Chemical shift (ppm)
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$, $R_3C–NR$	35–70
$R–CH_2–OH$	50–90
RC≡CR	75–95
$R_2C=CR_2$	110–150
RCOOH	160–185
	165–175
	190–200
$R_2C=O$	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

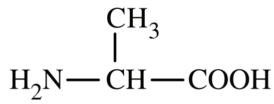
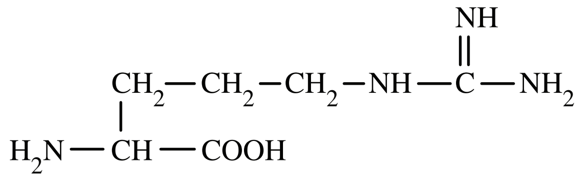
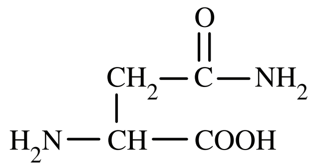
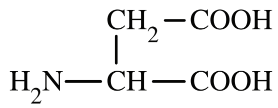
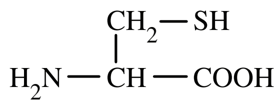
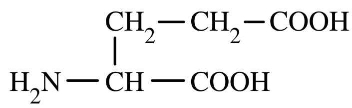
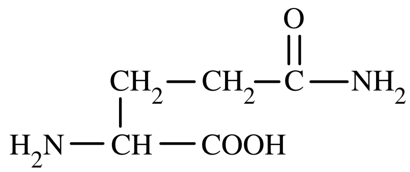
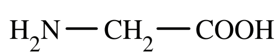
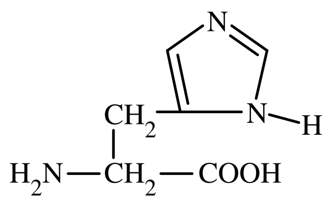
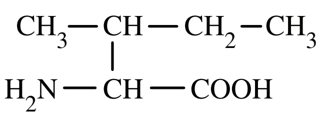
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

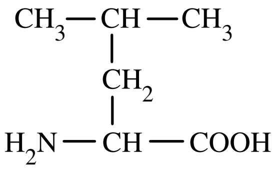
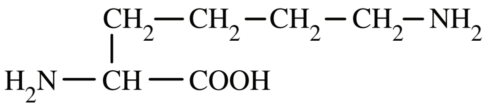
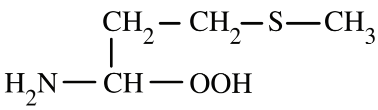
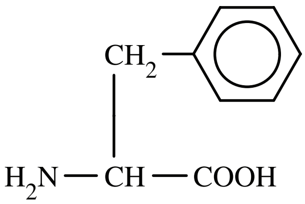
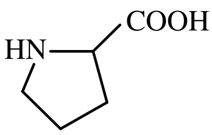
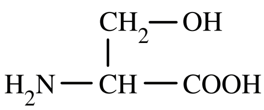
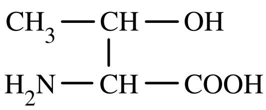
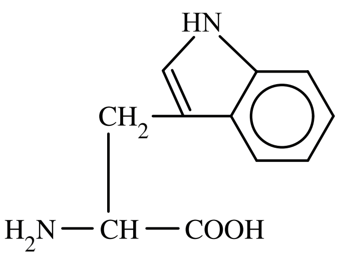
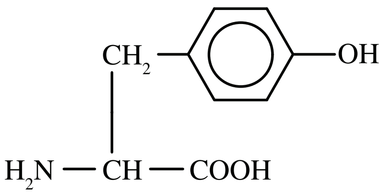
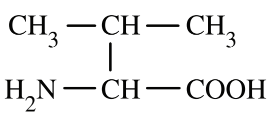
Type of proton	Chemical shift (ppm)
$R{-}C\mathbf{H}_3$	0.9–1.0
$R{-}C\mathbf{H}_2{-}R$	1.3–1.4
$RCH{=}CH{-}C\mathbf{H}_3$	1.6–1.9
$R_3{-}C\mathbf{H}$	1.5
$C\mathbf{H}_3{-}C({=}O){-}OR$ or $C\mathbf{H}_3{-}C({=}O){-}NHR$	2.0
$R{-}C({=}O){-}C\mathbf{H}_3$	2.1–2.7
$R{-}C\mathbf{H}_2{-}X$ (X = F, Cl, Br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

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

17. 2-amino acids (α-amino acids)

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

Name	Symbol	Structure
alanine	Ala	
arginine	Arg	
asparagine	Asn	
aspartic acid	Asp	
cysteine	Cys	
glutamic acid	Glu	
glutamine	Gln	
glycine	Gly	
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 BOOKLET

Neap

Trial Examination 2022

VCE Chemistry Unit 3

Written Examination

Multiple-choice Answer Sheet

Student's Name: ______________________________

Teacher's Name: ______________________________

Instructions

Use a **pencil** for **all** entries. If you make a mistake, **erase** the incorrect answer – **do not** cross it out.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than **one** answer is completed for any question.

All answers must be completed like this example: A B C D

Use pencil only

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D