Neap

Trial Examination 2020

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

Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided 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 and hand them in.

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 2020 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

Le Chatelier's principle states that a change made to

A. any chemical reaction will be completely opposed.
B. any chemical reaction will be partially opposed.
C. a system at equilibrium will be completely opposed.
D. a system at equilibrium will be partially opposed.

Use the following information to answer Questions 2 and 3.

Carbon monoxide poisoning can lead to rapid death of a victim.

Question 2

Which one of the following situations is **most** likely to lead to carbon monoxide poisoning?

A. mowing lawns on a hot, still day
B. using an electrical motor without adequate ventilation
C. running a combustion engine in a confined space
D. burning fuel with an abundant supply of oxygen gas

Question 3

What is the result of the recommended treatment (administering pure oxygen) for carbon monoxide poisoning?

A. Carbon monoxide is converted to carbon dioxide.
B. The total mass of haemoglobin in the body increases.
C. Oxygen-carrying molecules are made available.
D. Carbon is removed from carbon monoxide, leaving only oxygen in the body.

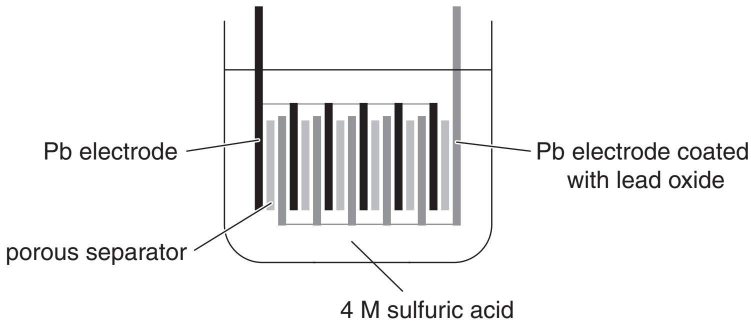
Question 4

Which one of the following energy transformations does **not** occur in either an electrolytic cell or a galvanic cell?

A. heat energy to electrical energy
B. chemical energy to heat energy
C. electrical energy to chemical energy
D. chemical energy to electrical energy

Use the following information to answer Questions 5–7.

The diagram below shows the design of a rechargeable lead–acid battery.



Question 5

What feature does the lead–acid battery have in common with a primary galvanic cell?

A. The products of the cell reaction remain in contact with the electrodes.
B. Spontaneous redox reactions are used to generate electricity.
C. The cathode is always the negative electrode of the cell.
D. During discharge, oxidation occurs at the positive electrode.

Question 6

Suggested functions of the porous separator in a battery include the following:

I It allows ions to pass through.
II It provides a path for electrons to transfer.
III It prevents the electrodes from coming into contact.

Which of these functions are correct of the separator in the lead–acid battery?

A. I and II only
B. II and III only
C. I and III only
D. I, II and III

Question 7

The electromotive force (emf) of the lead–acid battery is 12 V but the battery will need recharging after continued use.

Which electrode of the battery should be connected to the positive terminal of the power recharger, and what voltage must be applied in recharging?

	Electrode of battery connected to the positive terminal of the power recharger	Voltage applied in recharging
A.	positive	exactly 12 V
B.	negative	exactly 12 V
C.	positive	more than 12 V
D.	negative	more than 12 V

Question 8

A dilute solution of lithium iodide, LiI(aq), is electrolysed using carbon electrodes.

What product is likely to be formed at the anode?

A. I_2

B. Li

C. OH^-

D. O_2

Question 9

What is the maximum volume of carbon dioxide gas, measured at 110 kPa and 30°C, that could be produced by the complete combustion of 65.0 g of octane?

A. 10.0 L

B. 13.0 L

C. 84.0 L

D. 104 L

Question 10

When 500 g of pure water at 20°C is heated using the energy from the complete combustion of 2.0 g of ethanol, the maximum possible final temperature of the water would be

A. 28°C

B. 48°C

C. 68°C

D. 88°C

Question 11

Aluminium is produced industrially by the reduction of Al^{3+} ions in an electrolytic cell using a current of 35 000 A.

How many kilograms of aluminium could be produced per hour, assuming 100% efficiency?

A. 11.8

B. 35.3

C. 106

D. 183

Question 12

Features present in different electrochemical cells include:

I catalytic electrodes

II electrodes made from inert material

III non-porous electrodes

IV electrodes with a large surface area

Which of these features are likely to be present in the hydrogen–oxygen fuel cell?

A. I and II only

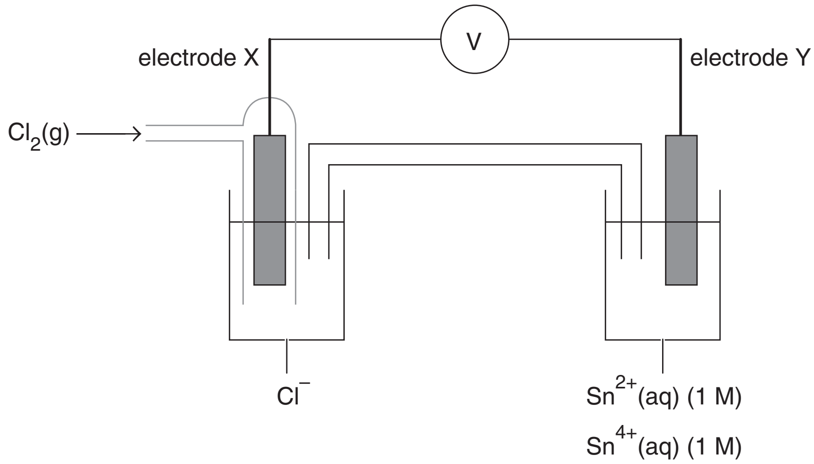
B. I, II and IV only

C. III and IV only

D. II, III and IV only

Question 13

The cell shown below is set up under standard conditions. The electrodes are made of platinum.



Which one of the following occurs when the cell is producing electrical energy?

A. Electrode Y is positive.

B. The chloride ion concentration decreases.

C. Hydrogen gas forms at electrode Y.

D. The double-charged tin ion concentration decreases.

Question 14

In an experiment, two beakers are set up under standard laboratory conditions as follows:

Beaker 1: 1.5 g of pure magnesium in 50 mL of 1.0 M Mn^{2+} solution

Beaker 2: 1.5 g of pure magnesium in 50 mL of 1.0 M Fe^{3+} solution

The following statements relate to the results of the experiment:

I The reaction in beaker 1 will be non-spontaneous.

II The reaction in beaker 2 must reach completion first.

III The reaction in beaker 1 has a smaller K_c value.

Which of these statements is/are **incorrect**?

A. I only

B. I and II only

C. II and III only

D. I, II and III

Use the following information to answer Questions 15 and 16.

The formation of sulfur trioxide gas from sulfur dioxide gas is shown in the equation below.

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

The activation energy for the reaction is 460 kJ mol^{-1}. The value of the equilibrium constant for the reaction at 500°C is 398 M^{-1}.

Question 15

If additional oxygen is added to an equilibrium mixture at constant volume and temperature, the reaction will move to the

A. right to re-establish equilibrium because the concentration fraction is less than the equilibrium constant.

B. right to re-establish equilibrium because the concentration fraction is greater than the equilibrium constant.

C. left to re-establish equilibrium because the concentration fraction is greater than the equilibrium constant.

D. left to re-establish equilibrium because the concentration fraction is less than the equilibrium constant.

Question 16

Consider the reaction shown below.

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

Which one of the following shows the correct values for the activation energy (kJ mol^{-1}) and the magnitude of the equilibrium constant for the reaction at 500°C?

	Activation energy	Equilibrium constant
A.	657	–398
B.	263	2.5×10^{-3}
C.	263	–398
D.	657	2.5×10^{-3}

Question 17

The combustion of a component of biodiesel is represented by the equation below.

$$2C_{17}H_{34}O_2(l) + 49O_2(g) \rightarrow 34CO_2(g) + 34H_2O(g) \quad \Delta H = -1.18 \times 10^4 \text{ kJ mol}^{-1}$$

According to the equation, what mass of greenhouse gases would be produced for each megajoule of energy released in the combustion of the biodiesel component?

A. 127 g

B. 179 g

C. 127 kg

D. 179 kg

 CHEMU3_QA_2020.FM

Use the following information to answer Questions 18 and 19.

The metals P, Q and R were tested separately for any reaction in solutions of the metal ions. The results are shown in the table below.

P in Q^{2+} solution	**Q in R^{2+}solution**	**R in P^{2+} solution**
no reaction	metal R forms	no reaction

Question 18

The order of increasing oxidising strength is

A. $Q^{2+} < P^{2+} < R^{2+}$

B. $Q < P < R$

C. $R^{2+} < P^{2+} < Q^{2+}$

D. $R < P < Q$

Question 19

The metals were also tested separately with a 1 M H^+ solution.

Which one of the following shows the likely results of this test?

A. Only metals P and Q will react.

B. Only metals Q and R will react.

C. All of the metals will react.

D. The information supplied is insufficient to predict likely results.

Question 20

In the Maxwell–Boltzmann distribution curve, which one of the following is **not** changed when a sample of a gas is heated in a sealed container?

A. height of the curve

B. position of the peak of the curve

C. total area under the curve

D. average kinetic energy of the particles

END OF SECTION A

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 booklet are **not** drawn to scale.

Question 1 (8 marks)

Zinc is an important and widely used metal that is extracted from zinc sulfide (ZnS) ore using different methods.

a. The first stage in extracting zinc from ZnS involves heating the ore very strongly in a current of air. The following equation shows the reaction that occurs:

$$2ZnS(s) + 3O_2(g) \rightleftharpoons 2ZnO(s) + 2SO_2(g)$$

i. With reference to equilibrium principles, explain why a **current** of air is used. 2 marks

____

____

____

____

____

____

ii. Suggest a reason why pure oxygen is **not** used in this reaction. 1 mark

____

____

b. One method used to isolate the zinc metal is to heat zinc oxide in a furnace using an industrial fuel called coke. Coke is essentially carbon with air pockets. In the furnace, the coke burns and produces carbon monoxide and other products. The carbon monoxide then reduces the zinc oxide, as shown by the following equation:

$$ZnO(s) + CO(g) \rightarrow Zn(g) + CO_2(g)$$

Write a balanced equation for the formation of the carbon monoxide by the combustion of carbon. 1 mark

____

 CHEMU3_QA_2020.FM

c. A large majority of zinc is produced industrially by electrolysis. Zinc oxide is reacted with sulfuric acid to produce an aqueous solution of zinc sulfate that is diluted further to produce the electrolyte in the electrolytic cell.

i. Zinc is formed on one of the electrodes.

Identify the polarity (positive or negative) and name (anode or cathode) of this electrode. 1 mark

___

ii. Use the electrochemical series to predict the reaction that will occur at the other electrode and write the half-equation for this reaction. 1 mark

___

iii. Explain why zinc can be produced in an electrolytic cell using an aqueous solution as the electrolyte, whereas magnesium can only be produced using a molten electrolyte. 2 marks

___

___

___

___

___

___

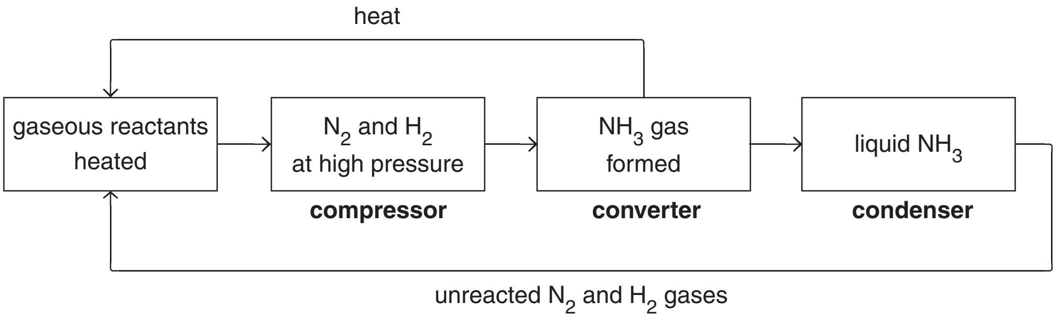
Question 2 (14 marks)

Australian scientists are working to develop a process by which the fuel hydrogen gas can be manufactured in Australia and exported overseas as liquid ammonia (NH_3). After delivery overseas, the ammonia would be reconverted to nitrogen and hydrogen gases.

a. Ammonia gas is produced from nitrogen and hydrogen gases according to the following chemical equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The main steps in the industrial manufacture of ammonia are shown in the flow chart below.



i. Based on the information provided above, explain whether the chemical reaction generating ammonia is endothermic **or** exothermic. 2 marks

____

____

____

ii. Explain why the reactant gases are used at high pressure in the compressor. 2 marks

____

____

____

____

iii. The process of ammonia production shown in the flow chart illustrates a conflict between the optimal condition needed for a high rate of reaction and the optimal condition needed for a high yield of product.

Outline the nature of this conflict and suggest how the conflict is resolved. 3 marks

____

____

____

____

____

____

b. The hydrogen gas will be produced by electrolysing water, using electricity generated by solar energy or wind power.

i. Write the equation for the reaction that produces hydrogen at one electrode in the electrolytic cell used to produce hydrogen gas. 1 mark

____

ii. Explain why hydrogen gas is **not** classed as a biofuel. 1 mark

____

____

____

iii. Explain why hydrogen gas **may** be classed as a renewable fuel. 1 mark

____

____

____

iv. Write a balanced thermochemical equation for the complete combustion of hydrogen gas. 2 marks

____

c. Suggest **two** advantages of transporting hydrogen gas fuel overseas as liquid ammonia rather than as hydrogen gas. 2 marks

____

____

____

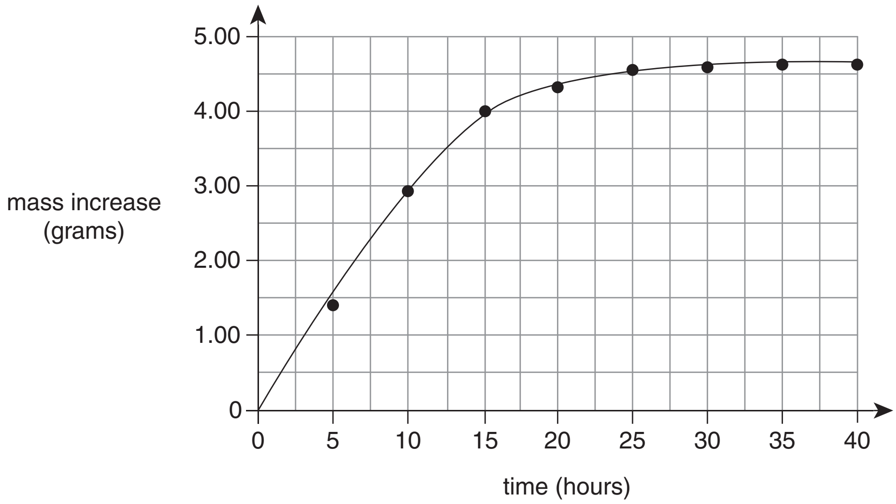
____

Question 3 (9 marks)

Heat packs are available for hikers and bushwalkers to warm parts of the body in cold conditions. These heat packs consist of powdered iron and other chemicals in a porous bag sealed in a plastic bag. When the plastic bag is torn open, oxygen from the air reacts with the iron according to the following equation:

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

One such heat pack was opened and its mass was recorded electronically at regular intervals over 40 hours. The graph below shows the change in mass of the pack against time.



a. The heat pack contained 11.2 g of powdered iron.

Calculate the volume of oxygen gas used in the reaction at standard laboratory conditions (SLC). 3 marks

b. With reference to the rate of reaction and collision theory, explain the shape of the graph in the following time intervals:

i. 15 to 25 hours 2 marks

ii. 30 to 40 hours 2 marks

 CHEMU3_QA_2020.FM

c. If the heat pack had been opened and kept in an atmosphere of pure oxygen, there may have been differences in the results.

On the graph shown on page 12, draw any changes that could be predicted if pure oxygen were used. 2 marks

Question 4 (9 marks)

Galvanic cells are used as portable power sources and are available in many different sizes and shapes.

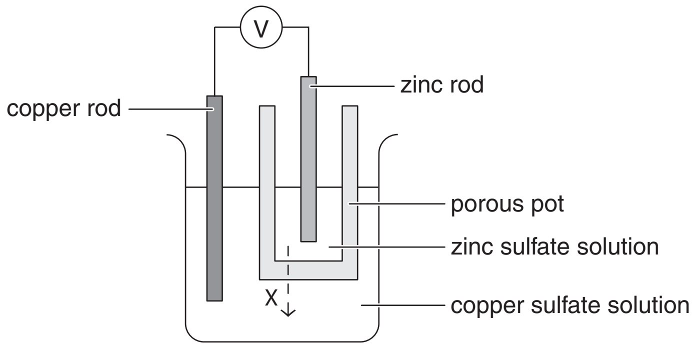
a. A novel use of a galvanic cell is a simple digital clock that can be powered by the current produced when a copper rod and zinc rod are pushed into a potato.

i. The potato acts as the salt bridge in this cell.

What important feature must the liquid in the potato exhibit to enable the cell to operate? 1 mark

ii. Write the half-equation for the reaction at the negative electrode of the cell. 1 mark

b. Copper and zinc are also used as the electrodes in the Daniell cell, as shown below.



i. Which component of this cell acts as the salt bridge? 1 mark

ii. Identify the chemical species X. 1 mark

iii. Using the electrochemical series, calculate the expected voltage of this cell. 1 mark

iv. Suggest **one** reason why the actual voltage of the cell is different to the expected voltage. 1 mark

c. A popular galvanic cell that uses a moist paste for the electrolyte is known as a 'dry' cell. An early model of the dry cell used a carbon rod as the cathode and zinc casing as the anode. The overall cell reaction is shown by the following equation:

$$Zn(s) + 2NH_4^+(aq) + 2MnO_2(s) \rightarrow Zn^{2+}(aq) + 2NH_3(aq) + Mn_2O_3(s) + H_2O(l)$$

A particular dry cell operates at 0.85 V.

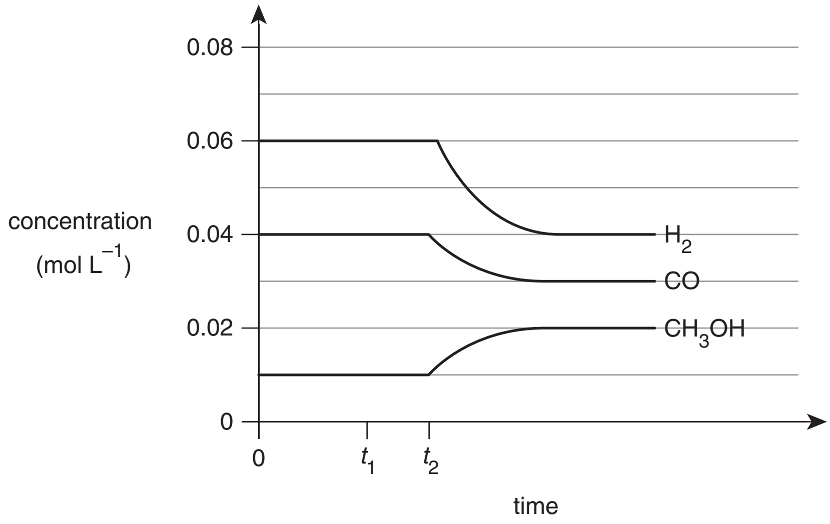
Calculate the amount of energy delivered for each 1.0 g of zinc consumed. 3 marks

Question 5 (11 marks)

Methanol is formed from carbon monoxide and hydrogen according to the following equation:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

a. The three gases were placed in a sealed vessel at a set temperature, and equilibrium was established. The graph below shows the concentration of the gases.



i. Calculate the value of K_c at time t_1. 2 marks

____

____

____

____

ii. At time t_2, the temperature of the reaction mixture was decreased.

Using the data provided, and without the use of calculations, explain whether the reaction for the formation of methanol is endothermic **or** exothermic. 2 marks

____

____

____

____

____

iii. Consider how the graph for H_2 would be affected if a suitable catalyst had also been introduced into the vessel at time t_2.

Draw any changes you would expect to see on the concentration–time graph given above**.** 2 marks

 CHEMU3_QA_2020.FM

b. Methanol can be used as a fuel by the following methods:

I used as the energy source in a fuel cell to generate electricity

II combusted to boil water to generate steam, which turns a turbine to generate electricity.

A set mass of methanol was used completely in methods I and II to generate electricity in separate experiments.

i. Outline a safety precaution that should be taken for method II. 1 mark

ii. Explain which method, if either, would produce the greater amount of electrical energy. 2 marks

iii. Explain which method, if either, would produce the greater amount of greenhouse gases. 2 marks

Question 6 (4 marks)

The following list contains statements about petrodiesel and biodiesel. There are a number of incorrect statements in the list.

1. The strongest type of intermolecular forces in biodiesel are dispersion forces.
2. Petrodiesel is extracted from crude oil without the use of chemical reactions in the oil.
3. In cold weather, petrodiesel will flow along fuel lines better than biodiesel.
4. Biodiesel will absorb more moisture from the atmosphere than petrodiesel.
5. A change in temperature will affect the viscosity of both fuel types equally.
6. Complete combustion of each fuel will yield identical products.
7. Petrodiesel is a mixture of hydrocarbons with the general formula C_nH_{2n+2}.
8. In extraction and production, only petrodiesel generates greenhouse gases.
9. Biodiesel can be produced from plant or animal material and is often a fatty acid methyl ester compound.

In the table below, identify **two** incorrect statements and explain why each statement is incorrect.

Incorrect statement number	**Explanation for why the statement is incorrect**

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2020

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.

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

1. Periodic table of the elements

Key: 79 (atomic number) Au (symbol of element) 197.0 (relative atomic mass) 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.

CHEMU3_DS_2020.FM

2. Electrochemical series

Reaction	**Standard electrode potential ($E°$) 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	$CF = \frac{VIt}{\Delta T}$
heat energy released in the combustion of a fuel	$q = mc\Delta T$
enthalpy of combustion	$\Delta H = \frac{q}{n}$
electric charge	$Q = It$
number of moles of electrons	$n(e^-) = \frac{Q}{F}$
% atom economy	$\frac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times \frac{100}{1}$
% yield	$\frac{\text{actual yield}}{\text{theoretical yield}} \times \frac{100}{1}$

4. Physical constants and standard values

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

5. Unit conversions

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

6. Metric (including SI) prefixes

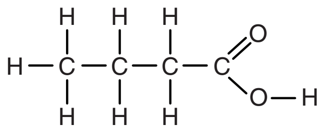
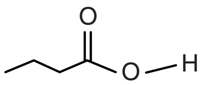
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

7. Acid–base indicators

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

8. Representations of organic molecules

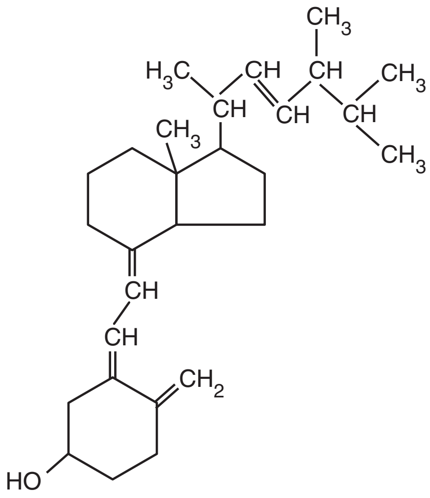
The following table shows different representations of organic molecules, using butanoic acid as an example.

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

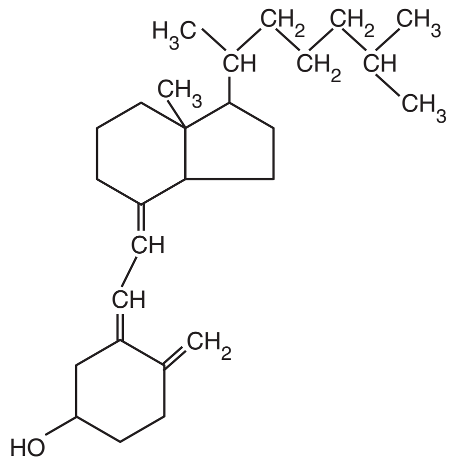
9. Formulas of some fatty acids

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

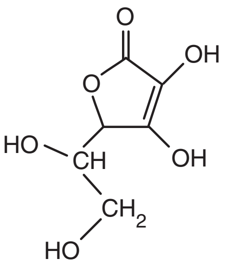
10. Formulas of some biomolecules



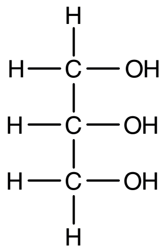
vitamin D_2 (ergocalciferol)



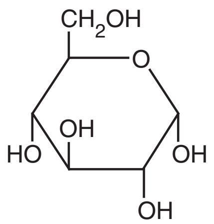
vitamin D_3 (cholecalciferol)



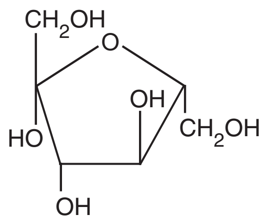
vitamin C (ascorbic acid)



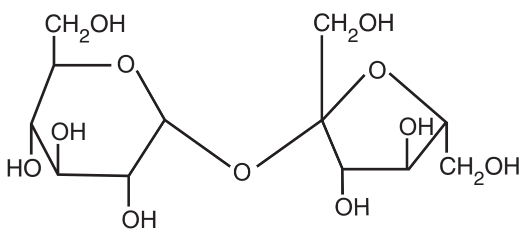
glycerol



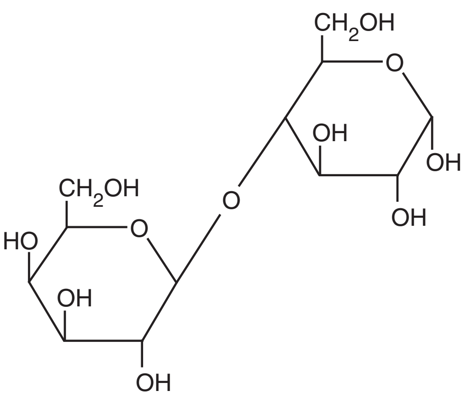
α-glucose



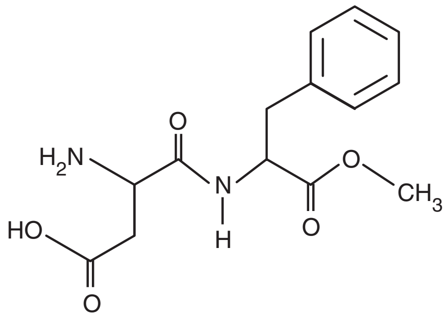
β-fructose



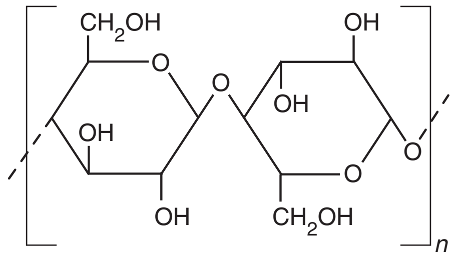
sucrose



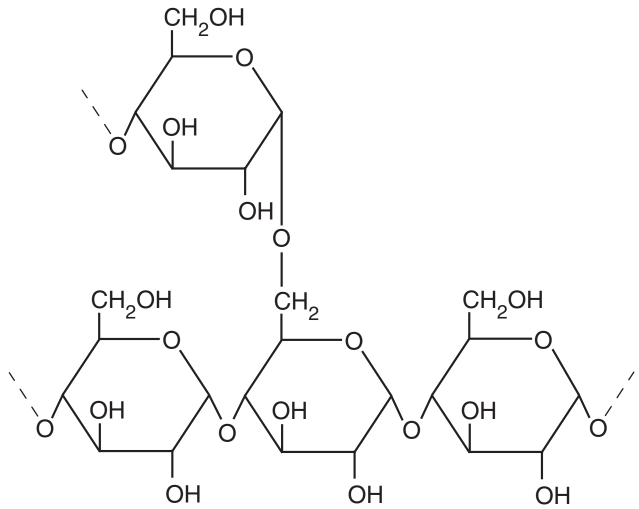
α-lactose



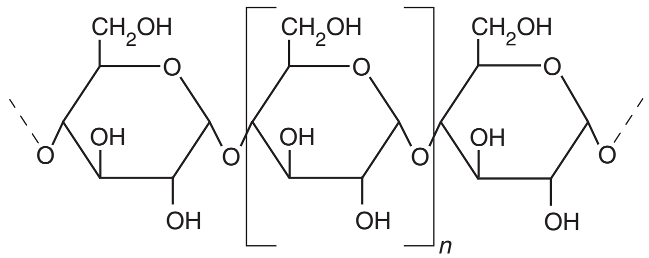
aspartame



cellulose



amylopectin (starch)



amylose (starch)

11. Heats of combustion of common fuels

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

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

12. Heats of combustion of common blended fuels

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

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

13. Energy content of food groups

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

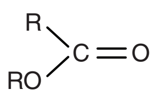
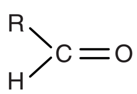
14. Characteristic ranges for infra-red absorption

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

15. ^{13}C NMR data

Typical ^{13}C shift values relative to TMS = 0

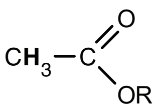
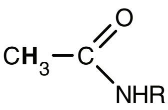
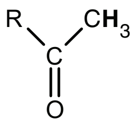
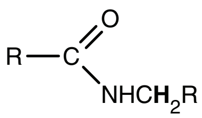
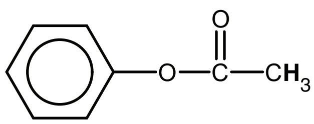
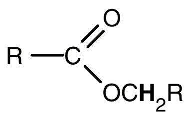
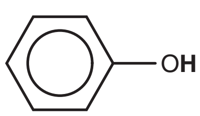
These can differ slightly in different solvents.

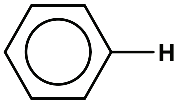
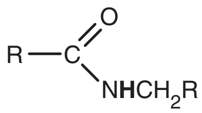
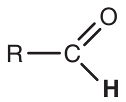
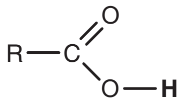
Type of carbon	**Chemical shift (ppm)**
$R{-}CH_3$	8–25
$R{-}CH_2{-}R$	20–45
$R_3{-}CH$	40–60
$R_4{-}C$	36–45
$R{-}CH_2{-}X$	15–80
$R_3C{-}NH_2$, $R_3C{-}NR$	35–70
$R{-}CH_2{-}OH$	50–90
RC≡CR	75–95
$R_2C{=}CR_2$	110–150
RCOOH	160–185
	165–175
	190–200
$R_2C{=}O$	205–220

16. ¹H NMR data

Typical proton shift values relative to TMS = 0

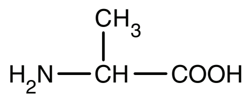
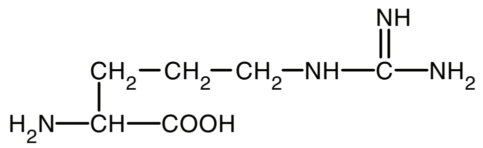
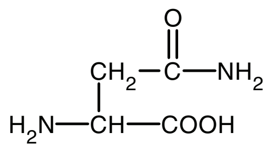
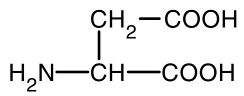
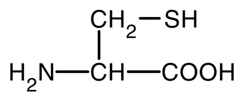
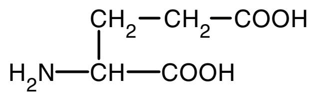
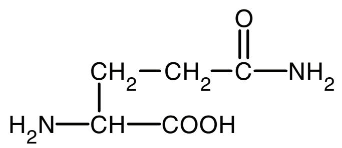
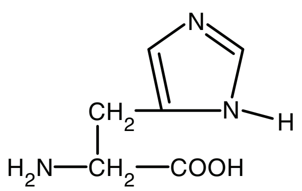
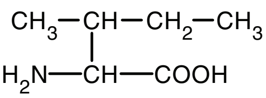
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

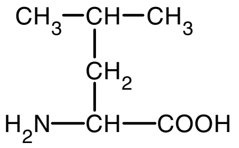
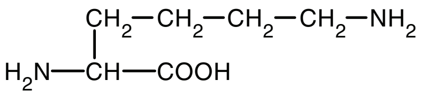
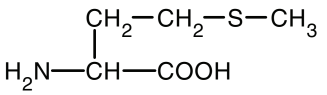
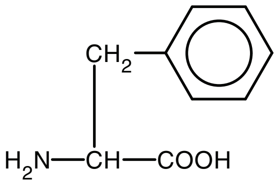
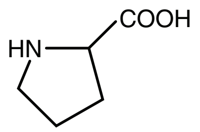
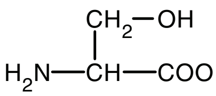
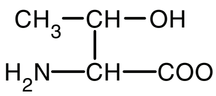
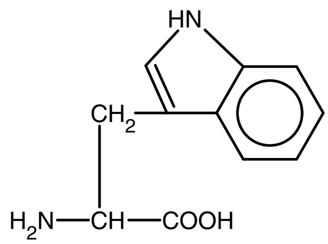
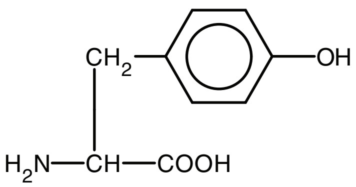
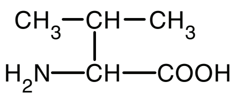
Type of proton	Chemical shift (ppm)
R–C**H**$_3$	0.9–1.0
R–C**H**$_2$–R	1.3–1.4
RCH=CH–C**H**$_3$	1.6–1.9
R$_3$–C**H**	1.5
 or 	2.0
	2.1–2.7
R–C**H**$_2$–X (X = F, Cl, Br or I)	3.0–4.5
R–C**H**$_2$–OH, R$_2$–C**H**–OH	3.3–4.5
	3.2
R–O–C**H**$_3$ or R–O–C**H**$_2$R	3.3–3.7
	2.3
	3.7–4.8
R–O–**H**	1–6 (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	$H_2N—CH_2—COOH$
histidine	His	
isoleucine	Ile	

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

END OF DATA BOOKLET

Neap

Trial Examination 2020

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 | (B shaded)

Use pencil only

1	A	B	C	D	11	A	B	C	D
2	A	B	C	D	12	A	B	C	D
3	A	B	C	D	13	A	B	C	D
4	A	B	C	D	14	A	B	C	D
5	A	B	C	D	15	A	B	C	D
6	A	B	C	D	16	A	B	C	D
7	A	B	C	D	17	A	B	C	D
8	A	B	C	D	18	A	B	C	D
9	A	B	C	D	19	A	B	C	D
10	A	B	C	D	20	A	B	C	D