Neap

Trial Examination 2021

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	5	5	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 17 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 2021 VCE Chemistry Unit 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

Coal seam gas

A. is not classified as a fossil fuel and is renewable.

B. is produced in industry from extracted coal.

C. consists mainly of methane, with some other gases present.

D. deposits are only found under the ocean.

Use the following information to answer Questions 2 and 3.

A gaseous equilibrium of the following endothermic reaction was set up in a 1.00 L vessel:

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

The magnitude of the equilibrium constant for the reaction is 4.5 at 80°C.

Question 2

What is magnitude of the equilibrium constant for the reaction $NO_2(g) \rightleftharpoons \frac{1}{2}N_2O_4(g)$ at 80°C?

A. 0.22

B. 0.47

C. 1.5

D. 4.5

Question 3

In a 1.00 L vessel, the original gaseous equilibrium was set up at 160°C.

What is the magnitude of the equilibrium constant for the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$?

A. 2.3

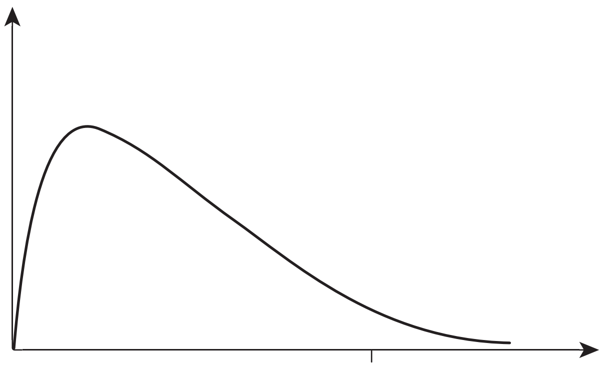
B. 4.5

C. 9.0

D. Insufficient information is provided to determine the exact value.

Use the following information to answer Questions 4 and 5.

The distribution of energies of the reactant gas particles in a chemical reaction at a particular temperature is shown below. E_a represents the activation energy for the reaction.



Question 4

Which one of the following would occur if the temperature of the reactant gases was lowered?

A. The height of the peak would change but not the position of E_a.

B. The area under the curve would change but not the position of E_a.

C. The height of the peak and the position of E_a would both change.

D. The area under the curve and the position of E_a would both change.

Question 5

If a suitable catalyst for the reaction was included at the original temperature, a change that would occur is that the

A. position of E_a would move to the right.

B. position of E_a would move to the left.

C. height of the peak would increase.

D. height of the peak would decrease.

Question 6

Two thermochemical equations are shown below.

I $\quad S(s) + \frac{3}{2}O_2(g) \rightarrow SO_3(g) \qquad \Delta H = -395 \text{ kJ mol}^{-1}$

II $\quad S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H = -295 \text{ kJ mol}^{-1}$

For the reaction $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ under the same conditions, the value of ΔH (in kJ mol^{-1}) is

A. –100

B. –200

C. –690

D. –1380

Use the following information to answer Questions 7 and 8.

The K_c values of a particular chemical reaction at different temperatures are shown in the table below.

Temperature (K)	298	400	500	600
K_c **value**	7.6×10^7 M^{-1}	1.2×10^4 M^{-1}	75 M^{-1}	2.5 M^{-1}

Question 7

The components of the homogenous equilibrium reaction are X, Y and Z.

Which one of the following is most likely to be the chemical equation for the reaction?

A. $2X \rightleftharpoons Y + Z$

B. $X + 2Y \rightleftharpoons Z$

C. $X + 2Y \rightleftharpoons 2Z$

D. $3X + Y \rightleftharpoons 2Z$

Question 8

Which one of the following correctly shows the type of chemical reaction described above and the substances that have the higher enthalpy?

	Type of reaction	**Higher enthalpy**
A.	endothermic	reactants
B.	endothermic	products
C.	exothermic	products
D.	exothermic	reactants

Question 9

An equilibrium mixture of nitrogen, hydrogen and ammonia gases is held in a sealed container.
An expression for the equilibrium constant, K_c, can be written for the system at equilibrium. A similar expression, the reaction quotient or concentration fraction, Q_c, can be written for the system at any time before equilibrium is reached or when a change is made to the system. Several changes can be made separately to the equilibrium system as follows:

I addition of argon at constant volume

II decreasing the size of the equilibrium container

III adding more hydrogen gas to the equilibrium mixture

IV increasing the temperature of the system

Which of the above changes, made separately to the equilibrium system, will alter the value of the concentration fraction (Q_c) but **not** alter the value of the equilibrium constant (K_c) when the change is made?

A. I and II only

B. II and III only

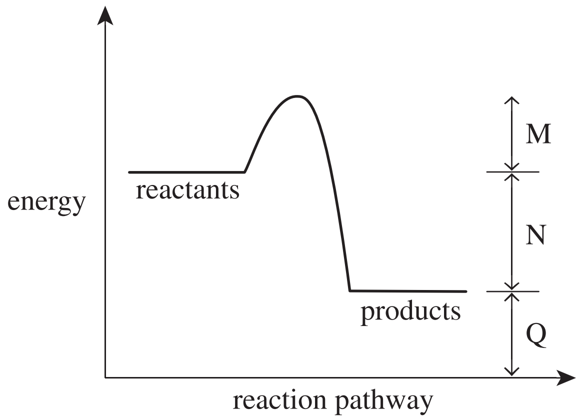
C. I, II and III only

D. I, II, III and IV

Question 10
Which one of these predictions is **not** made using the electrochemical series?
A. whether a redox reaction is spontaneous or not
B. which one of two chemical species is the stronger reducing agent
C. which one of two redox reactions has a higher reaction rate
D. whether the stronger oxidising agent is a reactant or product in a chemical reaction

Use the following information to answer Questions 11 and 12.

The energy profile for a chemical reaction is shown below. Certain energy values are denoted as M, N and Q.



Question 11
The enthalpy change for the forward reaction is
A. +(M + N)
B. –(M + N)
C. +N
D. –N

Question 12
The activation energy for the reverse reaction is
A. –M
B. M + N
C. N + Q
D. M + N + Q

Question 13
Which one of the following features is **not** common to all fuel cells?
A. Oxidation occurs at the positively charged anode.
B. Electrodes are porous and have a catalytic function.
C. Gaseous reactants are continually supplied to the cell.
D. The nature of the electrolyte affects the reactions occurring at each electrode.

Use the following information to answer Questions 14 and 15.

The electrolytic cells shown in the table below were set up using inert negative electrodes and 0.50 M aqueous solutions as electrolytes.

Cell	1	2	3	4
Positive electrode	silver	zinc	gold	nickel
Electrolyte	$AgNO_3$	$Zn(NO_3)_2$	$AuCl_3$	$NiSO_4$

Question 14

In each cell, metal was deposited on the

A. cathode where reduction occurred.

B. anode where oxidation occurred.

C. cathode where oxidation occurred.

D. anode where reduction occurred.

Question 15

The cells operated at the same current for identical durations.

Which cell deposited the smallest mass of metal?

A. 1

B. 2

C. 3

D. 4

Question 16

In which one of the following lists of aqueous solutions can all solutions be predicted to react with cadmium (Cd)?

A. $Mg(NO_3)_2(aq)$; $AgNO_3(aq)$; $NaNO_3(aq)$

B. $Ni(NO_3)_2(aq)$; $Zn(NO_3)_2(aq)$; $KNO_3(aq)$

C. $AgNO_3(aq)$; $Cu(NO_3)_2(aq)$; $Pb(NO_3)_2(aq)$

D. $Pb(NO_3)_2(aq)$; $Ni(NO_3)_2(aq)$; $Mg(NO_3)_2(aq)$

Question 17

During a study of incomplete combustion of a fuel, 1.5 g of CO was captured in a container at a temperature of 25°C.

If the container volume was 4.00 L, what was the pressure exerted by the CO gas?

A. 2.8 kPa

B. 21 mmHg

C. 33 kPa

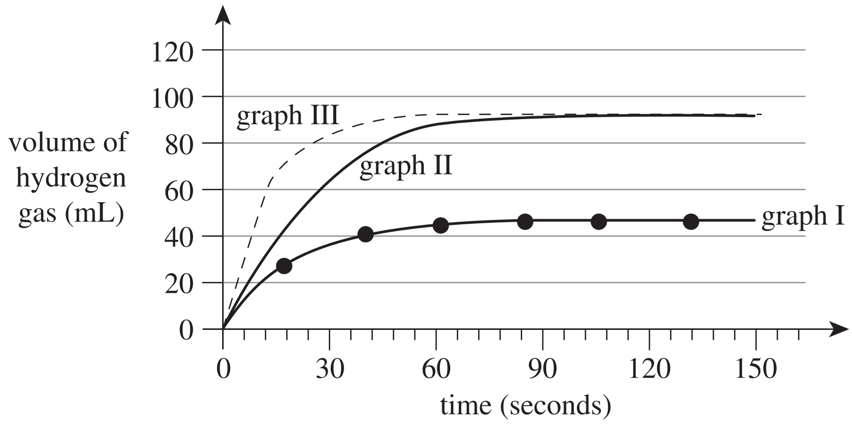
D. 928 mmHg

Use the following information to answer Questions 18 and 19.

A series of experiments was conducted to measure the rate of the following chemical reaction using excess hydrochloric acid:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The results of the initial experiment are shown in graph I below.



Question 18
In a second experiment, the initial experimental procedure was repeated under identical conditions, except for one change.

What change was made to the initial experiment's conditions to produce the results shown in graph II above?

A. The temperature of the acid was increased.

B. The concentration of the acid was doubled.

C. The volume of the acid was doubled.

D. The mass of magnesium was doubled.

Question 19
In a third experiment, the second experimental procedure was repeated under identical conditions, except for one change.

What change that could be made to the second experiment's conditions would **not** produce the result shown in graph III above?

A. The volume of the acid was increased.

B. The concentration of the acid was increased.

C. The temperature of the acid was increased.

D. The surface area of magnesium was increased.

Question 20
Which one of the following is always a feature of a secondary cell?

A. The products of the discharge reaction are never gaseous.

B. The electrodes are only made from a reactive metal.

C. The reactants come into direct contact with each other in the discharge reaction.

D. The recharge reaction only transforms electrical energy to chemical energy.

END OF SECTION A

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 (12 marks)

Two useful fuels can be produced from coal in the following reaction:

$$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$$

a. Why is coal classified as non-renewable? 1 mark

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b. Both fuels, CO and H_2, can be used to generate energy by combustion. 10.0 L of each fuel at the same conditions of temperature (above 100°C) and pressure were separately oxidised completely.

Which one of the two fuels produced the greater mass of greenhouse gas? Explain your choice. 3 marks

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c. A more efficient way of deriving energy from each fuel is to use them as the energy source in fuel cells.

i. What is the energy transformation that occurs in a fuel cell? 1 mark

ii. Explain why using fuel cells is more efficient than using the combustion of fuels in the process of generating electricity. 2 marks

d. One hydrogen–oxygen fuel cell uses an acidic electrolyte.

i. Write a balanced equation for the reaction occurring at the anode of this cell. 1 mark

ii. Outline **one** safety consideration when using hydrogen gas as the energy source in a fuel cell. 1 mark

e. The carbon monoxide fuel cell uses a silver cathode and a nickel anode with an aqueous carbonate ion (CO_3^{2-}) electrolyte. The overall cell reaction is as follows:

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

i. The cathode reaction occurs according to the following half-equation:

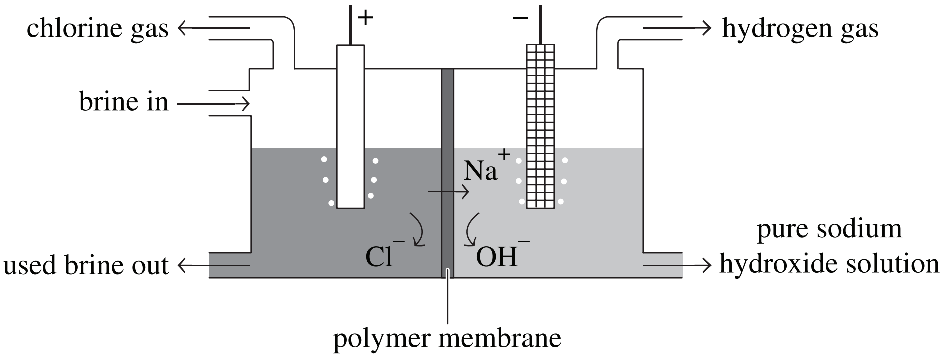
$$CO(g) + CO_3^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$$

Write the balanced equation for the anode reaction. 1 mark

ii. If the voltage of the cell is 1.33 V at 25°C, calculate the electrical energy provided by the cell for each mole of CO consumed. 2 marks

Question 2 (10 marks)

An important industrial electrolytic cell that uses a special polymer membrane is shown in the diagram below.



The membrane allows only sodium ions to pass through from one electrode chamber to the other. Concentrated sodium chloride solution (known as brine) is electrolysed to produce the following overall chemical reaction:

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

a. Write the balanced half-equation for the reaction occurring at the cathode of the above electrolytic cell. 1 mark

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b. Explain why it is important that the products in the overall reaction are kept separate from each other in the electrolytic cell. 2 marks

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c. Other industrial electrolytic cells use copper or iron electrodes, but these materials are **not** used in the cell shown.

Suggest a reason to explain this. 2 marks

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d. The production of chlorine gas during the electrolysis of aqueous sodium chloride is not predicted by the electrochemical series.

i. Explain why the production of chlorine gas is not predicted. 1 mark

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ii. Outline why chlorine gas is actually produced in this cell. 1 mark

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e. One electrolytic cell uses a current of 2000 A.

Calculate the maximum mass of chlorine gas that could be produced in 24 hours. 3 marks

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Question 3 (14 marks)

A series of experiments was conducted to investigate the properties of a sample of petrodiesel and a sample of biodiesel.

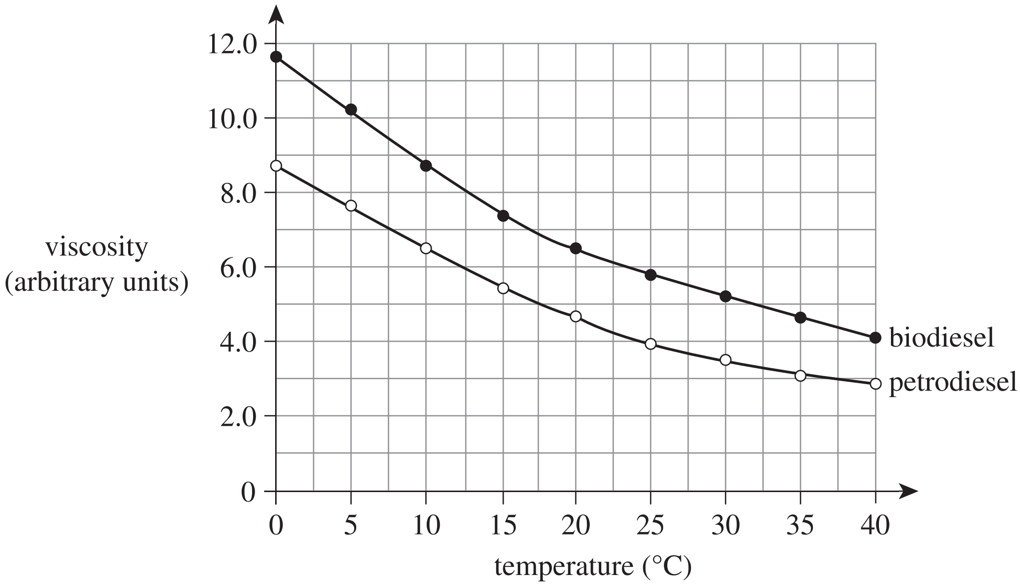
a. **i.** A component of petrodiesel is $C_{12}H_{26}$, which has a heat content of 43 kJ g^{-1}.

Write the thermochemical equation for the complete combustion of this component, showing the ΔH in units of kJ mol^{-1}. 2 marks

ii. A major component of the biodiesel is methyl palmitate.

Using information in the Data Booklet, write the semi-structural formula of methyl palmitate. 1 mark

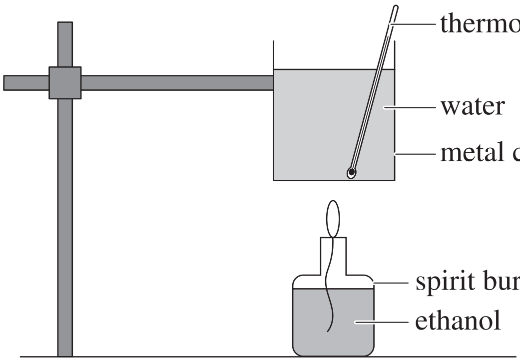
b. The viscosity of each fuel sample was measured at different temperatures and the results are shown in the graph below.



i. Using structure and bonding, explain why the viscosity of biodiesel is higher than that of petrodiesel at any given temperature. 3 marks

ii. What implications does this information on viscosity have on the selection of a fuel for use in a transport vehicle in colder weather? 2 marks

c. To determine the heat content of each fuel, an experiment was conducted using the set-up shown below. Ethanol was initially burnt in the spirit burner as it has a known heat of combustion, and so the heat loss from the apparatus could be determined.



The experiment was repeated by removing the ethanol and burning each of the fuels petrodiesel and biodiesel separately in the spirit burner to heat 100.0 g of water. The results are shown in the table.

Liquid fuel	Mass of fuel burnt (g)	Initial temperature of water (°C)	Final temperature of water (°C)
ethanol	2.15	18.0	35.9
petrodiesel	1.93	17.5	42.3
biodiesel	2.06	18.2	41.1

i. Using information in the Data Booklet, calculate the amount of energy released by burning 2.15 g of ethanol. 1 mark

ii. Calculate the percentage of heat released from burning ethanol that was transferred to the water in the metal can. 2 marks

iii. Using information from **part c.ii.** and the results table, determine the heat of combustion of petrodiesel in MJ kg^{-1}. 3 marks

Question 4 (10 marks)
The following equilibrium reaction was used in a number of experiments:

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -88 \text{ kJ mol}^{-1}$$

a. Write an expression for the equilibrium constant (K_c) for the reaction. 1 mark

b. In a 500 mL container, 1.15 mol of PCl_3, 0.30 mol of Cl_2 and 0.60 mol of PCl_5 were placed and allowed to reach equilibrium at 523 K. At equilibrium, the amount of Cl_2 present had been halved.

Calculate the equilibrium constant for the reaction. 4 marks

c. In another experiment, 1.85 mol of PCl_3, 0.95 mol Cl_2 and 1.60 mol of PCl_5 were present in a 1.00 L container at 523 K.

Show that the gas mixture was **not** at equilibrium. 2 marks

d. In a further experiment, an equilibrium mixture was established in a 2.00 L container at 523 K and a number of changes were made separately to the mixture.

Complete each row in the table below to show the effect on the position of equilibrium and on the value of K_c for each individual change to the original mixture listed. 3 marks

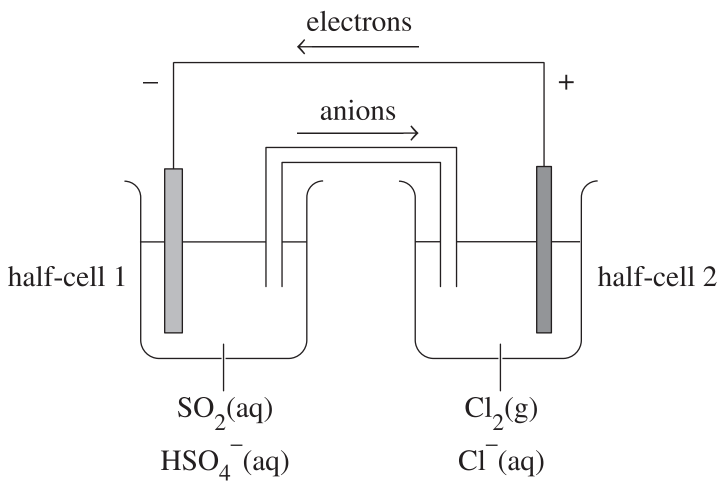
Change to original mixture		Shift in equilibrium position 'to the product side', 'to the reactant side' or 'unchanged'?	Change to value of K_c 'increases', 'decreases' or 'unchanged'?
i.	0.1 mol of Cl_2 gas injected at 523 K		
ii.	0.1 mol of He gas injected at 523 K		
iii.	temperature lowered to 423 K		

Question 5 (9 marks)

A galvanic cell was set up with platinum electrodes under standard conditions using the following cell reaction:

$$Cl_2(g) + SO_2(aq) + 2H_2O(l) \rightarrow 2Cl^-(aq) + 3H^+(aq) + HSO_4^-(aq)$$

a. The diagram of the cell shown below has a number of fundamental errors.



Identify **two** fundamental errors shown in the diagram above. 2 marks

b. **i.** Write the formula of a suitable compound that could be dissolved in water and used in preparing a salt bridge. 1 mark

ii. Apart from solubility, name **one** other property of the compound given in **part b.i.** that makes it suitable to use in a salt bridge. 1 mark

c. **i.** Write the equation for the reaction that occurs in half-cell 1 (as labelled in **part a.**). 1 mark

ii. Tick **one** box in the table below to show the type of reaction occurring and identity of the electrode in half-cell 1 (as labelled in **part a.**). 1 mark

	Oxidation	**Reduction**
Anode		
Cathode		

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d. The voltage of the cell is 1.25 V.
Calculate the standard electrode potential of the half-reaction that occurs in half-cell 1. 1 mark

e. Briefly describe how the cell could be recharged in a school laboratory. 2 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2021

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

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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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 thulmium	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	$n(e^-) = \frac{Q}{F}$
% 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

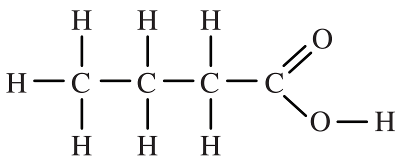
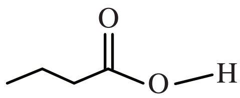
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

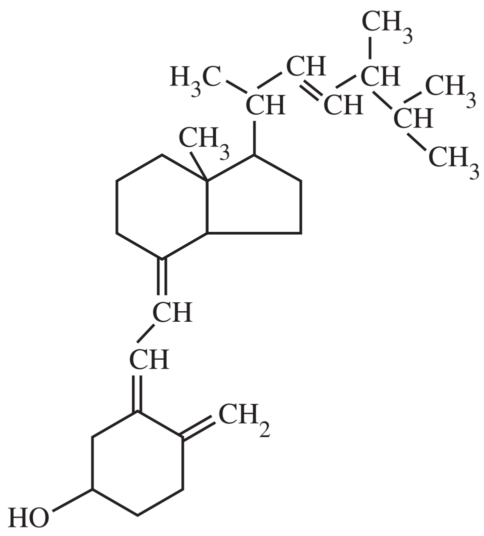
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

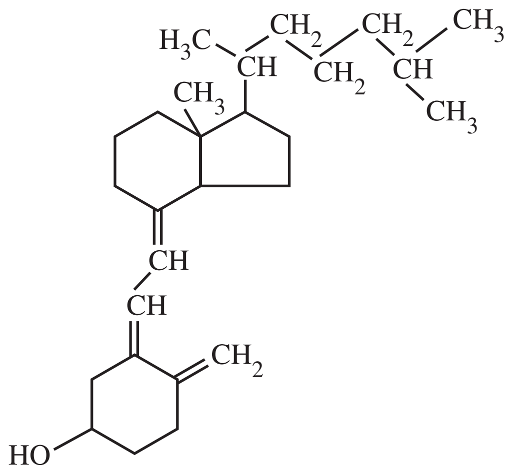
9. Formulas of some fatty acids

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

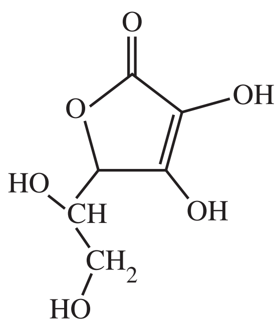
10. Formulas of some biomolecules



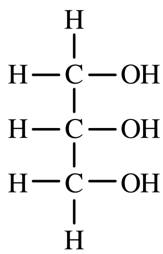
vitamin D_2 (ergocalciferol)



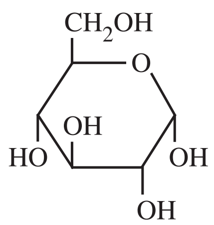
vitamin D_3 (cholecalciferol)



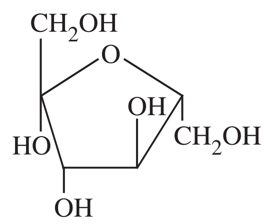
vitamin C (ascorbic acid)



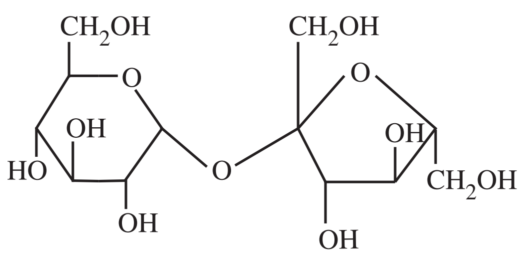
glycerol



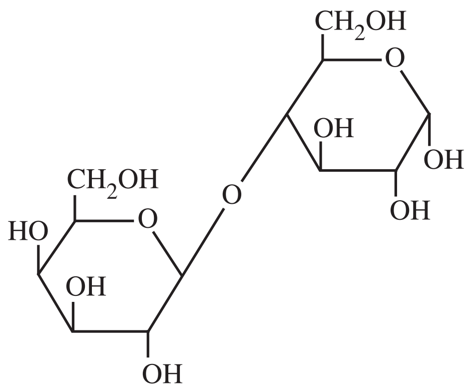
α-glucose



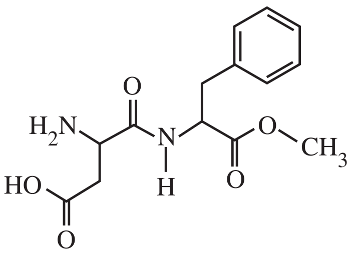
β-fructose



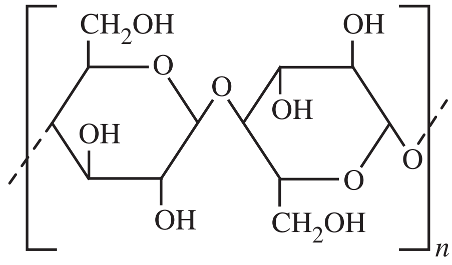
sucrose



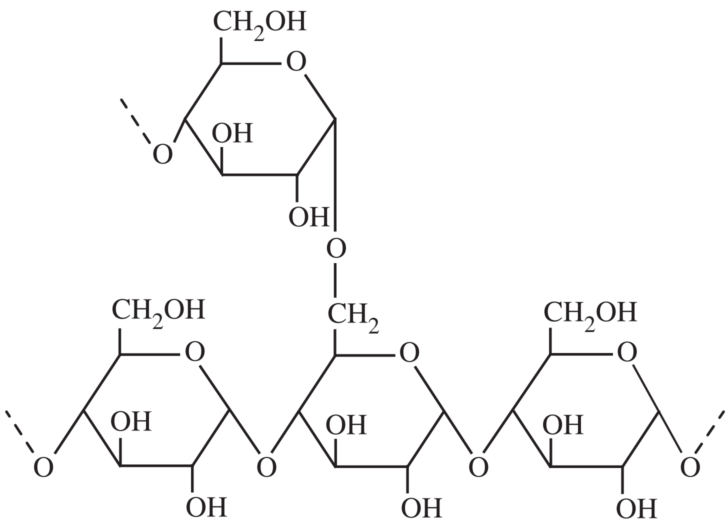
α-lactose



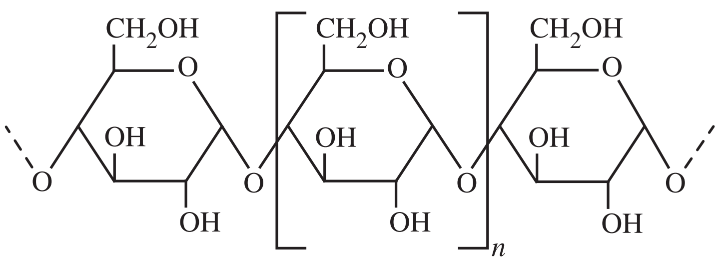
aspartame



cellulose



amylopectin (starch)



amylose (starch)

 ChemU3_DS_2021

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

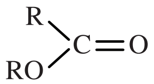
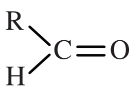
14. Characteristic ranges for infra-red absorption

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

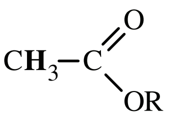
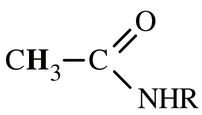
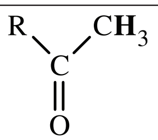
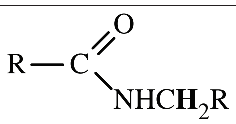
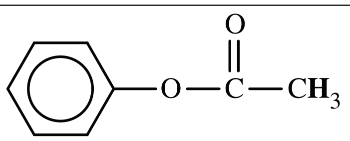
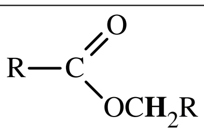
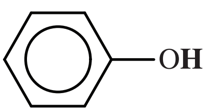
These can differ slightly in different solvents.

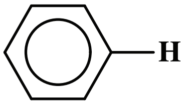
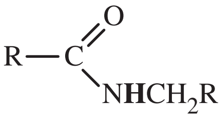
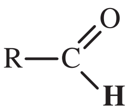
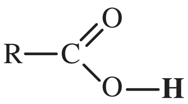
Type of carbon	Chemical shift (ppm)
R–CH_3	8–25
R–CH_2–R	20–45
R_3–CH	40–60
R_4–C	36–45
R–CH_2–X	15–80
R_3C–NH_2, R_3C–NR	35–70
R–CH_2–OH	50–90
RC≡CR	75–95
R_2C=CR_2	110–150
RCOOH	160–185
	165–175
	190–200
R_2C=O	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

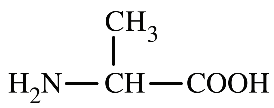
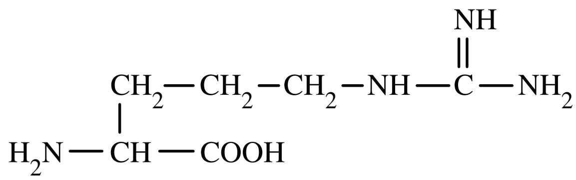
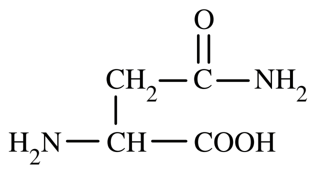
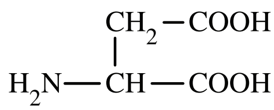
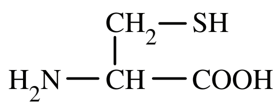
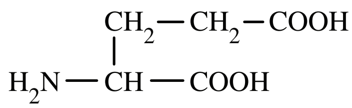
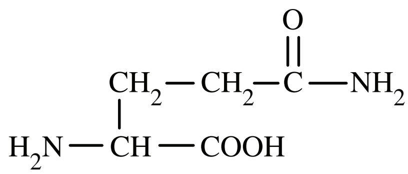
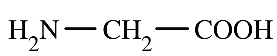
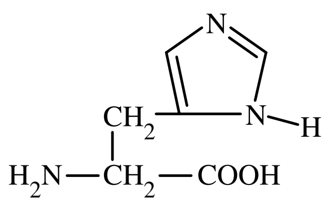
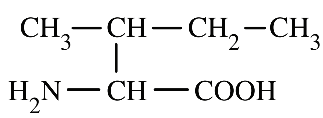
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

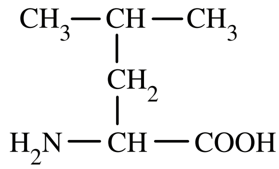
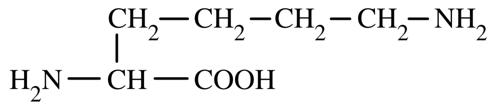
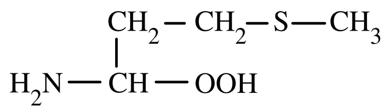
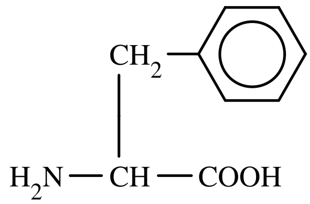
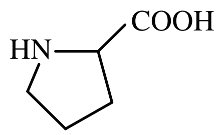
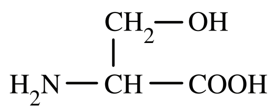
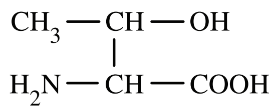
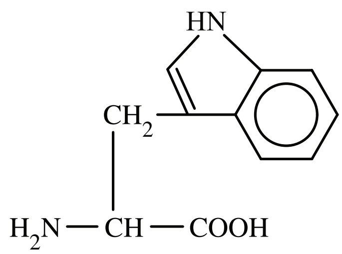
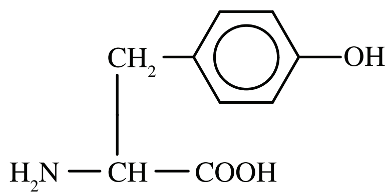
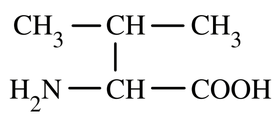
Type of proton	Chemical shift (ppm)
$R{-}C\mathbf{H}_3$	0.9–1.0
$R{-}C\mathbf{H}_2{-}R$	1.3–1.4
$RCH{=}CH{-}C\mathbf{H}_3$	1.6–1.9
$R_3{-}C\mathbf{H}$	1.5
 or 	2.0
	2.1–2.7
$R{-}C\mathbf{H}_2{-}X$ (X = F, Cl, Br or I)	3.0–4.5
$R{-}C\mathbf{H}_2{-}OH$, $R_2{-}C\mathbf{H}{-}OH$	3.3–4.5
	3.2
$R{-}O{-}C\mathbf{H}_3$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

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

17. 2-amino acids (α-amino acids)

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

Name	Symbol	Structure
alanine	Ala	
arginine	Arg	
asparagine	Asn	
aspartic acid	Asp	
cysteine	Cys	
glutamic acid	Glu	
glutamine	Gln	
glycine	Gly	
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 2021

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	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