Neap

Trial Examination 2020

VCE Chemistry Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 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	30	30	30
B	10	10	90
			Total 120

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 25 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.

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 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

Exothermic reactions

A. are always combustion reactions.
B. have a high activation energy.
C. are faster than endothermic reactions.
D. generate products of lower energy than the reactants.

Question 2

Which one of the following features do fossil fuels and biofuels have in common?

A. chemical structure
B. elemental composition
C. high energy content
D. size of fuel reserves

Question 3

What is the strongest bonding directly involved in the secondary structure of a protein?

A. dispersion forces
B. covalent bonding
C. hydrogen bonding
D. ion-dipole bonding

Question 4

Denaturation of a protein usually involves

A. breaking down the peptide bonds.
B. lowering the temperature to about 4°C.
C. disrupting weak bonds within the protein.
D. separating the amino acid residues in the polypeptide chain.

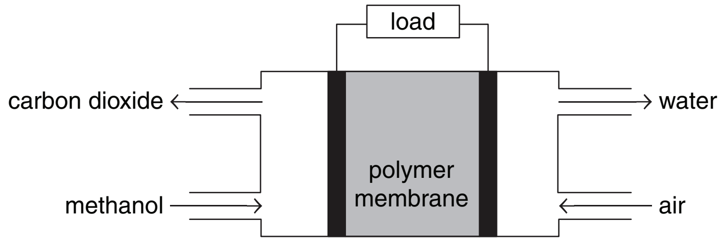
Question 5

Which one of the following fatty acids has the lowest melting point?

A. linolenic acid
B. oleic acid
C. stearic acid
D. linoleic acid

Use the following information to answer Questions 6–9.

The diagram below shows an acidic methanol fuel cell.



Question 6

The electrodes are best described as being

A. porous and conductive.
B. non-porous and inert.
C. catalytic and non-conductive.
D. non-conductive and non-porous.

Question 7

Which one of the following half-reactions is likely to occur at the negative electrode?

A. $CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$

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

C. $CH_3OH(l) + H_2O(l) + 6e^- \rightarrow CO_2(g) + 6H^+(aq)$

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

Question 8

Which one of the following features is common to both the methanol fuel cell and a galvanic cell?

A. Both cells use non-spontaneous redox reactions to generate electricity.
B. Electrons are transferred along a wire connecting the cathode and anode.
C. The negative electrode in both cells is the cathode.
D. Oxidation occurs at the positive electrode in each cell.

Question 9

Methanol can also be burnt in a supply of oxygen to produce energy.

Consider the following statements about the output from the methanol fuel cell and combustion of methanol when the set mass of methanol is used completely:

I The mass of carbon dioxide produced per gram of methanol is identical in both situations.

II The fuel cell would produce only electrical energy and the combustion would produce only heat.

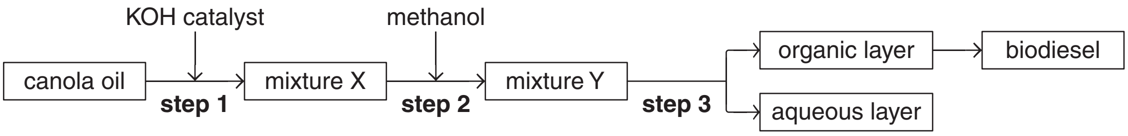
III The fuel cell is likely to be 100% efficient and produce energy that can be used for a range of purposes.

Which of the above statements are **incorrect**?

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

Use the following information to answer Questions 10–12.

The flow chart below shows a process to produce biodiesel.



Question 10

What is the main type of reaction in step 1?

A. hydrolysis
B. condensation
C. oxidation
D. esterification

Question 11

Which one of the following shows compounds that are present in large amounts in mixtures X and Y?

	Mixture X	Mixture Y
A.	glycerol	methyl esters
B.	free fatty acids	ethyl esters
C.	potassium hydroxide	free fatty acids
D.	methyl esters	glycerol

Question 12

Biodiesel

A. consists only of hydrogen atoms and carbon atoms.
B. is soluble in both organic solvents and aqueous solutions.
C. contains more energy per gram than petrodiesel.
D. is more viscous than petrodiesel at low temperatures.

Question 13

The data from a redox volumetric analysis of the vitamin C content of tablets are shown below.

Mass of crushed vitamin C tablet analysed	1.286 g
Concentration of iodine solution used in titration	0.0500 M
Average titre of iodine solution	24.50 mL
Molar mass of vitamin C ($C_6H_8O_6$)	176 g mol^{-1}

The chemical reaction that occurred in the titration is shown by the following equation:

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$$

The percentage of vitamin C by mass in the tablet is closest to

A. 15.3%
B. 16.8%
C. 21.4%
D. 23.9%

Question 14

When 0.152 g of a particular substance is burnt completely in excess oxygen, 7022 J of heat energy are released.

The substance is most likely to be

A. ethyne gas.
B. kerosene liquid.
C. natural gas.
D. diesel liquid.

Question 15

Three students conducted an investigation to determine the melting temperature of a sample of paraffin wax. The following results were recorded. The exact value of the melting temperature was given as 37.45°C.

Student	**Melting temperature (°C)**			
	Test 1	**Test 2**	**Test 3**	**Test 4**
W	37.2	37.5	36.9	37.3
X	36.8	37.8	31.5	37.7
Y	37.5	37.4	37.6	37.5

Based on the data provided in the table above, it can be concluded that the

A. results for student W showed poor precision but very high accuracy.
B. value for student X in test 3 was likely to be the result of a systematic error.
C. results for student Y showed high precision and accuracy.
D. results for all students showed equal precision and accuracy.

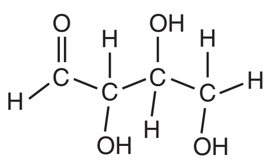
Question 16

The validity of experimental data depends mainly on

A. how close the averaged set of experimental values is to the correct value.
B. whether the data is obtained by testing with one independent variable only.
C. the reproducibility of the measurements made in the experiment.
D. whether the set of data is obtained using measurements that have no associated random error.

Question 17

The structural formula of an organic compound is shown below.



Which one of the following statements applies to this compound?

A. The compound is likely to be insoluble in water but highly soluble in hexane.
B. The compound could be synthesised by oxidation of a tertiary alcohol.
C. Bromine (Br_2) will react with the compound in an addition reaction.
D. The percentage by mass of oxygen is greater than the percentage by mass of carbon in the compound.

Question 18

Which one of the following takes place during discharge in both primary and secondary electrochemical cells?

A. There is a near 100% energy transformation from chemical to electrical energy.

B. A spontaneous exothermic redox reaction occurs.

C. Products of the redox reactions remain in contact with the electrodes.

D. Cations in the electrolyte are attracted to the negatively charged cathode.

Use the following information to answer Questions 19–21.

Electrolysis of 0.1 M $AgNO_3$ solution, using inert electrodes, deposited 1.47 g of silver metal.

Question 19

If the electrolysis was conducted using a steady current of 4.0 A, what length of time would be required for the deposition of the 1.47 g of silver, assuming 80% efficiency?

A. 5.5 s

B. 263 s

C. 329 s

D. 411 s

Question 20

Under identical conditions, with the same efficiency and using the same current and duration, 0.1 M $Cr(NO_3)_3$ solution was electrolysed.

What mass of chromium would be expected to deposit?

A. 0.236 g

B. 0.708 g

C. 1.47 g

D. 2.13 g

Question 21

Under identical conditions, 0.5 M NaCl solution was electrolysed.

Which one of the following sets of substances could be formed?

A. oxygen gas, hydrogen gas and sodium metal

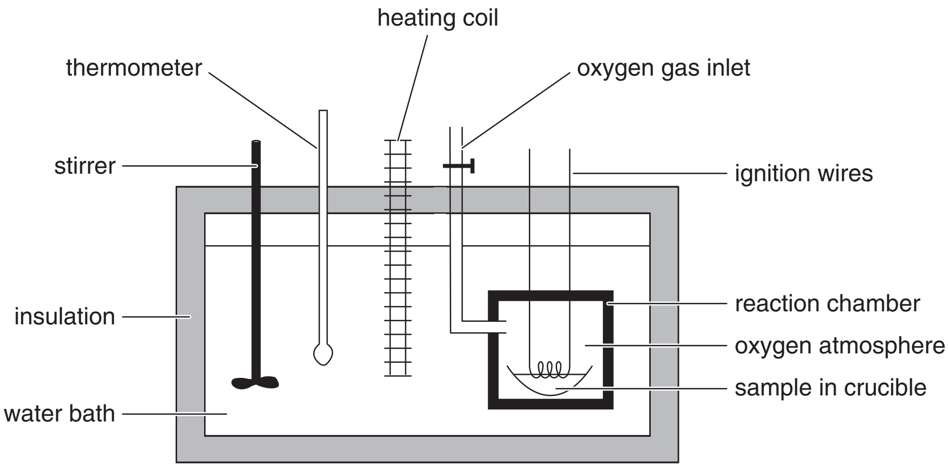
B. chlorine gas, sodium metal and oxygen gas

C. hydrogen gas, chlorine gas and oxygen gas

D. sodium metal, chlorine gas and hydrogen gas

Use the following information to answer Questions 22 and 23.

The bomb calorimeter shown below was calibrated electrically by using 5.8 V and a current of 3.4 A for 3.0 minutes. The temperature of the water increased by 0.39°C.



Question 22

The value of the calibration factor, in kJ $°C^{-1}$, is

A. 0.059

B. 0.15

C. 3.5

D. 9.1

Question 23

The heat of combustion of glucose was determined by burning 1.80 g of the compound in the calorimeter.

Which one of the following situations would give a **lower** experimental value for the heat of combustion than the accepted value?

A. Insufficient oxygen gas was pumped into the reaction chamber.

B. Some water leaked from the water bath after calibration.

C. The mass of glucose used was wrongly recorded as 1.80 g when in fact 1.90 g was used.

D. The heating coil was not used during the combustion reaction.

Use the following information to answer Questions 24 and 25.

Consider the following half-reactions from the electrochemical series:

$$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$$

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$$

Question 24

Which one of the following is correct in relation to the half-equations above?

	Weakest reducing agent	Weakest oxidising agent
A.	Cd^{2+}	Fe^{2+}
B.	Fe^{3+}	Cd
C.	Cd	Fe^{3+}
D.	Fe^{2+}	Cd^{2+}

Question 25

If a galvanic cell was constructed using these two half-reactions at standard conditions, the potential of the cell would be

A. 0.37 V, and electrons would travel towards the Cd electrode.
B. 0.37 V, and electrons would travel away from the Cd electrode.
C. 1.17 V, and electrons would travel towards the Cd electrode.
D. 1.17 V, and electrons would travel away from the Cd electrode.

Question 26

Which one of the following statements about glycogen and starch is **incorrect**?

A. Both compounds are produced in condensation reactions.
B. The monomer glucose is polymerised to form both compounds.
C. The linkages in each compound are known as ester or glycosidic.
D. Starch is used as a storage compound in plants, while glycogen is used as a storage compound in humans.

Question 27

Two compounds under investigation were known to be methyl propanoate and ethyl ethanoate. The labels on the compounds had accidentally been removed. To distinguish between the compounds, the low-resolution ^1H NMR spectrum and high-resolution ^1H NMR spectrum of each was obtained.

Which one of the following features of these spectra would be most useful for distinguishing between the compounds?

A. the number of peaks on the low-resolution spectra
B. the chemical shifts of the peaks on the low-resolution spectra
C. the areas under the peaks on the low-resolution spectra
D. the splitting pattern of peaks on the high-resolution spectra

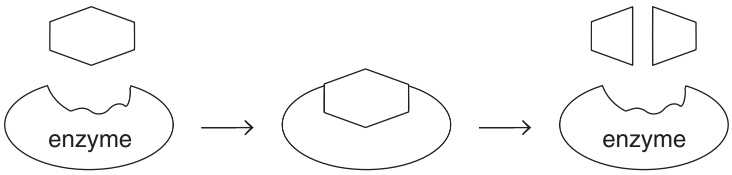
Question 28

Fats and oils differ in the

A. linkages bonding the fatty acids to the glycerol molecule.
B. temperature at which each substance melts.
C. number of fatty acids bonded to each glycerol molecule.
D. elements that compose each of the compounds.

Question 29

A chemistry student produced the following diagram to show the process of enzyme action using the **lock-and-key model**.



Which one of the following is correct in regards to the student's diagram?

	Accuracy of the diagram	Reasoning
A.	accurate	The active site is a flexible cavity that changes shape so that the substrate molecules fit exactly.
B.	accurate	There are always two product molecules generated in a reaction catalysed by an enzyme.
C.	inaccurate	The active site of the enzyme should be unchanged in shape before, during and after the catalysis.
D.	inaccurate	The structure of the enzyme molecule should be changed permanently after it has catalysed a chemical reaction.

Question 30

The fatty acid arachidonic acid reacts with hydrogen gas under suitable conditions.

How many grams of hydrogen gas are likely to react with one mole of arachidonic acid?

A. 1
B. 2
C. 4
D. 8

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.

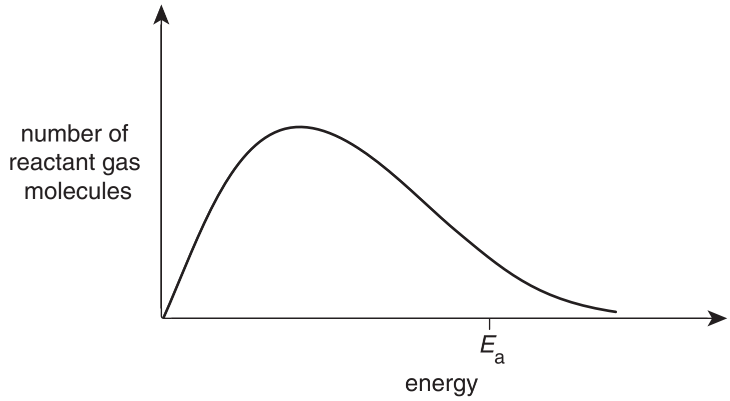
Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

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)

The diagram below shows the distribution of kinetic energy of sulfur dioxide, SO_2, and oxygen molecules at a particular temperature. The activation energy for the reaction is marked as E_a.



a. What is meant by the term 'activation energy'? 1 mark

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b. On the diagram above, draw the graph that would be expected if the temperature of the reactant gas molecules was increased. 1 mark

c. A student claimed that the only reason the rate of reaction increased with increasing temperature was because there were more collisions between the reactant molecules.

Critically evaluate this claim with reference to the graph drawn in **part b.** 3 marks

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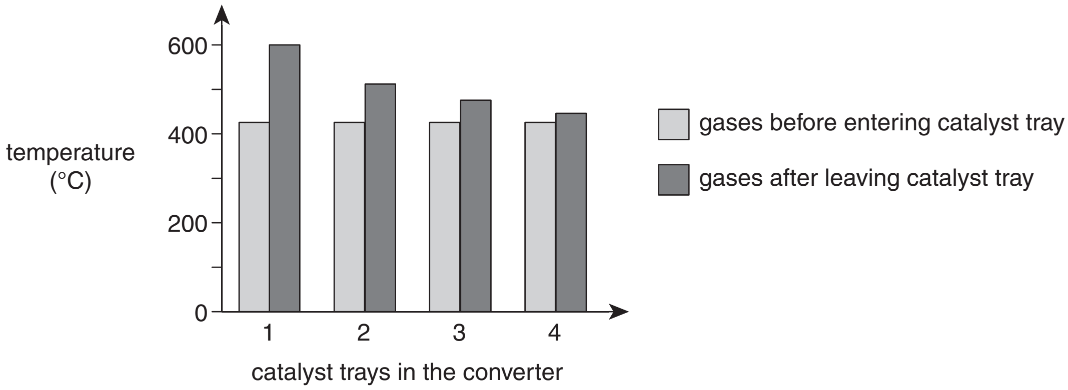
d. In the industrial production of SO_3 gas from SO_2 and O_2, the equilibrium gas mixture is passed progressively over several trays that contain a catalyst. A graph showing the entry and exit temperatures of the gas mixtures in this process is shown below.



i. Outline why the catalyst is spread out over several trays. 1 mark

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ii. Suggest why the difference between the entry and exit temperatures of the gas mixture decreases from tray 1 to tray 4. 2 marks

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Question 2 (12 marks)

Methane gas can be produced industrially using the following reaction:

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g) \qquad \Delta H = -165 \text{ kJ mol}^{-1}$$

a. The pressure chosen for the industrial process is 200 to 300 kPa.

i. Why does a high pressure increase the rate of reaction? 2 marks

ii. Why does a high pressure increase the equilibrium yield? 2 marks

iii. A high pressure is beneficial for both rate of reaction and the equilibrium yield.

Suggest **one** reason why a much higher pressure is **not** used in the industrial process. 1 mark

b. Methane can also be produced from animal waste as a component of biogas. Bacteria break down the waste in a digester to make biogas, which is approximately 65% methane and 35% carbon dioxide. The biogas is processed to remove water vapour and carbon dioxide, leaving almost pure methane.

i. Compare the renewability of methane gas obtained from biogas with methane gas produced industrially by reacting carbon dioxide and hydrogen gases. 3 marks

ii. Write the balanced thermochemical equation for the complete combustion of methane. 2 marks

iii. Methane gas and carbon dioxide gas both impact on the enhanced greenhouse effect.

Explain why using methane from biogas as a fuel is **less** environmentally damaging than leaving animal waste to decompose in fields. 2 marks

Question 3 (10 marks)

Whole seeds are rich in nutrients and are recommended by nutritionists to be part of a healthy diet. The composition of pumpkin seeds (in grams per 30 grams) is shown in the table below.

Protein	**Total fat**	**Saturated fat**	**Fibre**
9.1	14.3	2.7	1.8

a. One of the components of fibre is cellulose.

Outline why cellulose is **not** digested by humans. 1 mark

b. What percentage by mass of pumpkin seeds are fats that contain carbon-to-carbon double bonds? 2 marks

c. Calculate the amount of energy contained in the protein present in 200 grams of pumpkin seeds. 2 marks

d. A sequence of amino acid residues in one of the proteins in pumpkin seeds is Met-Glu-Val. When hydrolysed, these residues are released as free amino acids.

i. Draw the structure of the amino acid Glu in a high pH environment. 2 marks

ii. Tick one or more boxes in each row of the table below to show which amino acids, if any, exhibit the specified feature **in the side group**. 3 marks

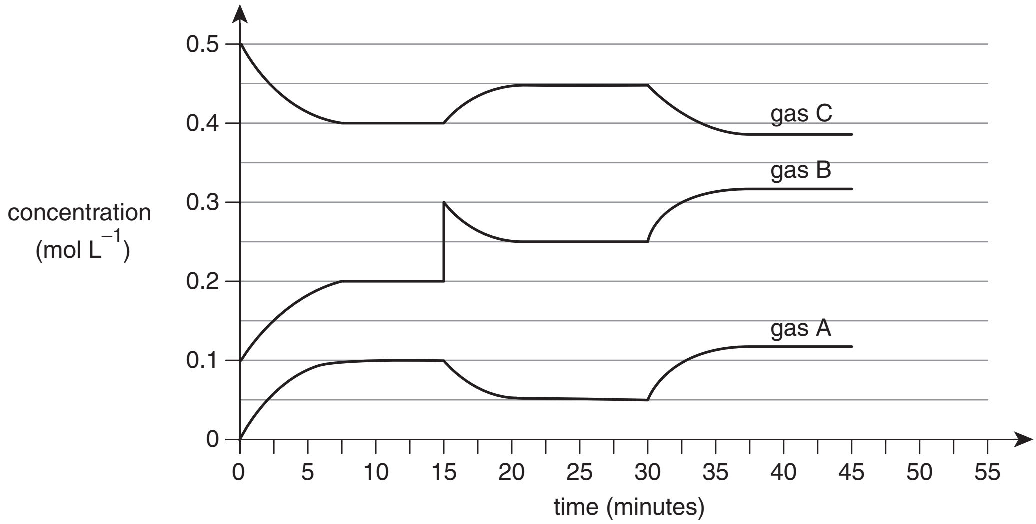
Feature of side group	**Met**	**Glu**	**Val**	**None of Met, Glu or Val**
Forms disulfide bonds with Cys				
Non-polar				
Able to form hydrogen bonds with Asn side group				

Question 4 (7 marks)

Two gases, A and B, react to form gas C in an equilibrium reaction as shown below:

$$A(g) + B(g) \rightleftharpoons C(g)$$

An experiment was conducted by placing two of these gases in a 5.0 L sealed container and recording the gas concentrations for the duration of the investigation.



a. Calculate the equilibrium constant, K_c, when the system first reached equilibrium. 2 marks

b. Explain the changes in the concentration of gases B and C in the time interval from 15 to 25 minutes. 2 marks

c. Heat was added to the system at 30 minutes.

Is the reaction for the formation of gas C exothermic or endothermic? 1 mark

d. At 45 minutes, the volume of the container was doubled at constant temperature.

On the axes above, draw the expected change in the graph for gas C from 45 minutes until equilibrium is reached again. 2 marks

Question 5 (9 marks)

a. Zirconium is one of a few metals that maintain their structural integrity when exposed to radiation. For this reason, zirconium can be used to make fuel rods in nuclear reactors. The following half-equation involves zirconium metal and a hydrated oxide of zirconium:

$$ZrO_2.H_2O(s) + H_2O(l) + 4e^- \rightarrow Zr(s) + 4OH^-(aq) \quad E^0 = -2.36 \text{ V}$$

i. State the change in oxidation number of the zirconium in the half-equation shown above. 1 mark

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ii. Write a balanced overall equation for the reduction of water by zirconium based on the half-equation shown above. 2 marks

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iii. The reduction of water by zirconium occurred during a nuclear reactor accident at the Three Mile Island Nuclear Generating Station in 1979. The hydrogen gas produced was vented successfully, avoiding an explosion.

If 1.00×10^6 g of zirconium reacted, what volume of hydrogen gas at 101.3 kPa and 1000°C would be produced? (M(Zr) = 91.2 g mol^{-1}) 3 marks

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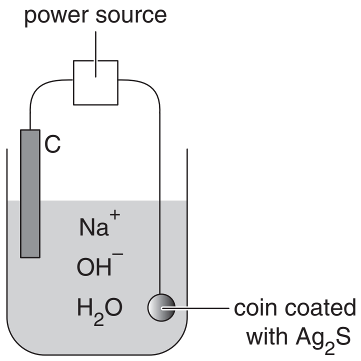
b. Silver coins dating from the early 1600s were recovered from a sunken ship. However, corrosion had resulted in the coins being covered in black silver sulfide deposits. Restoration of the coins was conducted using an electrolytic cell shown in the simplified diagram below.



Electrolysis to remove the sulfide coating used the reaction represented by the following half-equation:

$$Ag_2S(s) + 2e^- \rightarrow 2Ag(s) + S^{2-}(aq)$$

i. Suggest why the restoration did **not** use an abrasive, such as steel wool, to remove the Ag_2S coating on the coins. 1 mark

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ii. Is the coin functioning as the anode or cathode in this cell? 1 mark

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iii. Bubbles of gas were seen to form on the surface of the graphite electrode.
Write the half-equation for the reaction producing these bubbles. 1 mark

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Question 6 (12 marks)

a. 0.31 moles of a particular organic compound contains the same mass of:

- carbon as there is in 30.8 L of carbon dioxide gas at SLC
- hydrogen as there is in 21.1 g of H_2O_2
- oxygen as there is in 21.1 g of H_2O_2.

Show that the molecular formula of the compound is $C_4H_4O_4$. 4 marks

b. Some of the properties of the organic compound are shown in the table below.

For each property, write a conclusion about the nature of the compound revealed by this property. 3 marks

Property of the compound	**Conclusion**
It reacts with HBr in equimolar amounts to produce a single product.	
At 25°C, a 1 M solution of the compound has a pH between 4 and 7.	
Two moles of NaOH react with one mole of the compound.	

c. From the information given in **part a.** and **part b.**, draw the structural formula of the compound. 2 marks

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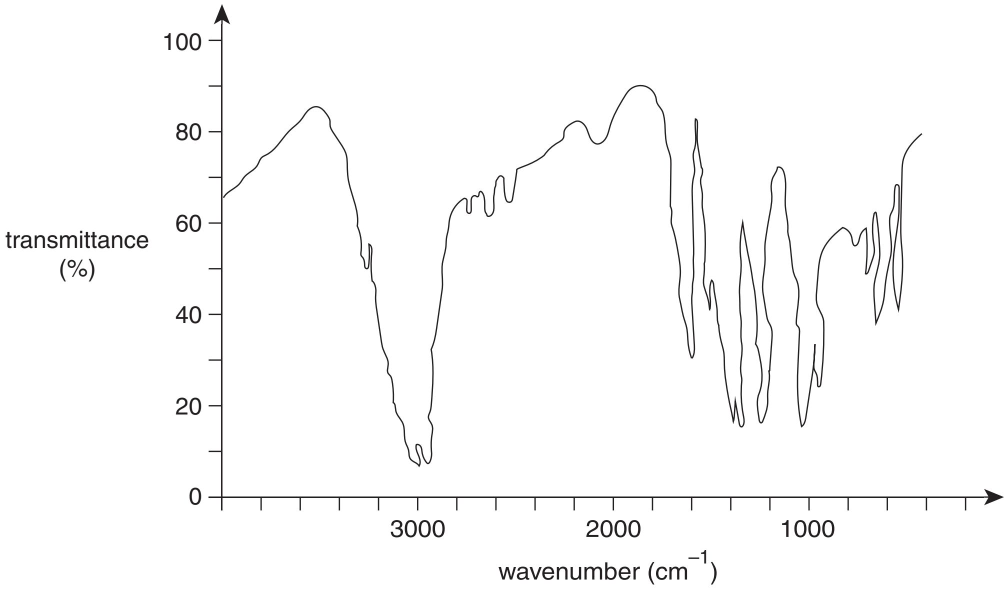
d. The infrared spectrum of the compound is shown below.



Explain how the signals at wavenumber 1690 cm^{-1} and around the 3000 cm^{-1} range are consistent with the structure of the compound drawn in **part c.** 2 marks

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e. In the ^{13}C NMR spectrum of the compound there is a signal at 130 ppm and another signal at 170 ppm.

Why are there only two signals for this compound? 1 mark

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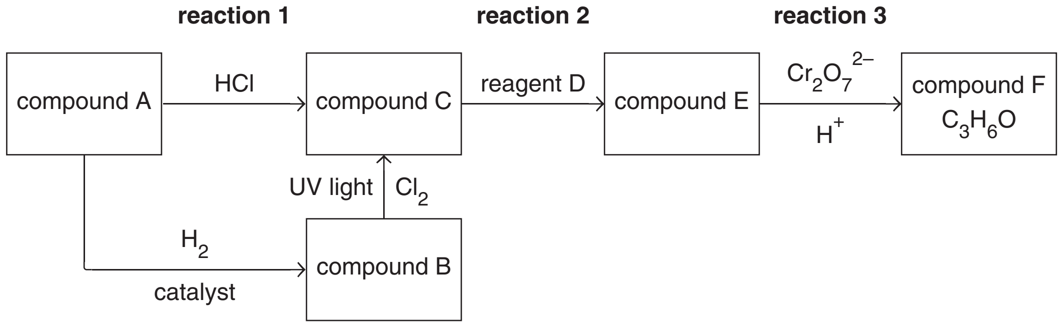
Question 7 (7 marks)

A range of chemical reactions is shown in the flow chart below. Compound F was produced by extensive reaction of compound E with the acidified dichromate solution.



a. Compound A is an unsaturated hydrocarbon compound containing 85.7% carbon by mass.

Draw the structural formula of compound A. 1 mark

b. Name compound B. 1 mark

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c. Give the semi-structural formula of compound C. 1 mark

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d. Draw the structural formula of compound E, showing all bonds. 1 mark

e. To what family of compounds does compound F belong? 1 mark

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f. Give a chemical formula for reagent D. 1 mark

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g. Identify the type of reaction occurring in reaction 2. 1 mark

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Question 8 (8 marks)

Campers and hikers often use a small stove that uses the fuel butane for heating water and cooking.

a. Calculate the mass of butane used for 500 g of water at 20°C to be heated to boiling point, assuming that 60% of the heat generated in the complete combustion of butane is transferred to the water. 3 marks

b. A different camping stove uses ethanol rather than butane and offers a safer, alternative method of cooking. A camper estimated that they would need 50.0 g of butane for a particular camping trip.

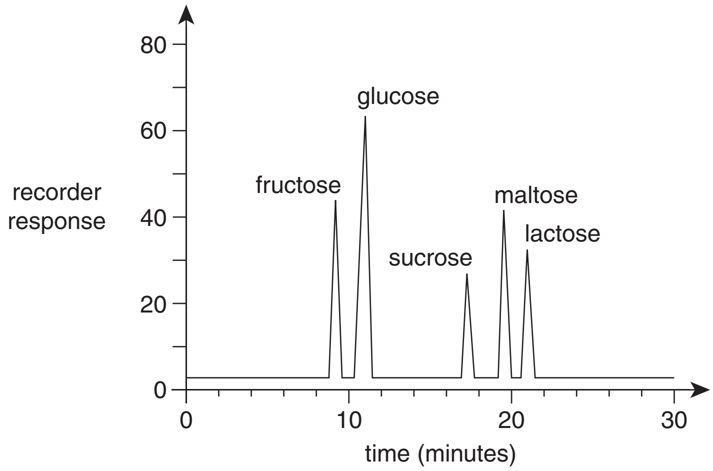
Calculate the volume of ethanol that contains an equal amount of energy to the 50.0 g of butane, given that the density of ethanol is 0.785 g mL^{-1}. 3 marks

c. Butane is derived from crude oil and ethanol can be produced as a biofuel.

Evaluate butane and bioethanol with respect to the environmental impacts related to the sourcing of each fuel. 2 marks

Question 9 (8 marks)

High-performance liquid chromatography (HPLC) was used to analyse a mixture of carbohydrate compounds and produced the output shown below.



a. The mobile phase used in the analysis is a polar organic solvent dissolved in water.

Explain why this liquid is suitable for the analysis. 2 marks

b. Maltose is formed from the reaction of two glucose molecules.

i. Name the type of chemical reaction that produces maltose. 1 mark

ii. From the groupings in the HPLC analysis (9–11 mins and 17–21 mins), explain on what basis the components of the mixture seem to be separated by the HPLC column. 2 marks

c. In the HPLC analysis, each compound's concentration was 0.5 mg mL^{-1} and 10 μL of the mixture was injected.

What effect would injecting 15 μL into the column have on the peak area for glucose? 1 mark

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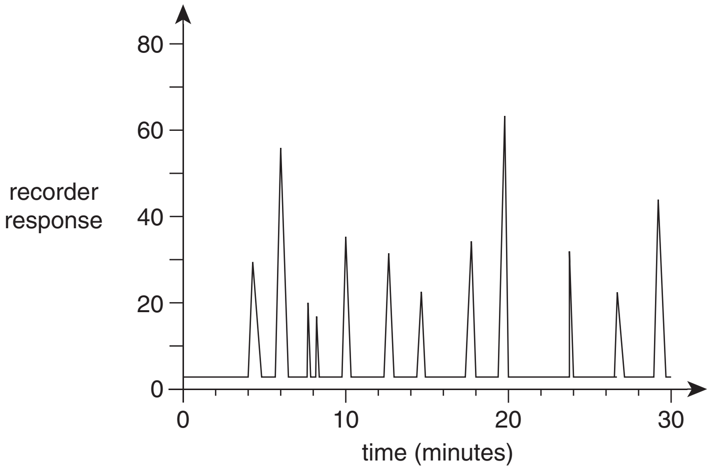
d. Some people are lactose-intolerant, which means that their digestive systems cannot break down lactose. To determine whether a certain food would be suitable for a lactose-intolerant person, a sample of the food was analysed on the same HPLC column under identical conditions. The output shown below was produced.



Using information from **both** HPLC analyses, explain whether this food would be suitable for lactose-intolerant people. 2 marks

Question 10 (9 marks)

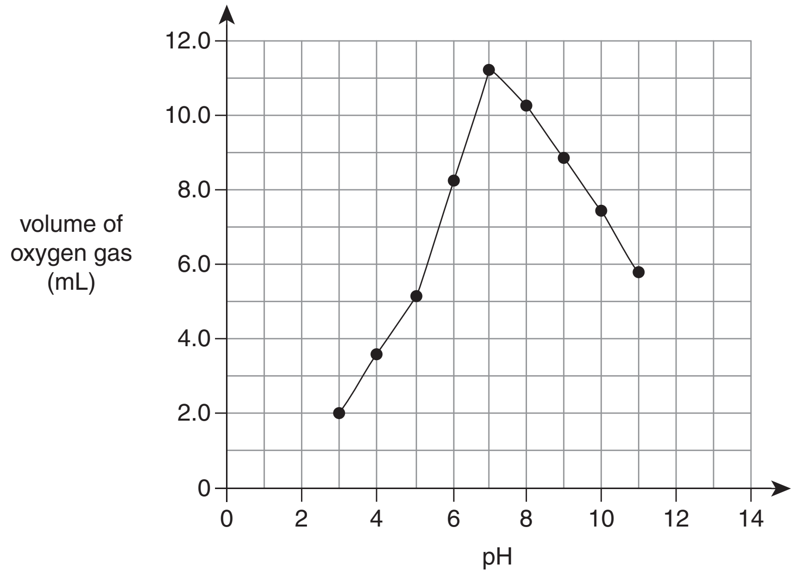
A series of experiments was conducted to determine the effect of pH on the activity of the enzyme catalase, which catalyses the breakdown of hydrogen peroxide as shown by the following equation:

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

A set volume of hydrogen peroxide at a particular pH was placed into a sealed flask with a set volume of catalase solution, and the amount of oxygen gas produced in 10 seconds was measured. The experiment was repeated under identical conditions, except that a different pH was used each time. The results produced are shown in the table below.

pH	3	4	5	6	7	8	9	10	11
Volume of O_2 gas formed in 10 seconds (mL)	2.0	3.6	5.1	8.2	11.2	10.2	8.9	7.4	5.8

A graph of the results of the experiment is shown below.



a. **i.** Identify the dependent variable in the experiment. 1 mark

____

ii. Apart from the volumes of the solutions used, state **two** variables that were kept constant in this experiment. 2 marks

____

____

____

iii. State **one** source of random error in this experiment. 1 mark

____

____

 CHEMU34_QA_2020.FM

b. Discuss how altering the pH changes the activity of the enzyme catalase, explaining these changes in terms of the enzyme's tertiary protein structure. 3 marks

c. A student observed that the hydrogen peroxide molecule and water molecule are composed of the same elements and are similar in many ways. The student then proposed that catalase could be used to generate hydrogen gas and oxygen gas from water by splitting the molecule apart.

Critically evaluate this proposition. 2 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2020

VCE Chemistry Units 3&4

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

1 **H** 1.0 hydrogen																	**2** **He** 4.0 helium
3 **Li** 6.9 lithium	**4** **Be** 9.0 beryllium											**5** **B** 10.8 boron	**6** **C** 12.0 carbon	**7** **N** 14.0 nitrogen	**8** **O** 16.0 oxygen	**9** **F** 19.0 fluorine	**10** **Ne** 20.2 neon
11 **Na** 23.0 sodium	**12** **Mg** 24.3 magnesium											**13** **Al** 27.0 aluminium	**14** **Si** 28.1 silicon	**15** **P** 31.0 phosphorus	**16** **S** 32.1 sulfur	**17** **Cl** 35.5 chlorine	**18** **Ar** 39.9 argon
19 **K** 39.1 potassium	**20** **Ca** 40.1 calcium	**21** **Sc** 45.0 scandium	**22** **Ti** 47.9 titanium	**23** **V** 50.9 vanadium	**24** **Cr** 52.0 chromium	**25** **Mn** 54.9 manganese	**26** **Fe** 55.8 iron	**27** **Co** 58.9 cobalt	**28** **Ni** 58.7 nickel	**29** **Cu** 63.5 copper	**30** **Zn** 65.4 zinc	**31** **Ga** 69.7 gallium	**32** **Ge** 72.6 germanium	**33** **As** 74.9 arsenic	**34** **Se** 79.0 selenium	**35** **Br** 79.9 bromine	**36** **Kr** 83.8 krypton
37 **Rb** 85.5 rubidium	**38** **Sr** 87.6 strontium	**39** **Y** 88.9 yttrium	**40** **Zr** 91.2 zirconium	**41** **Nb** 92.9 niobium	**42** **Mo** 96.0 molybdenum	**43** **Tc** (98) technetium	**44** **Ru** 101.1 ruthenium	**45** **Rh** 102.9 rhodium	**46** **Pd** 106.4 palladium	**47** **Ag** 107.9 silver	**48** **Cd** 112.4 cadmium	**49** **In** 114.8 indium	**50** **Sn** 118.7 tin	**51** **Sb** 121.8 antimony	**52** **Te** 127.6 tellurium	**53** **I** 126.9 iodine	**54** **Xe** 131.3 xenon
55 **Cs** 132.9 caesium	**56** **Ba** 137.3 barium	**57–71** lanthanoids	**72** **Hf** 178.5 hafnium	**73** **Ta** 180.9 tantalum	**74** **W** 183.8 tungsten	**75** **Re** 186.2 rhenium	**76** **Os** 190.2 osmium	**77** **Ir** 192.2 iridium	**78** **Pt** 195.1 platinum	**79** **Au** 197.0 gold	**80** **Hg** 200.6 mercury	**81** **Tl** 204.4 thallium	**82** **Pb** 207.2 lead	**83** **Bi** 209.0 bismuth	**84** **Po** (210) polonium	**85** **At** (210) astatine	**86** **Rn** (222) radon
87 **Fr** (223) francium	**88** **Ra** (226) radium	**89–103** actinoids	**104** **Rf** (261) rutherfordium	**105** **Db** (262) dubnium	**106** **Sg** (266) seaborgium	**107** **Bh** (264) bohrium	**108** **Hs** (267) hassium	**109** **Mt** (268) meitnerium	**110** **Ds** (271) darmstadtium	**111** **Rg** (272) roentgenium	**112** **Cn** (285) copernicium	**113** **Nh** (280) nihonium	**114** **Fl** (289) flerovium	**115** **Mc** (289) moscovium	**116** **Lv** (292) livermorium	**117** **Ts** (294) tennessine	**118** **Og** (294) oganesson

Key:

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

57 **La** 138.9 lanthanum	**58** **Ce** 140.1 cerium	**59** **Pr** 140.9 praseodymium	**60** **Nd** 144.2 neodymium	**61** **Pm** (145) promethium	**62** **Sm** 150.4 samarium	**63** **Eu** 152.0 europium	**64** **Gd** 157.3 gadolinium	**65** **Tb** 158.9 terbium	**66** **Dy** 162.5 dysprosium	**67** **Ho** 164.9 holmium	**68** **Er** 167.3 erbium	**69** **Tm** 168.9 thulium	**70** **Yb** 173.1 ytterbium	**71** **Lu** 175.0 lutetium
89 **Ac** (227) actinium	**90** **Th** 232.0 thorium	**91** **Pa** 231.0 protactinium	**92** **U** 238.0 uranium	**93** **Np** (237) neptunium	**94** **Pu** (244) plutonium	**95** **Am** (243) americium	**96** **Cm** (247) curium	**97** **Bk** (247) berkelium	**98** **Cf** (251) californium	**99** **Es** (252) einsteinium	**100** **Fm** (257) fermium	**101** **Md** (258) mendelevium	**102** **No** (259) nobelium	**103** **Lr** (262) lawrencium

The value in brackets indicates the mass number of the longest-lived isotope.

2. Electrochemical series

Reaction	**Standard electrode potential (E^0) in volts at 25°C**
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+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	$n(e^-) = \frac{Q}{F}$

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

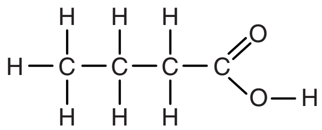
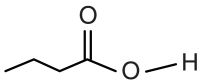
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

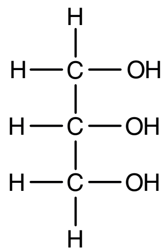
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

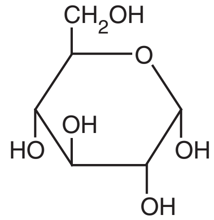
9. Formulas of some fatty acids

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

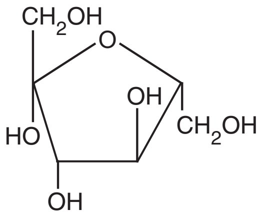
10. Formulas of some biomolecules



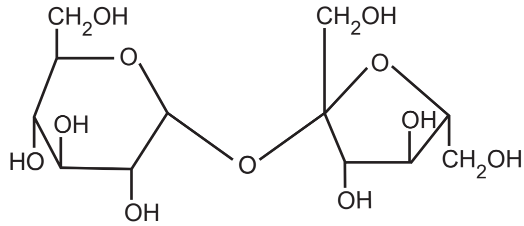
glycerol



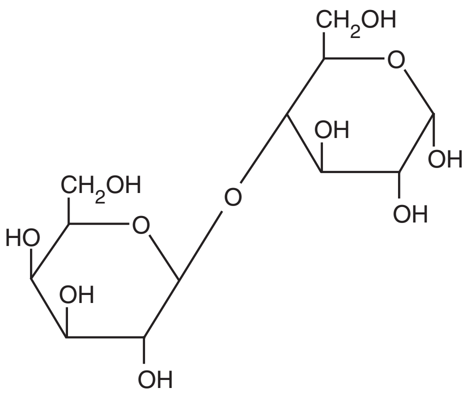
α-glucose



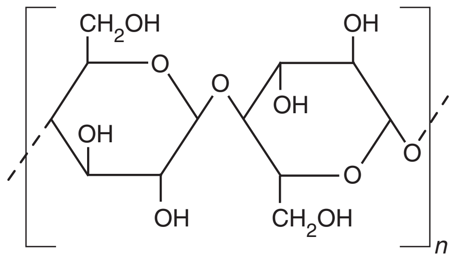
β-fructose



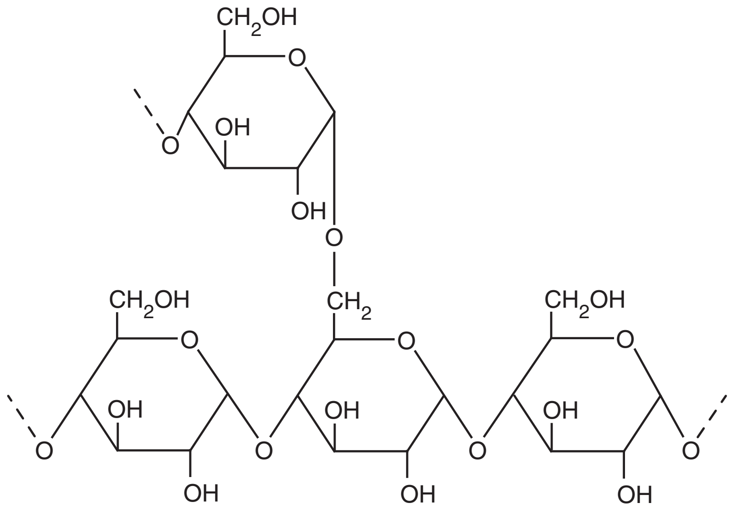
sucrose



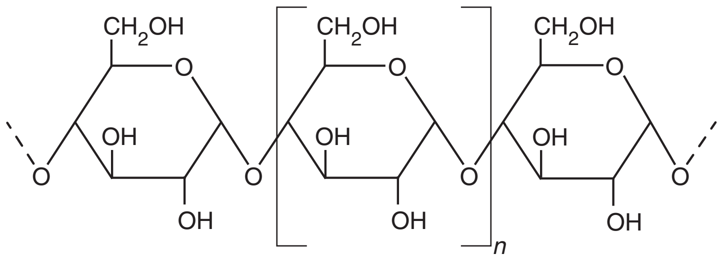
α-lactose



cellulose



amylopectin (starch)



amylose (starch)

11. Heats of combustion of common fuels

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

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

12. Heats of combustion of common blended fuels

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

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

13. Energy content of food groups

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

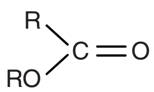
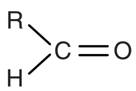
14. Characteristic ranges for infra-red absorption

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

15. ^{13}C NMR data

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

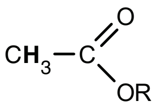
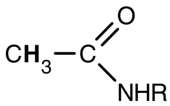
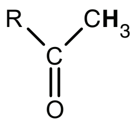
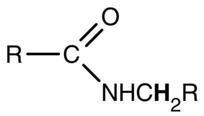
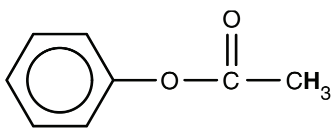
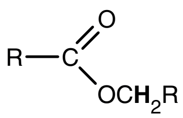
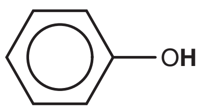
These can differ slightly in different solvents.

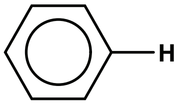
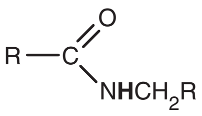
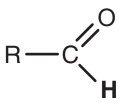
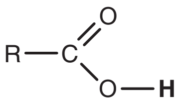
Type of carbon	**Chemical shift (ppm)**
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$, $R_3C–NR$	35–70
$R–CH_2–OH$	50–90
RC≡CR	75–95
$R_2C=CR_2$	110–150
RCOOH	160–185
	165–175
	190–200
$R_2C=O$	205–220

16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

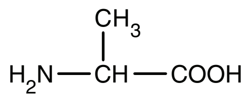
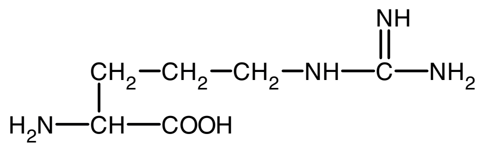
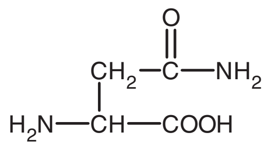
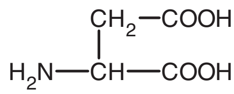
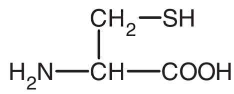
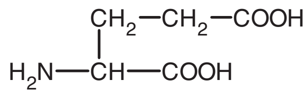
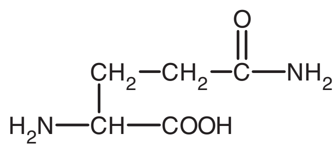
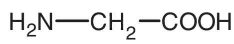
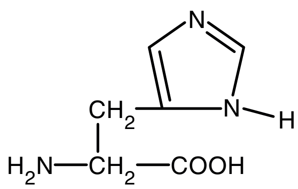
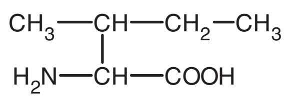
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

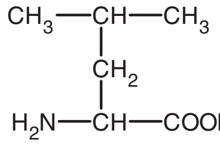
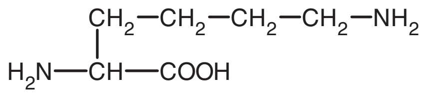
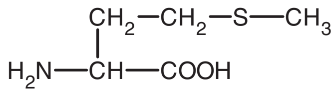
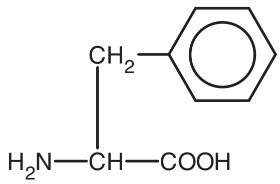
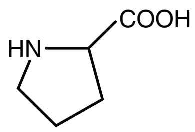
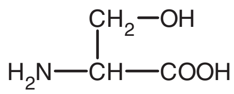
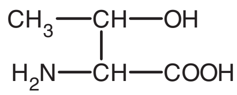
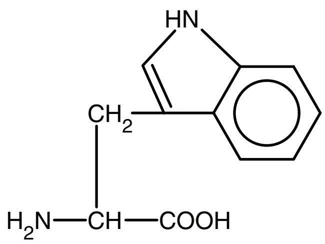
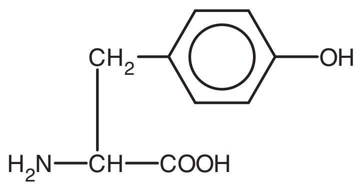
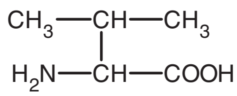
Type of proton	Chemical shift (ppm)
R–C**H**$_3$	0.9–1.0
R–C**H**$_2$–R	1.3–1.4
RCH=CH–C**H**$_3$	1.6–1.9
R$_3$–C**H**	1.5
 or 	2.0
	2.1–2.7
R–C**H**$_2$–X (X = F, Cl, Br or I)	3.0–4.5
R–C**H**$_2$–OH, R$_2$–C**H**–OH	3.3–4.5
	3.2
R–O–C**H**$_3$ or R–O–C**H**$_2$R	3.3–3.7
	2.3
	3.7–4.8
R–O–**H**	1–6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

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

17. 2-amino acids (α-amino acids)

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

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

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

END OF DATA BOOKLET

Neap

Trial Examination 2020

VCE Chemistry Units 3&4

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
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

21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D
25	A	B	C	D
26	A	B	C	D
27	A	B	C	D
28	A	B	C	D
29	A	B	C	D
30	A	B	C	D