Neap

Trial Examination 2021

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	9	9	90
			Total 120

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

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

Materials supplied

Question and answer booklet of 25 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 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

Carboxylic acids are isomers of

A. alcohols.

B. esters.

C. aldehydes.

D. ketones.

Use the following information to answer Questions 2 and 3.

Both petrodiesel and biodiesel are suitable for use as transport fuels under certain conditions.

Question 2

Which one of the following is **most** similar for petrodiesel and biodiesel?

A. chemical structure

B. viscosity in cold weather

C. products of complete combustion

D. functional groups in each fuel

Question 3

Which one of the following statements is correct?

A. Petrodiesel has approximately five times more energy per gram than biodiesel.

B. Biodiesel absorbs more moisture from the atmosphere than petrodiesel.

C. Biodiesel has no environmental impact in its production.

D. Petrodiesel is produced in a process using no net energy.

Question 4

The volume of hydrogen gas required at standard laboratory conditions (SLC) to react completely with 56.0 g of ethene gas to form ethane is

A. 1.23 L

B. 24.8 L

C. 49.6 L

D. 61.2 L

Use the following information to answer Questions 5 and 6.

Information about liquid hexane is shown in the table below.

Molar mass	Density	Energy released on complete combustion
86 g mol^{-1}	0.66 g mL^{-1}	4163 kJ per mole

Question 5
How many kilojoules of energy are released when 2.0 L of liquid hexane is burnt in excess oxygen?

A. 64

B. 1.0×10^3

C. 6.4×10^4

D. 4.7×10^8

Question 6
If the 2.0 L of liquid hexane was vaporised before combustion, the energy released when the gaseous hexane is burnt in excess oxygen would be

A. greater than the amount of energy released when liquid hexane is burnt.

B. identical to the amount of energy released when liquid hexane is burnt.

C. lower than the amount of energy released when liquid hexane is burnt.

D. impossible to predict without knowing the temperature of the gaseous hexane.

Question 7
A mixture of Cr_2O_3 and ZnO is used as a catalyst in the industrial production of methanol, by the following reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

The catalyst

A. increases the proportion of CH_3OH in the equilibrium mixture.

B. decreases the enthalpy change for the forward reaction.

C. decreases the rate of the formation of CO and H_2.

D. increases the amount of CH_3OH formed in a given time.

Question 8
One mole of which amino acid would react with exactly 572 mL of 3.50 M NaOH solution?

A. glutamic acid

B. glutamine

C. glycine

D. threonine

Question 9

Y is a metal that forms the oxide Y_2O according to the following equation.

$$4Y(s) + O_2(g) \rightarrow 2Y_2O \qquad \Delta H = -80.0 \text{ kJ mol}^{-1}$$

When a sample of Y_2O decomposes to form 0.20 mol of Y(s), then

A. 4.0 kJ of energy will be released.

B. 4.0 kJ of energy will be absorbed.

C. 16.0 kJ of energy will be released.

D. 16.0 kJ of energy will be absorbed.

Question 10

Many protein chains adopt a spiral shape.

This shape is mainly due to

A. the formation of disulfide links between amino acids that contain sulfur atoms.

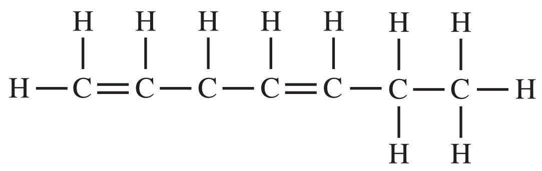
B. ionic bonds that form between COO^- and NH_3^+ side groups of different amino acids.

C. hydrogen bonds that develop between N–H groups of amino acid side groups.

D. interaction between N–H and C=O groups on non-adjacent amino acid residues.

Use the following information to answer Questions 11 and 12.

The structure of 1,4-heptadiene is shown in the diagram below.



Question 11

This molecule can show *cis-trans* isomerism.

How many *cis-trans* isomers are possible for this molecule (including the isomer shown)?

A. 1

B. 2

C. 3

D. 4

Question 12

1,4-heptadiene can react with hydrogen gas to form a saturated product.

What volume of hydrogen gas measured at 50°C and 150 kPa will react completely with 5.0 mol of 1,4-heptadiene?

A. 27 L

B. 89 L

C. 1.8×10^2 L

D. 2.7×10^4 L

Use the following information to answer Questions 13 and 14.

To check the reliability of a 25.00 mL pipette at 25°C, aliquots of pure water were taken using the pipette and weighed. The results are shown in the table below.

Aliquot	1	2	3	4	5
Mass (g)	24.58	24.55	24.54	24.56	24.59

Question 13

The results show

A. high accuracy and high precision.

B. high accuracy and low precision.

C. low accuracy and high precision.

D. low accuracy and low precision.

Question 14

The results also show evidence of

A. random error, which is removed by repeated measurements and taking an average.

B. random error, which is not reduced by repeated measurements and taking an average.

C. systematic error, which is remedied by repeated measurements and taking an average.

D. systematic error, which is not remedied by repeated measurements and taking an average.

Question 15

Coenzymes

A. act in combination with enzymes to enable a reaction to operate at a functional rate.

B. make a reaction occur at a faster rate when acting alone as a catalyst.

C. prevent the denaturation of proteins by preserving the primary structure.

D. are usually proteins that combine with substrate molecules.

Question 16

An omega-3 fatty acid has

A. only one double bond in the molecule.

B. a double bond on the third carbon atom near the carboxyl end of the molecule.

C. a set of three carboxyl functional groups in the molecule.

D. a C=C bond on the third carbon atom at the methyl end of the molecule.

Question 17

How many chiral carbon atoms are in 2-chlorobutane?

A. 0

B. 1

C. 2

D. 3

Question 18

During an experimental procedure, a student obtained the following results.

Value obtained by experiment: 7.911

Theoretical/expected value: 7.932

The percentage error in the result obtained, expressed to the correct number of significant figures, is

A. 0.26

B. 0.2648

C. 0.2654

D. 0.27

Question 19

When 0.662 g of sucrose (M = 342 g mol^{-1}) underwent combustion in a bomb calorimeter with a calibration factor of 3.90 kJ °C^{-1}, the temperature rose by 2.80°C.

Based on these results, the energy content of sucrose, in kJ mol^{-1}, is

A. 16.5

B. 5.64×10^3

C. 16.5×10^3

D. 5.64×10^6

Question 20

The following information is relevant to a particular chemical reaction with no catalyst and to the same reaction when it is catalysed.

Activation energy of uncatalysed reaction	Activation energy of uncatalysed reverse reaction	Activation energy of catalysed reaction
90 kJ mol^{-1}	140 kJ mol^{-1}	40 kJ mol^{-1}

What is the activation energy, in kJ mol^{-1}, of the catalysed reverse reaction?

A. 40

B. 50

C. 90

D. 140

Question 21

The concentration of an organic compound, Y, in a mixture is determined using high-performance liquid chromatography (HPLC).

Which one of the following steps is **not** required to complete this analysis?

A. Measure the retention time of compound Y using mobile phases of various polarities.

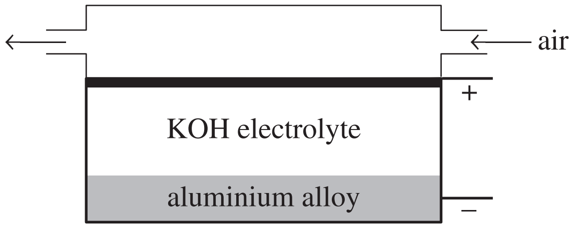
B. Determine the area under the peaks for solutions of compound Y of known concentrations.

C. Find the area under the peak for compound Y in the HPLC analysis.

D. Construct a calibration curve of peak area of standard solutions against concentration.

Use the following information to answer Questions 22–24.

The diagram below shows an aluminium–air cell, which produces electrical energy.



Question 22

Which one of the following statements is correct?

A. Aluminium is reduced and oxygen is oxidised when the cell operates.

B. The cell is usually recharged by using electrical energy to reverse the cell reaction.

C. The positive electrode is likely to be made from an inert and porous material.

D. Only non-spontaneous redox reactions will occur to produce electrical energy.

Question 23

The cell has been described as part galvanic cell and part fuel cell.

This is because

A. both of these types of cells contain an electrolyte.

B. electrons flow when the electrodes are connected to each other.

C. the oxidising agent and reducing agent react to generate electricity.

D. only one reactant is continuously supplied to the cell.

Question 24

The overall reaction when the cell generates electrical energy is

A. $4Al(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al^{3+}(aq) + 12OH^-(aq)$

B. $4Al(s) + 3O_2(g) + 12H^+(aq) \rightarrow 4Al^{3+}(aq) + 6H_2O(l)$

C. $4Al^{3+}(aq) + 12OH^-(aq) \rightarrow 4Al(s) + 3O_2(g) + 6H_2O(l)$

D. $4Al^{3+}(aq) + 6H_2O(l) \rightarrow 4Al(s) + 3O_2(g) + 12H^+(aq)$

Question 25

Foods that have a high amylopectin content

A. are hydrolysed more quickly than foods with a high amylose content.

B. have a much lower glycaemic index value than foods with a high amylose content.

C. produce very low quantities of glucose quite slowly during digestion.

D. are digested at the same rate as cellulose is hydrolysed in the digestive system.

Question 26

Vitamin D is best described as

A. an essential dietary requirement.

B. having many polar groups in its structure.

C. being soluble in oils and non-polar solvents.

D. a protein that catalyses a metabolic reaction.

Question 27

The percentage composition by mass of two foods is shown in the table below.

Food	Carbohydrate	Fats and oils	Protein
bread	45	5	10
cheese	3	29	21

How many grams of cheese has the same energy content as 100 g of bread?

A. 14.3

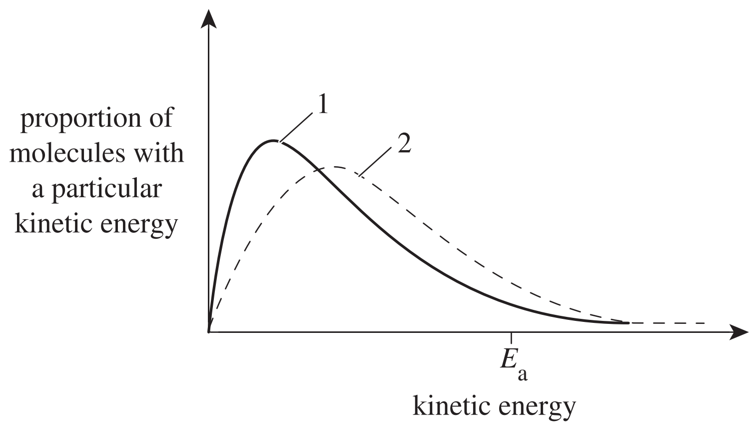
B. 72.7

C. 75.9

D. 137

Question 28

Two Maxwell–Boltzmann distribution curves for the same gas under different conditions are shown below.



The curves show the energies of reactant particles for a particular reaction.

Which one of the following statements about these curves is correct?

A. Curve 1 is at a higher temperature than curve 2.

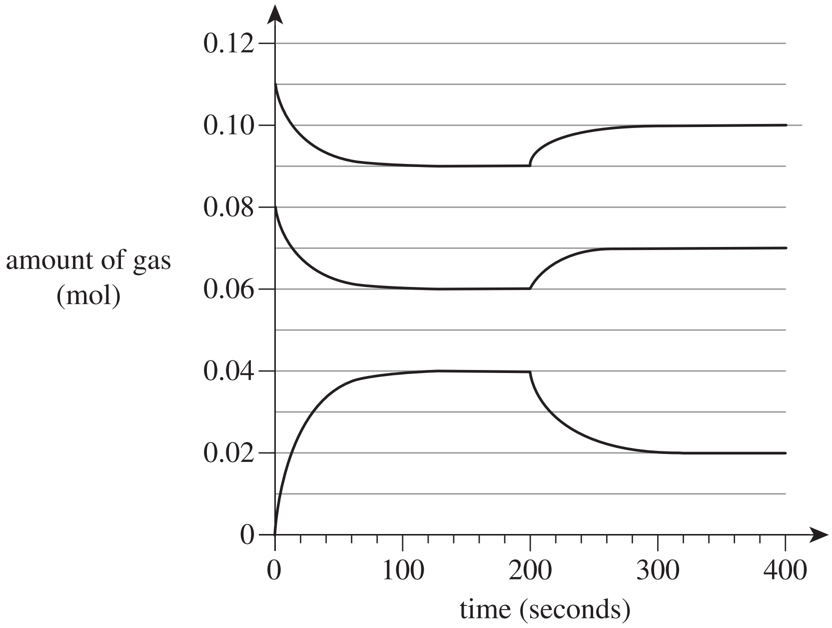
B. The number of reactant particles is higher in curve 1 than in curve 2.

C. Curve 1 has a catalyst present, whereas curve 2 does not.

D. Curve 2 results in a greater rate of reaction than curve 1.

Use the following information to answer Questions 29 and 30.

The results of an experiment on a gaseous equilibrium reaction were used to plot the graphs below. Initially, two gases were injected into an empty sealed vessel to begin the experiment.



Question 29

What are the units of the equilibrium constant (K_c) for the reaction?

A. no units

B. M^{-2}

C. M^{-1}

D. M^{2}

Question 30

Which one of the following actions was taken to cause a change during the experiment?

A. An inert gas was added.

B. A catalyst was introduced.

C. The volume of the vessel was changed.

D. The temperature of the gases was altered.

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 (11 marks)

Nitric acid is manufactured in a three-stage process using the sequence of exothermic chemical reactions shown in the table below.

Reaction	Chemical equation	Reaction conditions
I	$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$	moderate pressure; moderate temperature; Pt/Rh catalyst
II	$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$	high pressure; low temperature
III	$4NO_2(g) + O_2(g) + 2H_2O(l) \rightleftharpoons 4HNO_3(aq)$	high pressure

a. Oxygen is a reactant in all three reactions of the manufacturing process.

Explain the likely source of the oxygen and why this source is used. 2 marks

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b. **i.** Referring to collision theory and Le Chatelier's principle, explain the effect of high pressure on the rate and yield of reaction I, and account for the use of a moderate pressure to conduct the reaction during the production of nitric acid. 5 marks

ii. The equilibrium constant for reaction II at various temperatures is shown in the following table.

Temperature (K)	298	500	900	1100
Equilibrium constant (M^{-1})	3.9×10^{13}	6.6×10^{5}	4.4	0.30

Explain how these values indicate that reaction II is exothermic. 2 marks

c. Use oxidation numbers to determine the reducing agent in reaction III. 2 marks

Question 2 (11 marks)

Sucrose is one of the most widely-used compounds in the world.

a. During digestion, sucrose is initially broken down into two smaller products.

i. Write a balanced equation using molecular formulas for this reaction. (State symbols are **not** required.) 1 mark

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ii. Name the type of linkage broken during the digestion of sucrose. 1 mark

____

b. Aspartame is an artificial sweetener used in place of sucrose. Its structure is shown in the Data Booklet.

i. What is the main advantage in using aspartame as a sweetener to replace sucrose? 2 marks

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ii. The structure of aspartame is described as a methyl ester of a dipeptide that is synthesised using two naturally occurring amino acids.

Draw the structure, as a zwitterion, of the amino acid with the higher molar mass used to synthesise aspartame. 2 marks

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iii. Aspartame is formed using naturally occurring amino acids. If optical isomers of these amino acids are used in the structure, the compound is bitter and not sweet.

What are optical isomers? 2 marks

c. Sucrose is used in the industrial production of ethanol by fermentation using yeast.

i. Why is ethanol produced using this method classed as a biofuel? 1 mark

ii. Ethanol can also be produced industrially using ethene gas derived from crude oil. Temperatures around 300°C and a H_3PO_4 catalyst are used in the production process.

Write a balanced equation (including states) for this reaction. 2 marks

Question 3 (9 marks)

A 500 mL aqueous solution of KI was electrolysed using graphite electrodes for a short time with a current of 2.5 amperes.

a. At one electrode, $I_2(aq)$ was formed.

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

ii. Write the half-equation for the reaction at this electrode. 1 mark

b. i. Write the half-equation for the reaction at the other electrode. 1 mark

ii. Explain any pH changes that are likely to occur near this electrode as the electrolysis proceeds. 1 mark

c. After a short time in the electrolysis, 20.00 mL of the electrolyte was removed and titrated with 0.065 M sodium thiosulfate solution using the following chemical reaction.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

i. A titre of 28.50 mL was recorded.

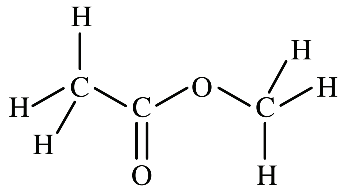
Calculate the number of mole of I_2 that reacted with the thiosulfate ion. 2 marks

ii. Calculate the amount of charge transferred during the electrolysis of the KI solution. 2 marks

iii. Calculate the duration of the electrolysis. 1 mark

Question 4 (9 marks)

a. Compound X and compound Y react to form compound Z. Compound Z has the following structure.



i. Give the systematic name of compound Z. 1 mark

____

ii. To what family of organic compounds does compound Z belong? 1 mark

____

iii. Outline the reactants and conditions needed to produce compound Z. 2 marks

____

____

iv. Calculate the atom economy of producing compound Z from compounds X and Y. 2 marks

____

____

____

b. Show how ethanamine can be produced from an alkane in a series of reactions. Include reagents and any intermediate products in the reaction pathway. Use structural formulas for all organic compounds involved. 3 marks

Question 5 (5 marks)

Carbon oxyfluoride decomposes according to the following equation.

$$2COF_2(g) \rightleftharpoons CF_4(g) + CO_2(g) \qquad \Delta H = -48 \text{ kJ mol}^{-1}$$

1.00 mole of COF_2 gas was placed in a 5.0 L sealed container and allowed to reach equilibrium at 200°C. At equilibrium, 0.40 mole of CF_4 gas was present.

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

b. Calculate the value of the equilibrium constant for the reaction at 200°C. 4 marks

Question 6 (11 marks)

a. When zinc metal is extracted from its ores, it is common to dissolve the ores in acid and remove any impurities from the solution of zinc ions. One method to remove any small amounts of silver ions is to add zinc dust.

i. Write an overall redox ionic equation for the reaction to remove the silver ion using zinc dust. 2 marks

ii. Using the electrochemical series, explain why this method is effective. 1 mark

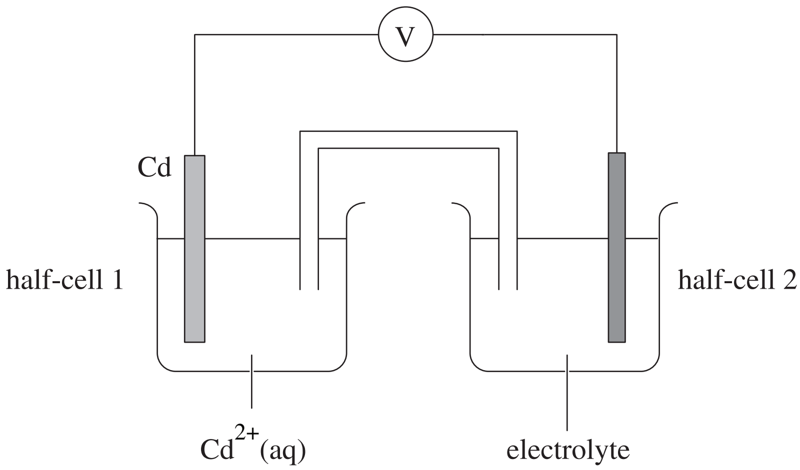
iii. Identify a metal that could **not** be removed by adding zinc dust. 1 mark

iv. Explain why zinc dust is used rather than granules of zinc of 5 mm diameter. 2 marks

v. Why is it reasonable to assume that the activation energy for this reaction has a low value? 1 mark

b. A galvanic cell was set up as follows under standard conditions using the cell reaction shown.

$$Br_2(l) + Cd(s) \rightarrow 2Br^-(aq) + Cd^{2+}(aq)$$



i. Calculate the voltage of the cell. 1 mark

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ii. State a suitable electrode material for half-cell 2. 1 mark

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iii. On the diagram above, draw an arrow immediately above the voltmeter to show the direction of movement of electrons, and write 'electrons' above this arrow. 1 mark

iv. On the diagram above, draw an arrow immediately above the salt bridge to show the direction of movement of anions, and write 'anions' above this arrow. 1 mark

Question 7 (12 marks)

One gram of each of the hydrocarbons shown in the table below releases 48 kJ of energy on complete combustion.

Hydrocarbon	**Molecular formula**	**Boiling point (°C)**
2,2,4-trimethylpentane	C_8H_{18}	99
nonane	C_9H_{20}	151
hexadecane	$C_{16}H_{34}$	287

a. **i.** Give the molecular formula of the compound that has 20 carbon atoms per molecule and is in the same group of hydrocarbons as those shown in the table above. 1 mark

___

ii. Draw the skeletal structure of 2,2,4-trimethylpentane. 1 mark

b. Write a balanced thermochemical equation for the complete combustion of nonane. 3 marks

___

___

___

c. Using structure and bonding, explain the trend in boiling points for the three hydrocarbons listed in the table above. 2 marks

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d. If a small sample of another hydrocarbon liquid, hexane (C_6H_{14}), is brought close to a lit match, it ignites immediately and burns with a sooty, yellow flame with black smoke.

i. Write a balanced chemical equation that is consistent with the information about the combustion of hexane. 2 marks

ii. Explain the observations for the burning of hexane after ignition. 2 marks

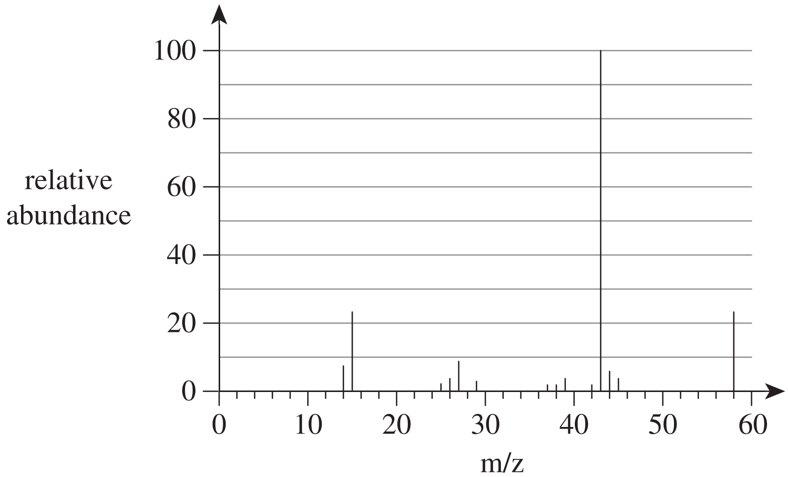
iii. All hydrocarbons will burn in air under suitable conditions. If a small sample of hexadecane is brought close to a lit match, no ignition will occur.

Explain why no ignition will occur under these conditions. 1 mark

Question 8 (12 marks)

Chemists use data from a range of instrumental analyses of organic compounds to confirm or deduce organic structures. Each of the organic compounds P, Q, R and S was analysed using a different analytical instrument.

a. Compound P has the empirical formula C_3H_6O. The mass spectrum of compound P is shown below.



i. Complete the following table by providing the relevant m/z values. 2 marks

Signal	base peak	molecular ion peak
m/z value		

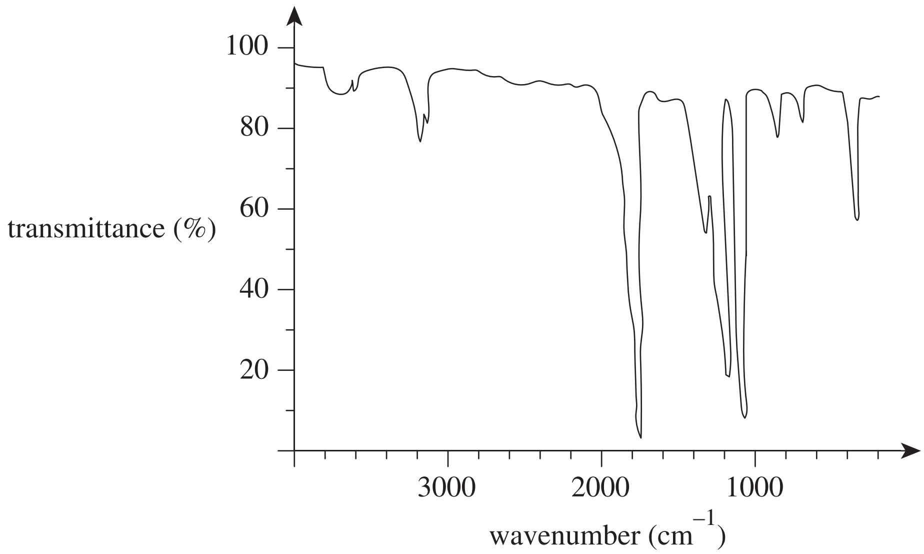
ii. State the molecular formula of compound P. 1 mark

____

iii. Identify a possible fragment that produced the signal at m/z 15. 1 mark

____

b. The infrared spectrum of compound Q is shown below.



Compound Q was produced by oxidation of a secondary alcohol.

i. Explain the meaning of the term 'secondary alcohol'. 1 mark

____

____

ii. Which functional group is present in compound Q? 1 mark

____

iii. Explain how the infrared spectrum above can be used to derive information about the functional group in compound Q. 1 mark

____

____

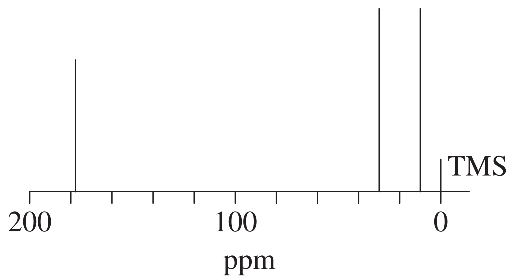
c. The proton NMR spectrum data of compound R are summarised in the table below.

Chemical shift (ppm)	Relative peak area	Peak splitting
1.2	3	triplet
2.4	2	quadruplet
11.8	1	singlet

Compound R is a carboxylic acid with three carbon atoms per molecule.

Explain how the information in the table is consistent with the information provided about the structure of compound R. 3 marks

d. The carbon-13 NMR of compound S is shown below.



i. Even without the label, it is clear that this is **not** a proton NMR spectrum.

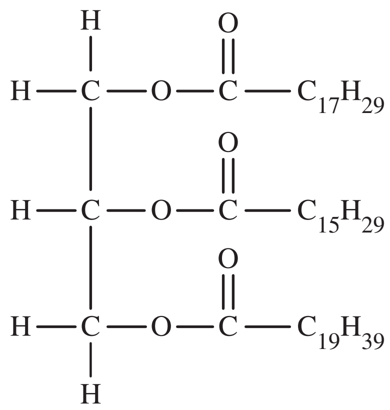
Explain why. 1 mark

ii. What information about compound S is revealed by this carbon-13 NMR spectrum? 1 mark

Question 9 (10 marks)

The enzyme lipase catalyses the breakdown of triglycerides.

a. The following triglyceride was hydrolysed using lipase.



i. Write the formula of the saturated fatty acid produced by the hydrolysis. 1 mark

___

ii. Give the name of the fatty acid produced that has the higher number of carbon–carbon double bonds per molecule. 1 mark

___

b. An experiment was conducted to investigate the effect of temperature on the activity of lipase in breaking down the fats in milk. The experiment used a series of test tubes, each with the following contents.

- 5.0 mL of milk
- 7.0 mL of sodium carbonate solution
- 0.25 mL of phenolphthalein indicator

Phenolphthalein indicator is coloured pink in alkaline solutions of pH 10, but below pH 8.3 it changes to colourless. Therefore, as the triglycerides are broken down, the pH decreases and the pink colour changes. The activity of the enzyme can be determined by how long it takes for the colour to change.

Each test tube and its contents was heated or cooled to a set temperature and the reaction was initiated by adding 1.0 mL of lipase solution at the appropriate temperature. The length of time it took for the indicator to change colour in each test tube was measured after the lipase was added. These results were recorded in the table below.

Temperature of contents (°C)	5	15	25	35	45	55
Time it took for colour to change (s)	450	360	240	180	320	430

i. Give the approximate temperature at which the enzyme has maximum activity. 1 mark

___

ii. Explain, at a molecular level, why the enzyme has lower activity at temperatures that are higher or lower than the temperature of maximum enzyme activity. 3 marks

iii. Why is it important that the temperature of the lipase solution that was added to initiate the reaction should match the temperature of the contents of each test tube? 2 marks

iv. Explain why the effect of pH on lipase activity could **not** be investigated using this type of experiment. 2 marks

END OF QUESTION AND ANSWER BOOKLET

Trial Examination 2021

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	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

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

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	$n=\dfrac{m}{M};\quad n=cV;\quad n=\dfrac{V}{V_m}$
universal gas equation	$pV=nRT$
calibration factor (CF) for bomb calorimetry	$\mathrm{CF}=\dfrac{VIt}{\Delta T}$
heat energy released in the combustion of a fuel	$q=mc\Delta T$
enthalpy of combustion	$\Delta H=\dfrac{q}{n}$
electric charge	$Q=It$
number of moles of electrons	$n\left(e^{-}\right)=\dfrac{Q}{F}$
% atom economy	$\dfrac{\text{molar mass of desired product}}{\text{molar mass of all reactants}}\times\dfrac{100}{1}$
% yield	$\dfrac{\text{actual yield}}{\text{theoretical yield}}\times\dfrac{100}{1}$

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

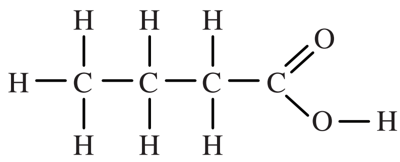
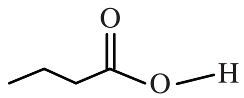
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

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

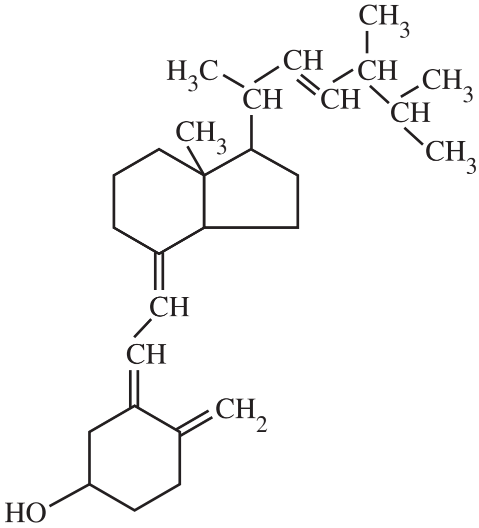
The following table shows different representations of organic molecules, using butanoic acid as an example.

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	

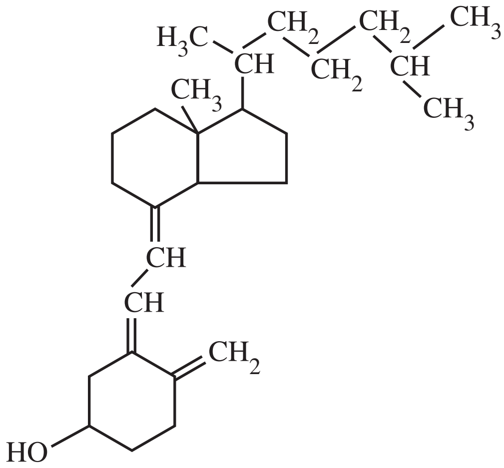
9. Formulas of some fatty acids

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

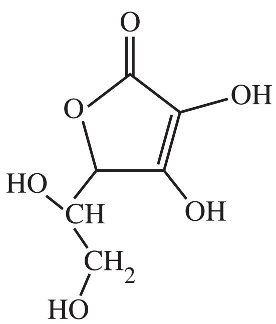
10. Formulas of some biomolecules



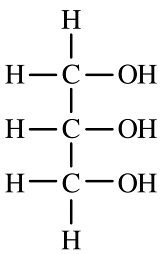
vitamin D_2 (ergocalciferol)



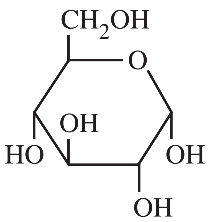
vitamin D_3 (cholecalciferol)



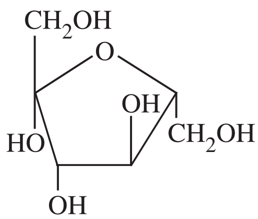
vitamin C (ascorbic acid)



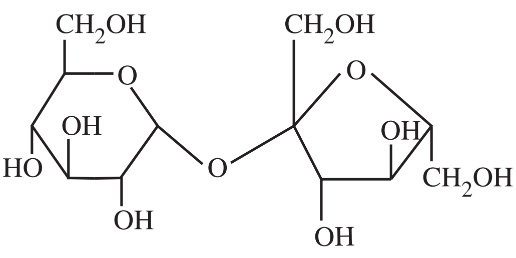
glycerol



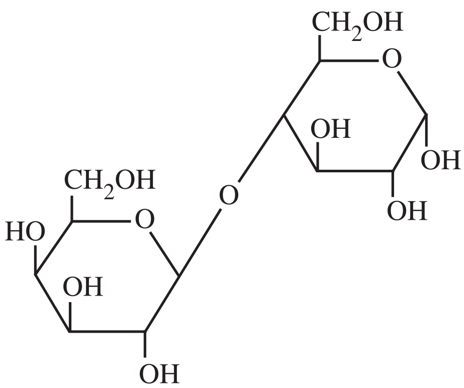
α-glucose



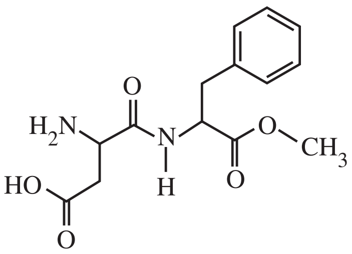
β-fructose



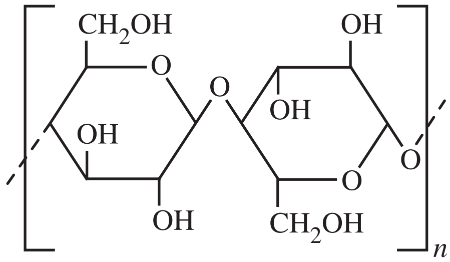
sucrose



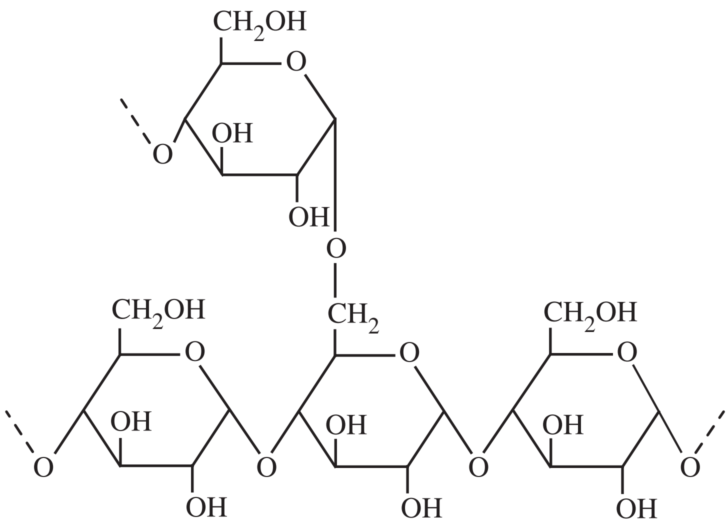
α-lactose



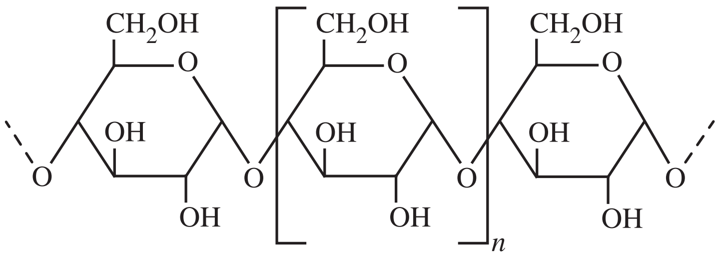
aspartame



cellulose



amylopectin (starch)



amylose (starch)

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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

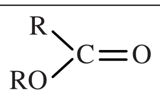
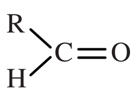
14. Characteristic ranges for infra-red absorption

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

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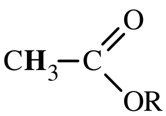
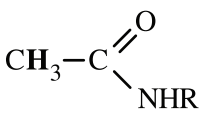
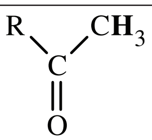
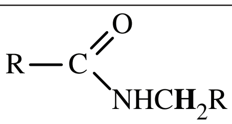
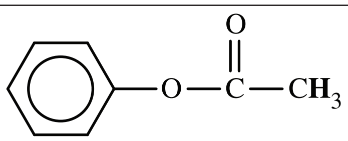
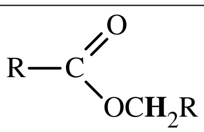
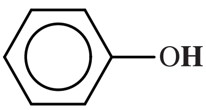
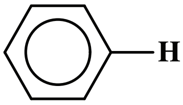
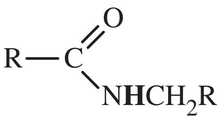
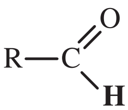
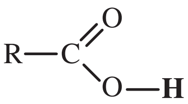
16. [1]H NMR data

Typical proton shift values relative to TMS = 0

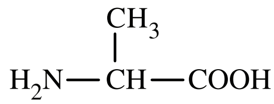
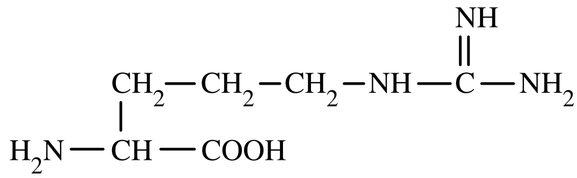
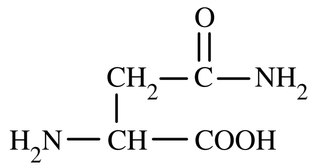
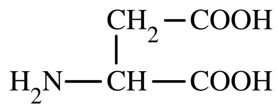
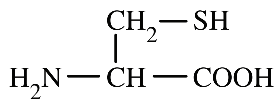
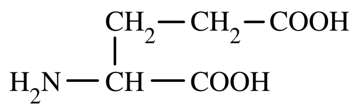
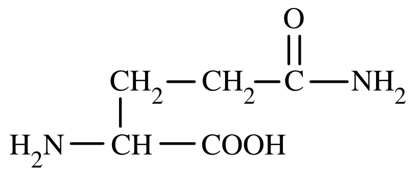
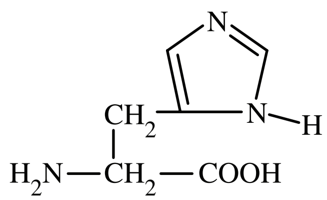
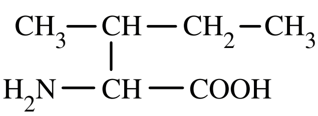
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

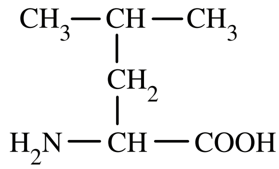
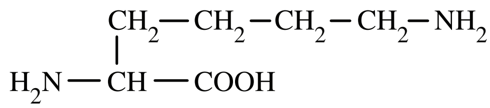
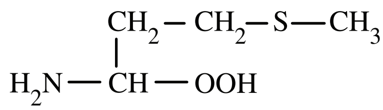
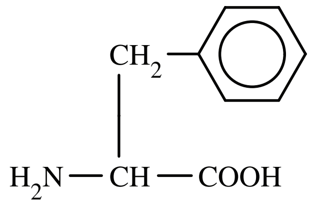
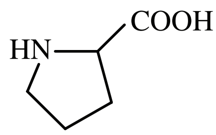
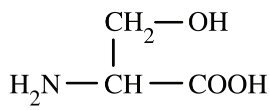
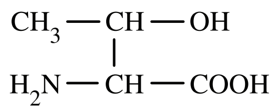
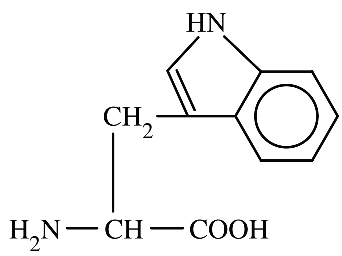
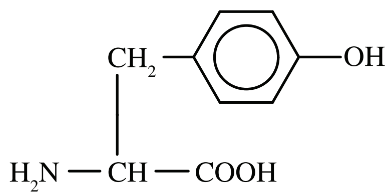
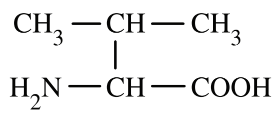
Type of proton	Chemical shift (ppm)
$R{-}C\mathbf{H}_3$	0.9–1.0
$R{-}C\mathbf{H}_2{-}R$	1.3–1.4
$RCH{=}CH{-}C\mathbf{H}_3$	1.6–1.9
$R_3{-}C\mathbf{H}$	1.5
 or 	2.0
	2.1–2.7
$R{-}C\mathbf{H}_2{-}X$ (X = F, Cl, Br or I)	3.0–4.5
$R{-}C\mathbf{H}_2{-}OH$, $R_2{-}C\mathbf{H}{-}OH$	3.3–4.5
	3.2
$R{-}O{-}C\mathbf{H}_3$ 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	H_2N-CH_2-COOH
histidine	His	
isoleucine	Ile	

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

END OF DATA BOOKLET

Neap

Trial Examination 2021

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

Use pencil only

1	A	B	C	D	11	A	B	C	D	21	A	B	C	D
2	A	B	C	D	12	A	B	C	D	22	A	B	C	D
3	A	B	C	D	13	A	B	C	D	23	A	B	C	D
4	A	B	C	D	14	A	B	C	D	24	A	B	C	D
5	A	B	C	D	15	A	B	C	D	25	A	B	C	D
6	A	B	C	D	16	A	B	C	D	26	A	B	C	D
7	A	B	C	D	17	A	B	C	D	27	A	B	C	D
8	A	B	C	D	18	A	B	C	D	28	A	B	C	D
9	A	B	C	D	19	A	B	C	D	29	A	B	C	D
10	A	B	C	D	20	A	B	C	D	30	A	B	C	D