Neap

Trial Examination 2022

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 32 pages

Data booklet

Answer sheet for multiple-choice questions

Instructions

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

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

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

You may keep the data booklet.

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

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

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1
In an equilibrium reaction, a catalyst alters the
A. enthalpy change of the reaction.
B. enthalpy of the reactants and products.
C. value of the equilibrium constant.
D. energy required to initiate the reaction.

Question 2
Which one of the following involves a condensation reaction?
A. any reaction that has water as a reactant
B. sucrose being broken down into monosaccharides
C. amino acids being produced from a tripeptide
D. starch forming from glucose monomers

Question 3
Which one of the following descriptions applies to enzymes but **not** to coenzymes?
A. They are organic molecules present in plants and animals.
B. Some can function alone to increase the rate of a reaction.
C. They are often derived from vitamins and bind to active sites during catalysis.
D. They always contain an active site that is never modified during functioning.

Question 4

Bromine and iodine gases react according to the following equation.

$$Br_2(g) + I_2(g) \rightleftharpoons 2IBr(g)$$

At a particular temperature, T_1, the equilibrium constant, K_c, for the reaction is 97.5.

At T_1, what is the K_c for the reaction $IBr(g) \rightleftharpoons \frac{1}{2}Br_2(g) + \frac{1}{2}I_2(g)$?

A. 2.05×10^{-2}

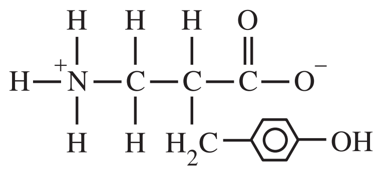
B. 0.101

C. 6.99

D. 48.8

Question 5

The structure of a particular form of a compound is shown below.



Which one of the following best describes this form of the compound?

A. It is found in a high pH environment.

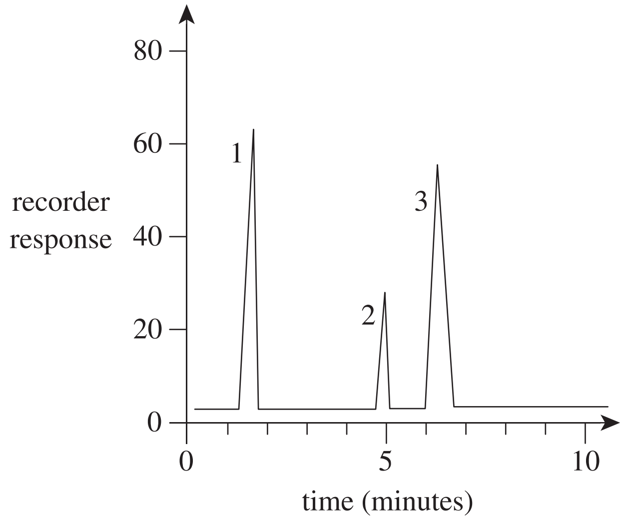
B. It is found in a low pH environment.

C. It is the zwitterion of a compound, which is a 2-amino acid.

D. It is the zwitterion of a compound, which is not a 2-amino acid.

Use the following information to answer Questions 6 and 7.

A mixture of three esters was analysed using high-performance liquid chromatography (HPLC). The output of the analysis is shown below.



Key
1 pentyl ethanoate
2 ethyl heptanoate
3 pentyl pentanoate

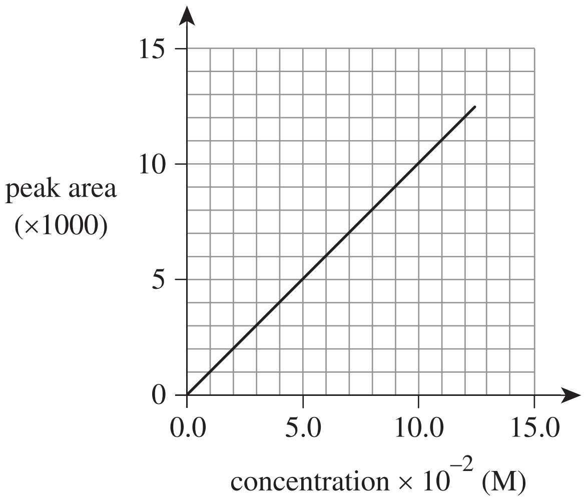
Question 6

Which row identifies the esters with the stated properties?

	Ester with the highest concentration in the mixture	Ester with the weakest attraction to the stationary phase
A.	1	1
B.	3	3
C.	3	1
D.	1	3

Question 7

To find the concentration of ethyl heptanoate in a different mixture of the three esters, a 5.0 mL sample of this mixture was diluted to 50.0 mL with solvent. This diluted sample was analysed on the same HPLC column under identical conditions. A calibration curve was produced for ethyl heptanoate and is shown below.



The peak area for the diluted sample of the mixture containing ethyl heptanoate was 8500 units.

The concentration of ethyl heptanoate in the undiluted sample is

A. 8.5×10^{-3} M

B. 8.5×10^{-2} M

C. 0.85 M

D. 8.5 M

Question 8

E10 fuel is 90% octane and 10% ethanol by mass.

How many kilojoules of energy are released when 1.00 kg of E10 fuel is burnt in excess oxygen?

A. 4.77×10^{3}

B. 4.61×10^{4}

C. 7.75×10^{4}

D. 5.05×10^{5}

Use the following information to answer Questions 9 and 10.

Ascorbic acid, also known as vitamin C, can be used to prevent oxidative rancidity in certain foods.

Question 9

Vitamin C

A. is a fat-soluble vitamin.

B. can be synthesised in the human body.

C. has physical properties identical to those of vitamin D.

D. is required by the human body in smaller amounts than amino acids.

Question 10

0.01 mol of each of four different fatty acids are stored under identical conditions. The fatty acids are arachidonic acid, linoleic acid, palmitoleic acid and arachidic acid.

The acid that would require the largest amount of vitamin C to prevent oxidative rancidity is

A. arachidonic acid.

B. linolenic acid.

C. palmitoleic acid.

D. arachidic acid.

Question 11

The formation of the ester 1-propyl butanoate (M = 130 g mol^{-1}) is shown in the following equation.

$$CH_3CH_2CH_2OH(l) + CH_3CH_2CH_2COOH(l) \rightleftharpoons CH_3CH_2CH_2COOCH_2CH_2CH_3(l) + H_2O(l)$$

What is the atom economy of this reaction?

A. 12.2%

B. 67.5%

C. 87.8%

D. 89.2%

Use the following information to answer Questions 12 and 13.

Fluorine gas is produced industrially by the electrolysis of liquid hydrogen fluoride according to the following equation.

$$2HF(l) \rightarrow F_2(g) + H_2(g)$$

Question 12

The following half-reaction occurs in the electrolytic cell.

$$2F^-(l) \rightarrow F_2(g) + 2e^-$$

This half-reaction occurs at the

A. anode, which is positive.

B. cathode, which is positive.

C. anode, which is negative.

D. cathode, which is negative.

Question 13

The electrolytic cell uses electrodes made from two different materials.

Which row identifies the most likely composition of each electrode?

	Composition of electrode at which H_2 gas forms	Composition of electrode at which F_2 gas forms
A.	carbon	iron
B.	iron	carbon
C.	copper	iron
D.	iron	copper

Question 14

Which of the following statements about the glycaemic index (GI) is **incorrect**?

A. A high proportion of amylopectin to amylose produces a lower GI value.

B. GI reflects the relative ease of digestion of carbohydrates.

C. A food's ability to raise the level of glucose in the blood is indicated by the GI value of the food.

D. Drinks with a high sugar content are likely to have high GI values.

Use the following information to answer Questions 15 and 16.

On a 500 km journey, a vehicle used 74.5 L of petrol and produced 1.81×10^5 g of carbon dioxide gas, CO_2. The vehicle was then converted to use liquefied petroleum gas (LPG) and completed the same journey under identical conditions with a fuel consumption of 19.5 L per 100 km.

Question 15

Which one of the following statements is correct?

A. A fuel derived from fossil fuels was used during one of the journeys only.

B. Petrol has a higher energy content per litre than LPG.

C. No carbon monoxide gas, CO, is likely to have been produced during either journey.

D. Both fuel tanks used in the vehicle would have been filled at atmospheric pressure.

Question 16

The second journey produced 1.63×10^5 g of CO_2 gas.

What is the quantity of CO_2 emissions in grams per litre of LPG burnt?

A. 1.67×10^3

B. 8.86×10^3

C. 3.26×10^4

D. 8.15×10^5

Question 17

The following half-cells are set up under standard laboratory conditions (SLC).

Half-cell 1	Half-cell 2	Half-cell 3	Half-cell 4
Ag rod in Ag^+(aq)	Ni rod in Ni^{2+}(aq)	Al rod in Al^{3+}(aq)	Cu rod in Cu^{2+}(aq)

Which combination of half-cells, under SLC, would produce the highest cell potential?

A. 1 and 2

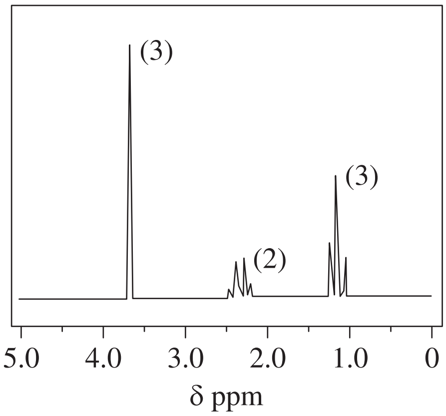
B. 3 and 4

C. 1 and 3

D. 2 and 4

Use the following information to answer Questions 18 and 19.

A simplified high-resolution nuclear magnetic resonance (NMR) spectrum of a compound is shown below. The compound has the empirical formula C_2H_4O and is known to contain one ester functional group per molecule.



Question 18

Which row describes the significance of the numbers in the spectrum above?

	Bracketed numbers ((3), (2), (3))	δ ppm (3.67, 2.32, 1.15)
A.	These identify the types of functional groups in the molecule.	These are the ratio of the number of carbon-13 atoms of each type in the molecule.
B.	These are the ratio of the number of carbon-13 atoms of each type in the molecule.	These identify the types of carbon-13 atoms in the molecule.
C.	These identify the types of protons in the molecule.	These are the ratio of the number of protons of each type in the molecule
D.	These are the ratio of the number of protons of each type in the molecule.	These identify the types of protons in the molecule.

Question 19

What is the name of the compound that produced the spectrum above?

A. butanoic acid

B. methyl methanoate

C. 1-propyl methanoate

D. methyl propanoate

Question 20

In a 100 g sample of a breakfast cereal, there are 11.6 g of protein and 17.8 g of fat. The total energy content of the sample is 1627 kJ.

The mass of carbohydrate in the sample is

A. 17.4 g

B. 24.1 g

C. 48.2 g

D. 70.6 g

Question 21

Methane is considered a biofuel when it is extracted from

A. coal seam gas.

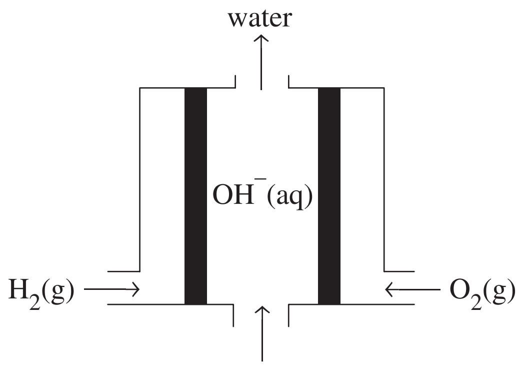
B. decomposing organic waste.

C. any material of organic origin.

D. gases formed in coal destruction.

Use the following information to answer Questions 22 and 23.

The design of a hydrogen–oxygen fuel cell with an alkaline electrolyte is illustrated in the following diagram.



Question 22

Which one of the following half-equations represents the reaction at the cathode?

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

B. $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$

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

D. $H_2(g) + 2e^- \rightarrow 2H^+(aq)$

Question 23

Cars have been designed to operate with an electric motor powered by the type of fuel cell shown above.

Which one of the following statements about the use of a fuel cell in a car is correct?

A. The cell is run at high temperatures to reduce the activation energy (E_a).

B. The flammability of oxygen gas is a problem, so the gas must be managed with care.

C. The cell is less efficient in terms of energy usage than the normal engine used in cars.

D. The safe storage of sufficient hydrogen gas in the car is an ongoing concern.

Question 24

In a 10.0 L tank, 100 g of propane gas is stored at 20.0°C.

If the amount of gas in the tank is doubled and the pressure remains constant, the final temperature of the gas will be

A. –127°C

B. 10.0°C

C. 14.7°C

D. 40.0°C

Question 25

As part of its structure, the aspartame molecule has

A. one peptide bond and one glycosidic linkage only.

B. one glycosidic linkage and one ester linkage only.

C. one peptide bond and one ester linkage only.

D. one peptide bond, one ester linkage and one glycosidic linkage.

Use the following information to answer Questions 26 and 27.

Rechargeable lithium-ion batteries are used as power sources in many popular portable electronic devices.

Question 26

When a lithium-ion battery is being recharged, the negative terminal of the power recharger is connected to the

A. positive terminal of the battery so that electrons are forced onto the electrode.

B. negative terminal of the battery so that electrons are forced onto the electrode.

C. positive terminal of the battery so that electrons are removed from the electrode.

D. negative terminal of the battery so that electrons are removed from the electrode.

Question 27

The optimal environmental condition to recharge a lithium-ion battery is a temperature between approximately 10°C and 20°C. A Chemistry student suggested that the poor recharging outcomes when the temperature is well outside this range are due to the following reasons.

I Recharging the battery involves chemical reactions that occur due to collisions of particles. In cold conditions, collisions are less frequent and fewer particles have sufficient energy to break bonds during collisions.

II At high temperatures, gases move away from the electrodes and possibly escape from the battery.

III At high and low temperatures, electrons are prevented from moving within the lithium metal in the battery.

Which of the students' suggested reasons are plausible explanations for the poor recharging of a lithium-ion battery?

A. I and II only

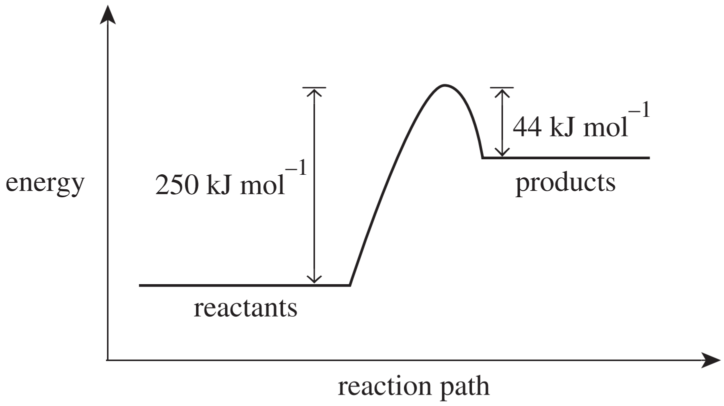
B. II and III only

C. I and III only

D. I, II and III

Question 28

The energy profile diagram for a particular reaction is shown below.



Which one of the following statements about the energy profile diagram is correct?

A. The enthalpy change (ΔH) of the forward reaction is +250 kJ mol^{-1}.

B. The forward reaction is exothermic and has an activation energy (E_a) of 44 kJ mol^{-1}.

C. The E_a of the reverse reaction is lower than the E_a of the forward reaction.

D. The ΔH of the reverse reaction is +206 kJ mol^{-1}.

Question 29

The temperature of 250 g of water was increased by 21.0°C when heated by burning 1.15 g of a liquid fuel. Only 75% of the heat from the combustion was transferred to the water.

What is the heat of combustion of the liquid fuel?

A. 14.3 kJ g^{-1}

B. 16.4 kJ g^{-1}

C. 25.4 kJ g^{-1}

D. 29.2 kJ g^{-1}

Question 30

One change was made to a sample of gas in a 2.0 L closed vessel. As a result of this change, the peak of the Maxwell-Boltzmann distribution curve moved to the right and the graph flattened; however, the area under the graph did not change.

Which one of the following statements is inconsistent with the change made to the gas sample?

A. More gas was injected into the closed vessel.

B. More collisions between the gas particles occurred.

C. The temperature of the vessel increased.

D. The average kinetic energy of the particles increased.

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)

a. Ethene can be produced using the following two methods.

- Method 1: Using a chemical reaction known as 'cracking' to break apart unwanted hydrocarbons derived from crude oil. For example:

$$C_{16}H_{34} \rightarrow C_7H_{16} + 3C_2H_4 + C_3H_6$$

- Method 2: Using a dehydrating agent such as sulfuric acid to convert ethanol to ethene. For example:

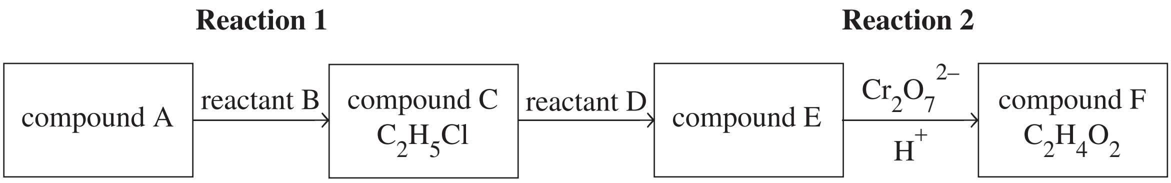
$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

i. Explain why it is not sustainable to produce ethene using Method 1. 2 marks

ii. Bioethanol can be used as the reactant in Method 2.

Explain how bioethanol is produced. 2 marks

b. The following pathway shows the reactions required to synthesise compound F. In this pathway, compound A is an alkane.



i. Compound C could be produced using ethene as a reactant.

Write the chemical equation of this reaction. State symbols are **not** required. 1 mark

____

ii. What type of reaction is reaction 1 in the pathway above? 1 mark

____

iii. What type of reaction is reaction 2 in the pathway above? 1 mark

____

iv. Complete the table below to identify the chemical names and reaction conditions in the pathway. 3 marks

	Chemical name	**Reaction conditions**
Reactant B		
Reactant D		

v. Draw the skeletal structure of compound F. 1 mark

Question 2 (8 marks)

Carbohydrate metabolism in plants and animals involves a complex series of chemical reactions.

a. Starch and cellulose are two polysaccharides involved in carbohydrate metabolism.

i. What is the main role of starch in plants? 1 mark

___

ii. State why humans are unable to digest cellulose. 1 mark

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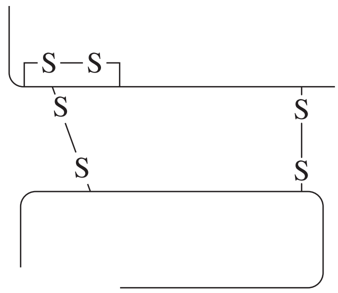
Insulin is a protein hormone involved in regulating aspects of carbohydrate metabolism.

The structure of insulin consists of two polypeptide chains, as shown in the following simplified diagram.



b. In terms of structure and bonding, describe each of the following with reference to the structure of insulin. 4 marks

Tertiary structure ___

___

___

___

___

___

Quaternary structure ___

___

___

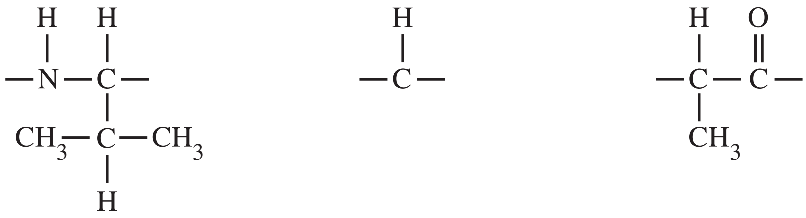
___

___

___

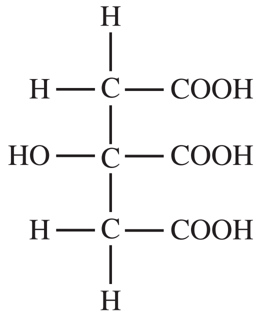
c. A sequence of amino acid residues in insulin is -Val-Glu-Ala-.

Complete the structure of this section of insulin below. 2 marks



Question 3 (7 marks)

The components of a fruit drink are citric acid, sweeteners, food colouring and water. The structure of citric acid is as follows.



Volumetric analysis was used to determine the concentration of citric acid in a fruit drink according to the following steps.

1. A 250.0 mL sodium hydroxide (NaOH) solution was made by dissolving NaOH pellets in water and then standardising the solution. The concentration of the solution was found to be 0.105 M.

2. 20.00 mL aliquots of the fruit drink were titrated with the standardised NaOH solution using a phenolphthalein indicator.

The following titres were used to reach the endpoint.

Titre	1	2	3	4	5
Volume (mL)	17.65	17.85	17.60	17.80	17.60

a. The NaOH solution was prepared to be 0.110 M, but, when standardised, it was found to have a concentration of 0.105 M.

Explain how the NaOH solution was prepared to be 0.110 M. Include relevant calculations in your answer. 3 marks

b. Explain why NaOH is unsuitable as a primary standard. 2 marks

c. The average of the five titres is 17.70 mL.

Explain why this volume should **not** be used in calculations of the concentration of citric acid in the fruit drink. 2 marks

Question 4 (10 marks)

Both biodiesel and petrodiesel can be used as fuel in a diesel motor vehicle.

a. The molecular formulas of typical molecules in biodiesel and petrodiesel are $C_{19}H_{38}O_2$ and $C_{12}H_{26}$, respectively.

Describe the structure and bonding in a single molecule of the following.

i. $C_{19}H_{38}O_2$ in biodiesel — 2 marks

ii. $C_{12}H_{26}$ in petrodiesel — 2 marks

b. The comparative viscosities of the two types of fuel at different temperatures are shown in the following table.

	5°C	**15°C**	**25°C**
Biodiesel	10.2	7.3	5.8
Petrodiesel	7.6	5.4	4.1

i. As temperature increases, the viscosities of both fuels show a similar trend.

With reference to structure and bonding, explain this trend. — 2 marks

ii. Based on the viscosity values shown in the table on page 19, which fuel would be better suited for use in a diesel motor vehicle in cold conditions? Explain your answer. 2 marks

c. A sample of petrodiesel produces 7.4 g of CO_2 for each megajoule of energy released. It is known that the energy content of this petrodiesel is 43 kJ g^{-1}.

Calculate the mass of petrodiesel that would need to be burnt to produce 1.0 tonne (10^6 g) of CO_2. 2 marks

Question 5 (9 marks)

Nitrogen and hydrogen gases react in an equilibrium reaction to produce ammonia gas according to the following equation.

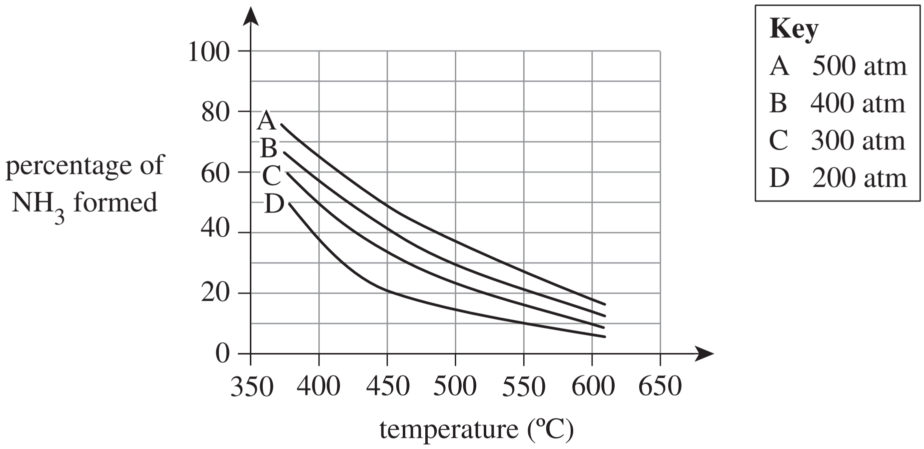
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.3 \text{ kJ mol}^{-1}$$

At 25°C, the equilibrium constant, K_c, for this reaction is 640 M^{-2}.

a. In an experiment, 0.46 mol of N_2 and 0.96 mol of H_2 were at equilibrium in a sealed 2.0 L container at 25°C.

Calculate the amount of NH_3, in moles, in the gas mixture. 3 marks

b. The yield of NH_3 under varying conditions of temperature and pressure is shown in the following graph.



In the industrial production of ammonia, specific conditions are used.

Explain why each of the following conditions are used.

i. a pressure no greater than 250 atm 2 marks

ii. a temperature of approximately 400°C 2 marks

iii. a catalyst in a sponge-like form 2 marks

Question 6 (5 marks)

Lauric acid, myristic acid and palmitic acid are fatty acids. They are shown in the Data Booklet.

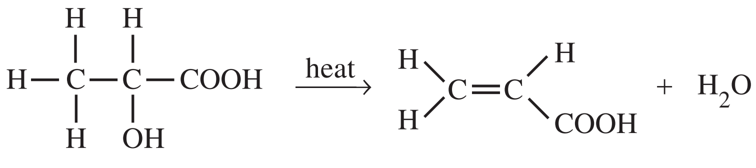
a. Which of these fatty acids has the highest melting point? Explain your answer. 3 marks

b. Palmitic acid can react with glycerol to form a triglyceride.

Using the semi-structural formula of palmitic acid, draw the structural formula of the triglyceride. 2 marks

Question 7 (9 marks)

Compound Y can be produced by heating compound X, as shown in the following equation. Both compounds are organic.



compound X compound Y

a. The following information is known about the elements in one of the compounds.

- In 0.1 mol of the compound, the amount of carbon is the same as in 13.2 g of CO_2.
- In 0.2 mol of the compound, the amount of hydrogen is the same as in 7.44 L of methane at SLC.
- In 0.3 mol of the compound, there are 5.42×10^{23} oxygen atoms.

Using appropriate calculations, show that this information applies to compound X, **not** compound Y. 4 marks

b. The following table shows the m/z values of peaks and their corresponding relative abundances in the mass spectrum of compound X. The highest and lowest peaks are included.

m/z	15	18	29	43	45	56	74	102
Relative abundance	2.9	18.7	10.9	12.1	100	2.5	6.7	1.2

Identify the charged particle responsible for the base peak. 1 mark

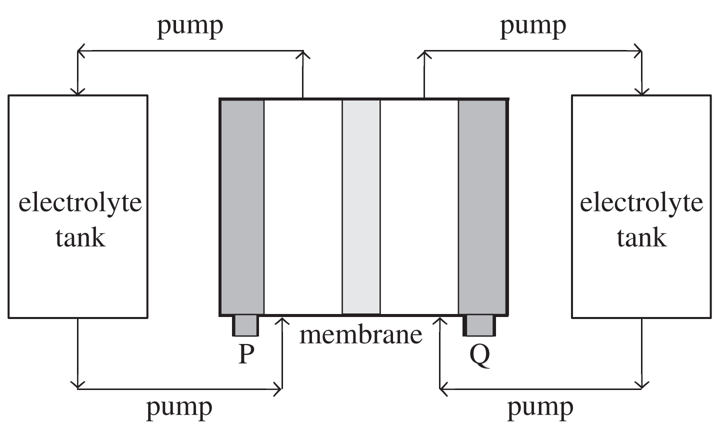
c. State **two** specific ways in which the infrared spectrum of compound Y would differ from that of compound X. 2 marks

d. A chemist has a sample that is either compound X or compound Y.

Suggest a simple laboratory test for identifying whether the sample is compound X or compound Y. Include the possible results of the test in your answer. 2 marks

Question 8 (8 marks)

The following diagram shows the design of a vanadium redox battery, which uses vanadium in various oxidation states in chemical reactions to generate electrical energy. Electrode Q is positive when electrical energy is produced.



The following reactions are used in the operation of the battery.

$$VO_2^{+}(aq) + 2H^{+}(aq) + e^{-} \rightleftharpoons VO^{2+}(aq) + H_2O(l) \qquad E^0 = +1.00\ V$$

$$V^{3+}(aq) + e^{-} \rightleftharpoons V^{2+}(aq) \qquad E^0 = -0.26\ V$$

One of the important features of the battery is that it can be recharged using electrical energy.

The set-up of the battery during discharge and recharge is shown in the following table.

Discharge	Recharge
Electrodes P and Q are connected to operate electrical devices or to put power back into the electricity grid.	Renewable energy sources are connected to electrodes P and Q so that electrical energy recharges the battery.

a. Suggest **one** renewable energy source that is likely to be used to recharge the battery. 1 mark

____

b. State **one** function of the membrane located between the half-cells. 1 mark

____

____

c. In **one** box in the table below, write the half-equation for the reaction that occurs in half-cell 1 when the battery is discharging. Write the half-equation in the box that identifies the type of electrode and type of reaction. 2 marks

	Oxidation	**Reduction**
Anode		
Cathode		

d. Write the overall equation for the reaction that occurs during recharge. 2 marks

____

e. Outline whether this battery should be classified as a primary cell, a secondary cell, a fuel cell or a hybrid of any of these cell types. Justify your answer. 2 marks

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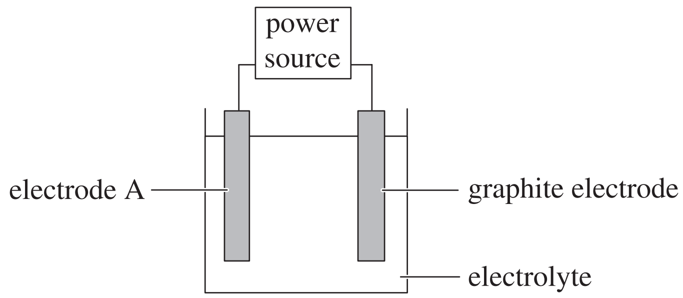
Question 9 (14 marks)

An experiment was conducted to determine the effect that the charge on a metal ion has on the mass of metal deposited in an electroplating cell.

The set-up of the electroplating cell is shown in the following diagram. Metal was deposited on electrode A.



Four different 1.0 M electrolytes were electrolysed separately for 10.0 minutes using a current of 2.00 amperes, and the increase in mass of electrode A was determined in each case. The results of the experiment are shown in the following table.

Electrolyte	$AgNO_3(aq)$	$Cu(NO_3)_2(aq)$	$Cr(NO_3)_3(aq)$	$SnCl_2(aq)$
Mass increase of electrode A (g)	1.37	0.39	0.21	0.87

a. Identify the following variables in this experiment.

i. the independent variable — 1 mark

____

ii. **two** controlled variables — 2 marks

1 ______________________________

2 ______________________________

b. **i.** Analyse the validity of this experiment. — 2 marks

____

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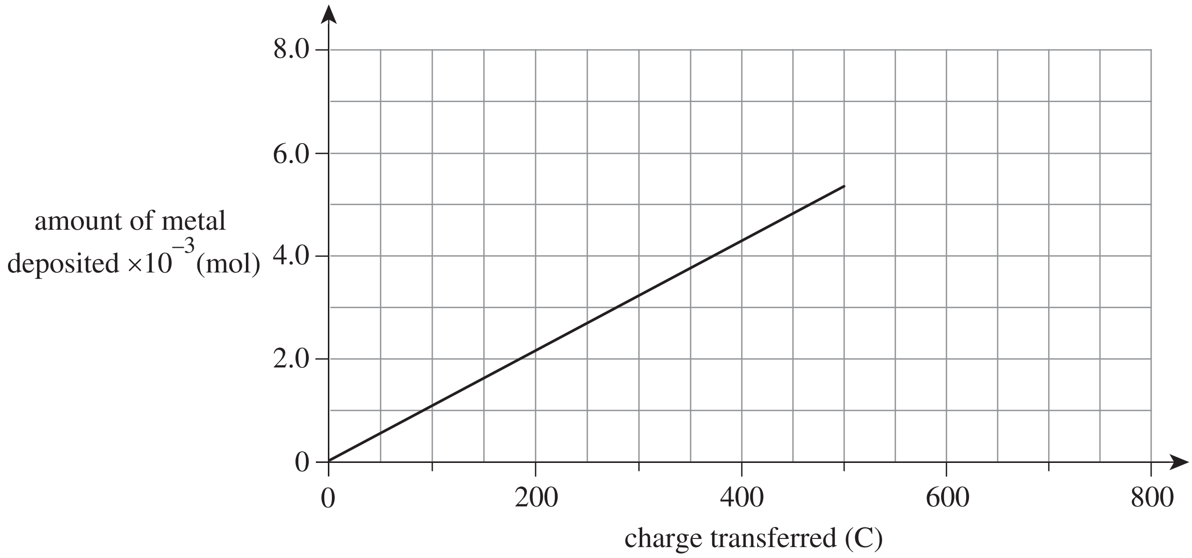
ii. Suggest **two** improvements that could be made to the experimental design. 2 marks

iii. Do the results of this experiment reveal any relationship between the mass of metal deposited and the charge on the metal ion in an electrolyte? Justify your answer. 2 marks

c. A further experiment was conducted using the same set-up but only 1.0 M $AgNO_3$(aq) was electrolysed for various durations using a current of 2.00 amperes. The results are shown in the following table.

Duration (minutes)	1.0	2.0	3.0	4.0	5.0
Mass increase of electrode A (g)	0.14	0.27	0.41	0.55	0.68

Appropriate calculations using the results for the durations of 1.0 to 4.0 minutes were completed to plot the following graph.



i. Show the calculations that would need to be completed to plot the data for the electroplating duration of 5.0 minutes. 2 marks

ii. On the graph above, draw the expected graph if $SnCl_2$(aq) had been used as the electrolyte instead of $AgNO_3$(aq). 1 mark

iii. Using the graph above for the deposition of Ag and the relevant half-equation, calculate the charge, in coulombs, on 1 mol of electrons. 2 marks

Question 10 (9 marks)

The following passages refer to the influence of stereoisomerism in food molecules on human health and senses. Stereoisomerism also affects the physical properties of compounds.

> Trans fats, or trans fatty acids, are unsaturated fatty acids that come from either natural or industrial sources. Naturally occurring trans fats come from animal sources, such as cows and sheep. Trans fats are also produced through an industrial process that adds hydrogen to vegetable oil, converting the liquid into a solid, resulting in 'partially hydrogenated' oil. High trans fat intake increases the risk of coronary heart disease, most likely because of lipid levels – trans fats increase 'bad' cholesterol levels while lowering 'good' cholesterol levels.

> Spearmint and caraway are both plants and have identifiable, but very different, aromas. The oils found in spearmint and caraway are both abundant in the chemical carvone. The carvone in the oils must be chemically different, otherwise the difference in aroma would not be observed. The difference lies in the stereochemistry of carvone in each plant. Carvone has two stereoisomers, and the difference in aroma is observed because several receptors in the nose register these stereoisomers differently.

a. Using the molecules of the fatty acid oleic acid and the amino acid alanine as examples, demonstrate your understanding of stereoisomerism. You may include diagrams in your answer.

In your answer, refer to:

- the nature of geometric and optical isomerism
- **one** example of the effect of one type of stereoisomerism on a physical property of compounds. 5 marks

b. Molecules of butanol exhibit structural isomerism, and these structural isomers may show differences in their chemical reactivity.

For **two** isomers of butanol:

- draw the molecules to illustrate structural isomerism
- explain the nature of the structural isomerism shown
- describe **one** difference in the chemical reactions of the isomers. 4 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2022

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

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

1 H 1.0 hydrogen																	2 He 4.0 helium
3 Li 6.9 lithium	4 Be 9.0 beryllium											5 B 10.8 boron	6 C 12.0 carbon	7 N 14.0 nitrogen	8 O 16.0 oxygen	9 F 19.0 fluorine	10 Ne 20.2 neon
11 Na 23.0 sodium	12 Mg 24.3 magnesium											13 Al 27.0 aluminium	14 Si 28.1 silicon	15 P 30.1 phosphorus	16 S 32.1 sulfur	17 Cl 35.5 chlorine	18 Ar 39.9 argon
19 K 39.1 potassium	20 Ca 40.1 calcium	21 Sc 45.0 scandium	22 Ti 47.9 titanium	23 V 50.9 vanadium	24 Cr 52.0 chromium	25 Mn 54.9 manganese	26 Fe 55.8 iron	27 Co 58.9 cobalt	28 Ni 58.7 nickel	29 Cu 63.5 copper	30 Zn 65.4 zinc	31 Ga 69.7 gallium	32 Ge 72.6 germanium	33 As 74.9 arsenic	34 Se 79.0 selenium	35 Br 79.9 bromine	36 Kr 83.8 krypton
37 Rb 85.5 rubidium	38 Sr 87.6 strontium	39 Y 88.9 yttrium	40 Zr 91.2 zirconium	41 Nb 92.9 niobium	42 Mo 96.0 molybdenum	43 Tc (98) technetium	44 Ru 101.1 ruthenium	45 Rh 102.9 rhodium	46 Pd 106.4 palladium	47 Ag 107.9 silver	48 Cd 112.4 cadmium	49 In 114.8 indium	50 Sn 118.7 tin	51 Sb 121.8 antimony	52 Te 127.6 tellurium	53 I 126.9 iodine	54 Xe 131.3 xenon
55 Cs 132.9 caesium	56 Ba 137.3 barium	57–71 lanthanoids	72 Hf 178.5 hafnium	73 Ta 180.9 tantalum	74 W 183.8 tungsten	75 Re 186.2 rhenium	76 Os 190.2 osmium	77 Ir 192.2 iridium	78 Pt 195.1 platinum	79 Au 197.0 gold	80 Hg 200.6 mercury	81 Tl 204.4 thallium	82 Pb 207.2 lead	83 Bi 209.0 bismuth	84 Po (210) polonium	85 At (210) astatine	86 Rn (222) radon
87 Fr (223) francium	88 Ra (226) radium	89–103 actinoids	104 Rf (261) rutherfordium	105 Db (262) dubnium	106 Sg (266) seaborgium	107 Bh (264) bohrium	108 Hs (267) hassium	109 Mt (268) meitnerium	110 Ds (271) darmstadtium	111 Rg (272) roentgenium	112 Cn (285) copernicium	113 Nh (280) nihonium	114 Fl (289) flerovium	115 Mc (289) moscovium	116 Lv (292) livermorium	117 Ts (294) tennessine	118 Og (294) oganesson

57 La 138.9 lanthanum	58 Ce 140.1 cerium	59 Pr 140.9 praseodymium	60 Nd 144.2 neodymium	61 Pm (145) promethium	62 Sm 150.4 samarium	63 Eu 152.0 europium	64 Gd 157.3 gadolinium	65 Tb 158.9 terbium	66 Dy 162.5 dysprosium	67 Ho 164.9 homium	68 Er 167.3 erbium	69 Tm 168.9 thulium	70 Yb 173.1 ytterbium	71 Lu 175.0 lutetium

89 Ac (227) actinium	90 Th 232.0 thorium	91 Pa 231.0 protactinium	92 U 238.0 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium	103 Lr (262) lawrencium

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

2. Electrochemical series

Reaction	Standard electrode potential (E^0) in volts at 25°C
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+1.23
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$	+0.68
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	–0.25
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	–0.28
$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$	–0.40
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	–1.18
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	–1.66
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	–2.37
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$	–2.87
$K^+(aq) + e^- \rightleftharpoons K(s)$	–2.93
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	–3.04

3. Chemical relationships

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

4. Physical constants and standard values

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

5. Unit conversions

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

6. Metric (including SI) prefixes

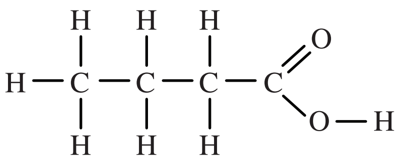
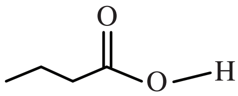
Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	10^9	1 000 000 000
mega (M)	10^6	1 000 000
kilo (k)	10^3	1000
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001
micro (μ)	10^{-6}	0.000001
nano (n)	10^{-9}	0.000000001
pico (p)	10^{-12}	0.000000000001

7. Acid–base indicators

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

8. Representations of organic molecules

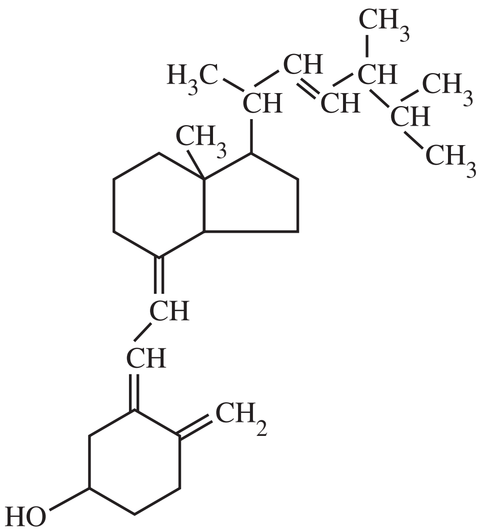
The following table shows different representations of organic molecules, using butanoic acid as an example.

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

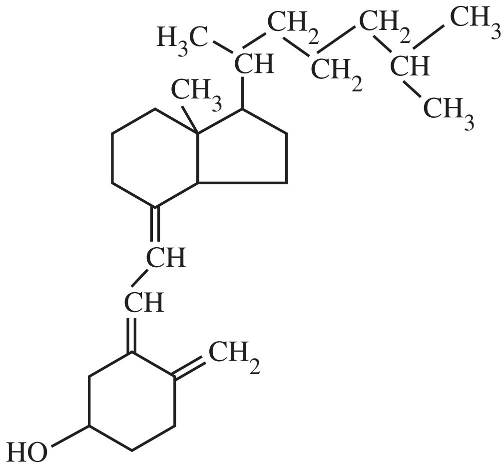
9. Formulas of some fatty acids

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

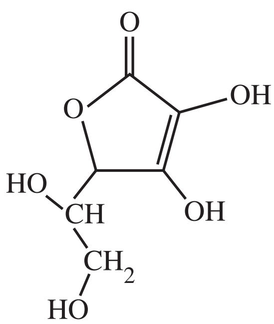
10. Formulas of some biomolecules



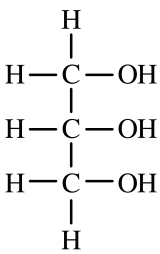
vitamin D_2 (ergocalciferol)



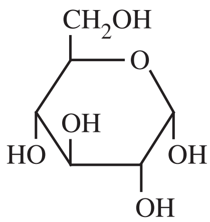
vitamin D_3 (cholecalciferol)



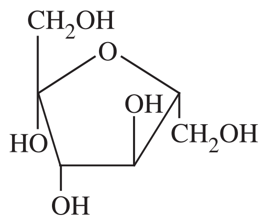
vitamin C (ascorbic acid)



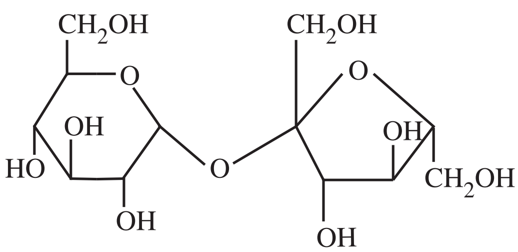
glycerol



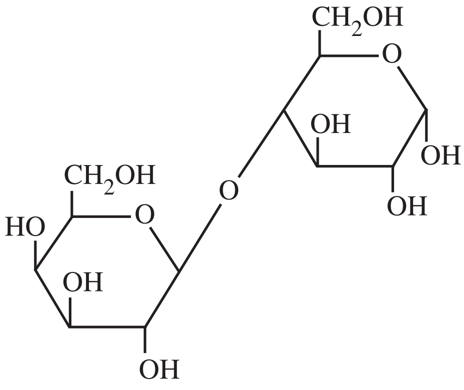
α-glucose



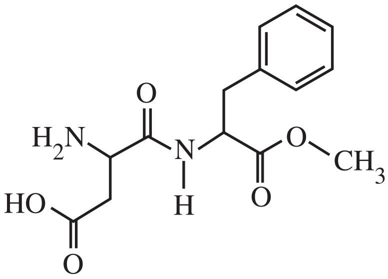
β-fructose



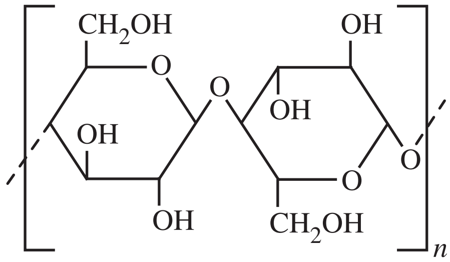
sucrose



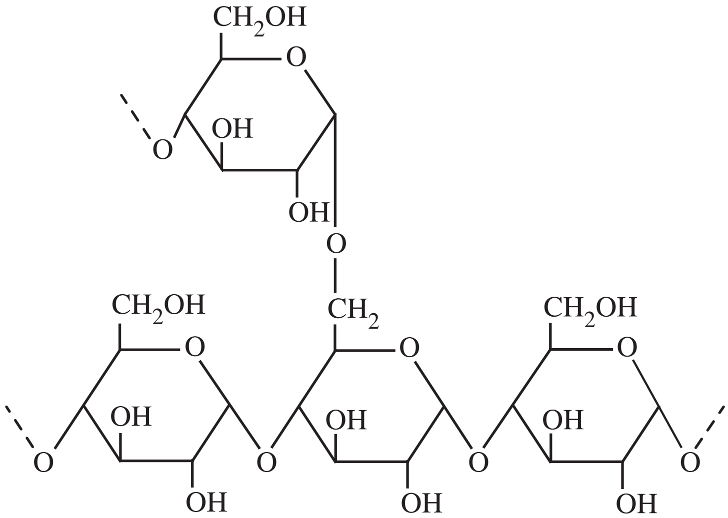
α-lactose



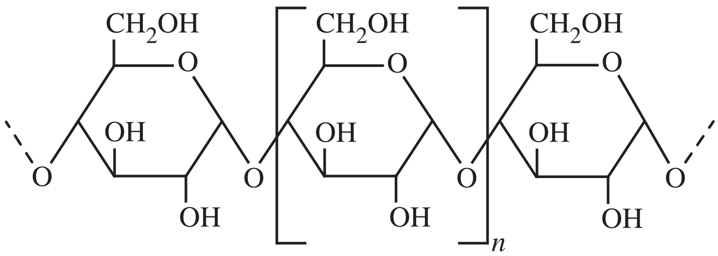
aspartame



cellulose



amylopectin (starch)



amylose (starch)

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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

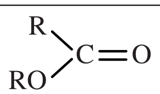
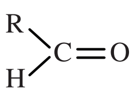
14. Characteristic ranges for infra-red absorption

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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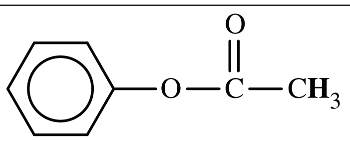
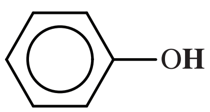
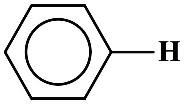
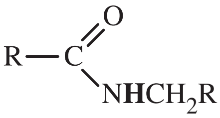
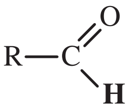
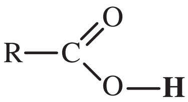
16. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

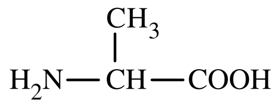
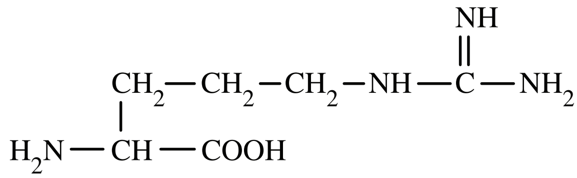
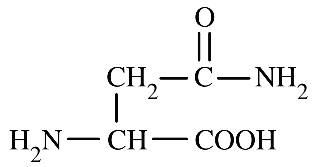
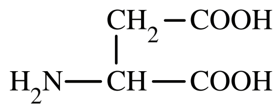
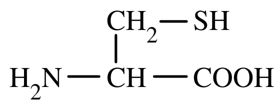
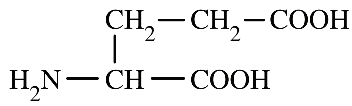
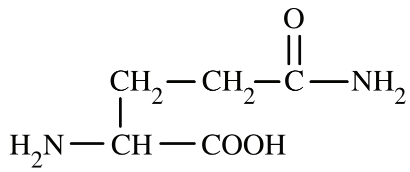
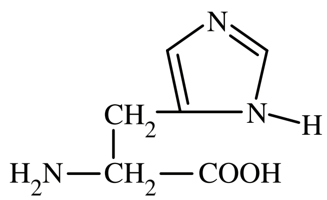
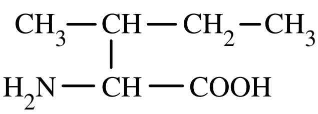
These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

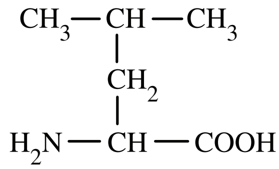
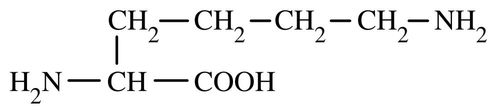
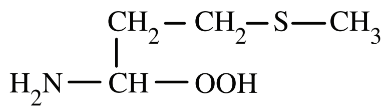
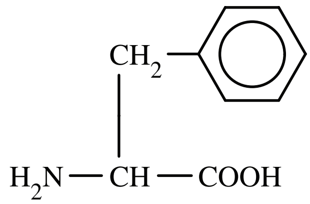
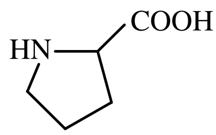
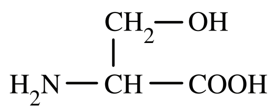
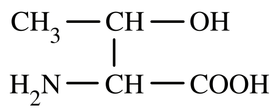
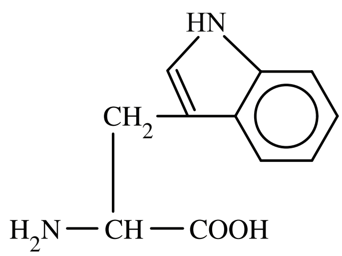
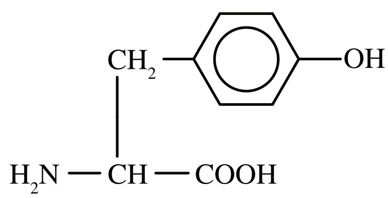
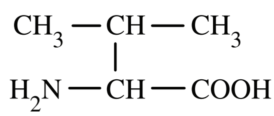
Type of proton	Chemical shift (ppm)
$R{-}C\mathbf{H}_3$	0.9–1.0
$R{-}C\mathbf{H}_2{-}R$	1.3–1.4
$RCH{=}CH{-}C\mathbf{H}_3$	1.6–1.9
$R_3{-}C\mathbf{H}$	1.5
$C\mathbf{H}_3{-}C(=O)OR$ or $C\mathbf{H}_3{-}C(=O)NHR$	2.0
$R{-}C(=O){-}C\mathbf{H}_3$	2.1–2.7
$R{-}C\mathbf{H}_2{-}X$ (X = F, Cl, Br or I)	3.0–4.5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

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

17. 2-amino acids (α-amino acids)

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

Name	Symbol	Structure
alanine	Ala	
arginine	Arg	
asparagine	Asn	
aspartic acid	Asp	
cysteine	Cys	
glutamic acid	Glu	
glutamine	Gln	
glycine	Gly	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 2022

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