2021
VCE
Chemistry
Trial Examination

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VICTORIAN CERTIFICATE OF EDUCATION
Year 2021

STUDENT NUMBER Letter

Figures									
Words									

CHEMISTRY

Trial Written Examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

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 white out liquid/tape.

Materials supplied
- Question and answer book of 31 pages.
- A data book
- Answer sheet for multiple-choice questions.

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- 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 book.
- You may keep the data book

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

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VCE CHEMISTRY 2021
Trial Written Examination

MULTIPLE-CHOICE ANSWER SHEET

Student Name _____

Student Number _____

Signature _____

If your name or number on this sheet is incorrect, notify the Supervisor.
Use a **PENCIL** for **ALL** entries. For each question, shade the box that indicates your answer.
All answers must be completed like **THIS** example.

A	■	C	D

Marks will **NOT** be deducted for incorrect answers.
NO MARK will be given if more than **ONE** answer is completed for any question.
If you make a mistake, **ERASE** the incorrect answer. **DO NOT** cross it out.

ONE ANSWER PER LINE **ONE ANSWER PER LINE**

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

SECTION A – Multiple-choice questions

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** for 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.

Question 1

Which one of the following statements is most accurate?

A. All electrochemical cells are galvanic.

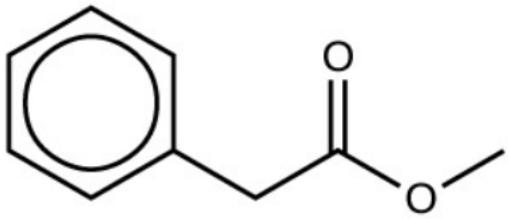
B. All electrochemical cells are electrolytic.

C. All primary cells are galvanic.

D. All fuel cells are electrolytic.

Question 2

Methyl phenylacetate has a honey odour and is represented by the skeletal formula



Honey
methyl phenylacetate

The number of hydrogen atoms in this skeletal formula is

A. 7

B. 8

C. 9

D. 10

Question 3

Which one of the following is true about the sugar substitute *aspartame*?

Aspartame contains

A. a glycosidic link only.

B. a peptide link and a glycosidic link.

C. an ester link only.

D. a peptide link and an ester link.

Question 4

Natural gas is best described as

A. a single compound with a higher heat of combustion than kerosene.

B. a single compound with a lower heat of combustion than kerosene.

C. a mixture of compounds with a higher heat of combustion than kerosene.

D. a mixture of compounds with a lower heat of combustion than kerosene.

Question 5

Which one of the following equations shows a reduction reaction for glucose?

A. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

B. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

C. $C_6H_{12}O_6 + 3O_2 \rightarrow 6CO + 6H_2O$

D. $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

Question 6

The hydrolysis of a triglyceride will produce

A. an ester and glycerol.
B. fatty acids and glycerol.
C. fatty acids and ketones.
D. an ester and fatty acids.

Question 7

In the electrolysis of 1.0 M LiCl(aq)

A. Li(s) is produced at the anode because $H_2O(l)$ is a stronger oxidising agent than $Li^+(aq)$.
B. Li(s) is produced at the cathode because $H_2O(l)$ is a weaker oxidising agent than $Li^+(aq)$.
C. $H_2(g)$ is produced at the anode because $H_2O(l)$ is a weaker oxidising agent than $Li^+(aq)$.
D. $H_2(g)$ is produced at the cathode because $H_2O(l)$ is a stronger oxidising agent than $Li^+(aq)$.

Question 8

Which one of the following half-cell combinations would give a voltage closest to 1.23 V?

A. $Ni^{2+}(aq) / Ni(s) // Pb^{2+}(aq) / Pb(s)$
B. $O_2(g) / OH^-(aq) // H_2O(l) / H_2(g), OH^-(aq)$
C. $Zn^{2+}(aq) / Zn(s) // Cd^{2+}(aq) / Cd(s)$
D. $Cu^{2+}(aq) / Cu(s) // H_2O(l) / H_2(g), OH^-(aq)$

Question 9

An equilibrium chemical reaction between four gases can be represented by the equation:

$$W(g) + X(g) \rightleftharpoons Y(g) + Z(g)$$

The activation energy of the forward reaction = E_a (forward).

The activation energy of the reverse reaction = E_a (reverse).

ΔH for the forward reaction is negative.

Which one of the following statements about the activation energies is true?

A. E_a (forward) > E_a (reverse)
B. E_a (forward) = E_a (reverse)
C. E_a (forward) < E_a (reverse)
D. There is insufficient information to determine the answer.

Question 10

The flashpoint of a fuel

A. is the highest temperature at which vapours of the fuel will ignite.
B. is the lowest temperature at which vapours of the fuel will ignite.
C. depends on the strength of the covalent bonding within the fuel molecules.
D. is the average temperature at which vapours of the fuel will ignite.

Question 11

Coenzymes make chemical reactions more efficient by changing

A. the surface shape of an enzyme.
B. the primary structure of an enzyme.
C. the secondary structure of an enzyme.
D. the peptide linkages in an enzyme.

Question 12

Which one of the following molecules contains a chiral carbon atom?

A. 2-chlorobutane
B. 1-chlorobutane
C. 1-chloro-2-methylpropane
D. 2-chloro-2-methylpropane

Question 13

Which one of the following amino acids contains a non-polar side group?

A. alanine
B. arginine
C. asparagine
D. aspartic acid

Question 14

Which one of the following is true for Vitamin C?

A. fat-soluble, essential, can be synthesised in the body
B. fat-soluble, non-essential, can be synthesised in the body
C. water-soluble, essential, cannot be synthesised in the body
D. water-soluble, non-essential, cannot be synthesised in the body

Use the following information to answer questions 15 and16.

An unsaturated fatty acid with the formula C_xH_yCOOH reacts with hydrogen gas to produce a saturated fatty acid C_xH_zCOOH. One mole of the unsaturated fatty acid reacts exactly with two mole of hydrogen gas.

Question 15

The formula of the unsaturated fatty acid could also be written as

A. $C_xH_{x-1}COOH$

B. $C_xH_{x-3}COOH$

C. $C_xH_{2x-1}COOH$

D. $C_xH_{2x-3}COOH$

Question 16

The unsaturated fatty acid could be

A. oleic.
B. linoleic.
C. linolenic.
D. arachidic.

Question 17

Dichloroethene (DCE) is a highly flammable, colourless liquid with a distinctive odour.

Dichloroethene has

A. two optical isomers.
B. two structural isomers.
C. three optical isomers.
D. three structural isomers.

Use the following information to answer questions 18 and 19.

A chemistry student is carrying out a titration analysis to determine the concentration of hydrochloric acid using a standard solution of sodium carbonate.

Question 18

Of the following, the best indicator to determine the end point of this titration would be

A. methyl orange.
B. bromothymol blue.
C. phenol red.
D. phenolphthalein.

Question 19

The equivalence point of this titration occurs when

A. the indicator changes colour.
B. there are equal amounts of HCl(aq) and Na_2CO_3(aq).
C. n(HCl) = 2 x n(Na_2CO_3).
D. n(Na_2CO_3) = 2 x n(HCl).

Use the following information to answer questions 20, 21 and 22.

Methane Pyrolysis has been suggested as a sustainable technology to produce high purity hydrogen with the advantage that CO_2 is not produced. The process is moderately endothermic, and yields hydrogen and solid carbon as indicated in the equilibrium equation:

$$CH_4(g) \rightleftharpoons C(s) + 2H_2(g) \quad \Delta H = +74.8 \text{ kJ mol}^{-1}$$

Methane is a very stable molecule due to the strong C–H bonds and the symmetry of its molecular structure. For these reasons, methane pyrolysis occurs only at temperatures above 1100–1200 °C in the non-catalytic process.

https://onlinelibrary.wiley.com/doi/10.1002/cite.202000029

Question 20

The best yield of hydrogen gas in *Methane Pyrolysis* would be obtained by using

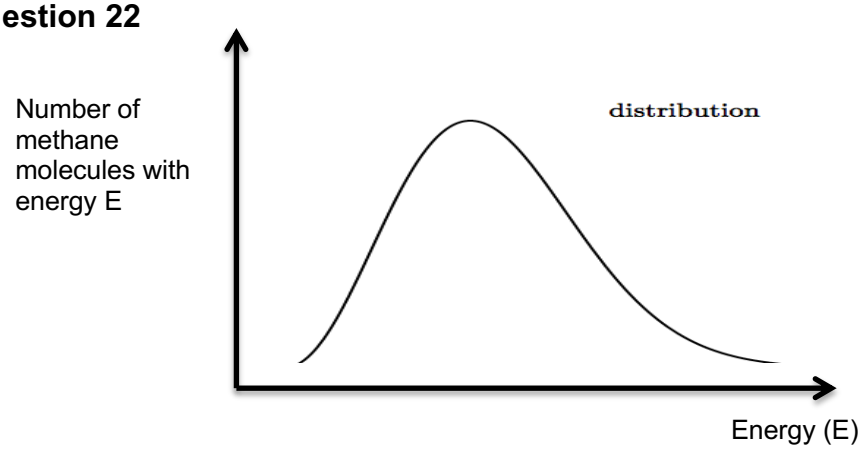
A. high pressure and low temperature.
B. high pressure and high temperature.
C. low pressure and low temperature.
D. low pressure and high temperature.

Question 21

The use of a suitable catalyst would

A. lower the activation energy of methane pyrolysis.
B. increase the equilibrium yield of hydrogen gas.
C. improve the purity of hydrogen gas.
D. produce carbon in the gas state.

Question 22



The diagram above shows the distribution of methane gas molecules at 1373 K. If the temperature were increased to 1575 K, the maximum point on the graph would

A. shift to the right and have a lower value.
B. shift to the left and have a lower value.
C. shift to the right and have a higher value.
D. shift to the left and have a higher value.

Question 23

Scientists typically repeat experiments many times before reporting their findings.

This ensures that experimental results are

A. more certain because systematic errors are removed.
B. more certain because random errors are removed.
C. more precise because a correct procedure is used.
D. more precise because all variables are controlled.

Question 24

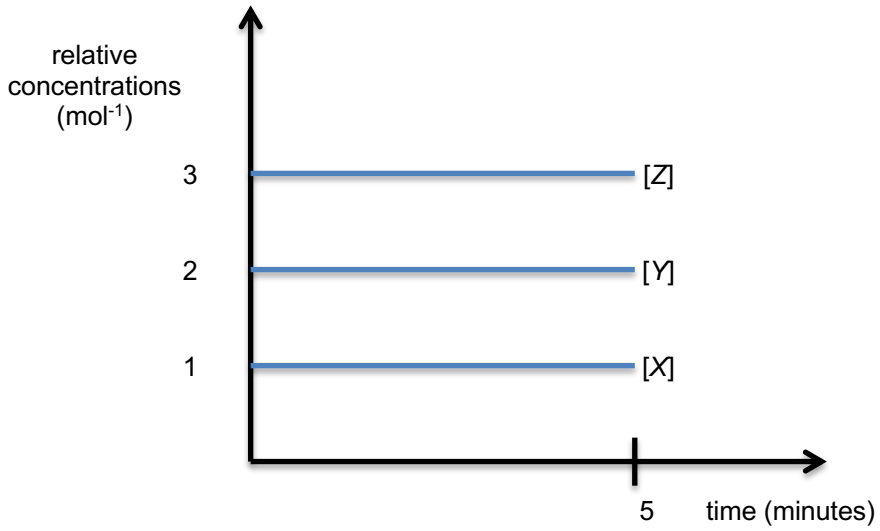
A current of 3.00 A is passed through a 1.0 L aqueous solution of 1.0 M tin(IV) nitrate. Inert electrodes are used. What is the maximum mass of tin metal that could be deposited at the cathode in 1 hour?

A. 0.1 g
B. 0.2 g
C. 3.3 g
D. 13.3 g

Question 25

Two gases *X* and *Y* combine in an equilibrium system to produce a third gas *Z* according to the equation: $X(g) + 2Y(g) \rightleftharpoons Z(g)$ $\Delta H = +10$ kJ mol^{-1}

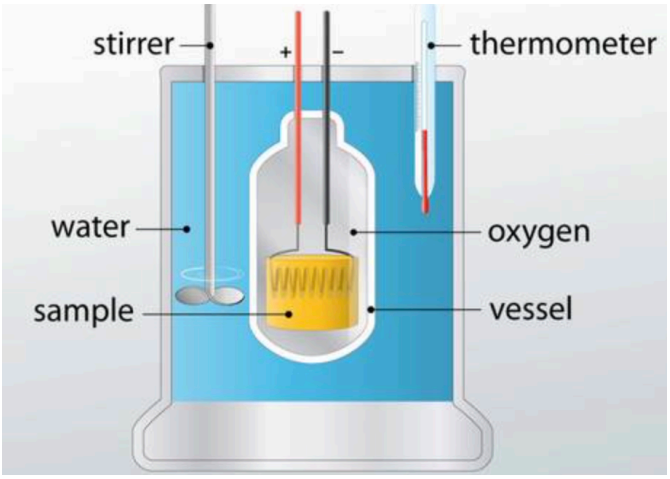
The graph below shows the **initial** equilibrium concentrations of *X*(g), *Y*(g) and *Z*(g) in a 1.0 L container.



At time 5 minutes, the volume of the container is increased from 1.0 L to 2.0 L at constant temperature and the system is allowed to reach a new equilibrium position. Which one of the following is true about the new equilibrium position?

A. [*Z*] = 1.5M
B. [*Z*] < 1.5M
C. [*Z*] > 1.5M
D. More information is required to determine the answer.

The bomb calorimeter shown below has a calibration factor of 12000 J^oC^{-1}



Adapted from https://study.com/academy/lesson/bomb-calorimeter-definition-equation-example.html

Question 26

10 g of a fuel reacts completely in this bomb calorimeter to produce a temperature rise of 24.7°C. Of the following, the fuel is most likely to be

A. butane.
B. octane.
C. methanol.
D. ethanol.

Question 27

Which one of the following is most likely to be present in the Infrared Spectrum of propanone?

A. Transmission line at 1750 cm^{-1}
B. Absorption line at 1750 cm^{-1}
C. Absorption line at 3300 cm^{-1}
D. Transmission line at 3300 cm^{-1}

Question 28

The number of peaks in the ^{13}C NMR spectra of
2,2-dimethyl-propan-1-ol and 2-methyl-butan-1-ol are in that order

A. 3 peaks; 4 peaks.
B. 4 peaks; 4 peaks.
C. 3 peaks; 5 peaks.
D. 4 peaks; 5 peaks.

Question 29

The equilibrium reaction between nitrogen gas and hydrogen gas to produce ammonia gas can be represented by both of the equations shown below. K_1 and K_2 are equilibrium constants measured at the same temperature.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K_1$$

$$2N_2(g) + 6H_2(g) \rightleftharpoons 4NH_3(g) \qquad K_2$$

Which statement is correct?

A. $K_2 = K_1$ and both equilibrium constants have the same units.
B. $K_2 = K_1$ and the equilibrium constants have different units.
C. $K_2 = (K_1)^2$ and both equilibrium constants have the same units.
D. $K_2 = (K_1)^2$ and the equilibrium constants have different units.

Question 30

A 0.0400 M standard solution of orange dichromate ions ($Cr_2O_7^{2-}$) is used to determine the concentration of $Fe^{2+}(aq)$ in a solution. This is a redox titration in which the $Cr_2O_7^{2-}$ is reduced to the green $Cr^{3+}(aq)$ ions in the presence of hydrogen ions, $H^+(aq)$, while the $Fe^{2+}(aq)$ is oxidised to $Fe^{3+}(aq)$. An external indicator is used to determine the end-point since, otherwise the end-point is not sharp. The volume of dichromate ions required to react exactly with 25.00 mL of $Fe^{2+}(aq)$ is 21.50 mL. The concentration of $Fe^{2+}(aq)$ is

A. 0.034 M
B. 0.172 M
C. 0.206 M
D. 0.241 M

END OF SECTION A

Instructions for Section B

Answer all questions in the spaces provided.

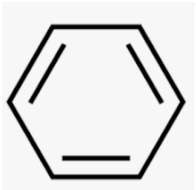
To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure all chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

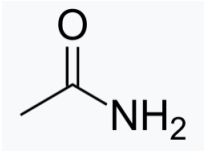
Question 1 (17 marks)

a. Write the IUPAC systematic name for each of the following organic compounds.

_____



_____



_____

(3 x 1 = 3 marks)

b. Which one of the compounds above is a saturated hydrocarbon?

_____

(1 mark)

Question 1 (continued)

c. Write two chemical equations to show how 1-bromobutane and 2-bromobutane could be produced from $CH_3CH_2CHCH_2$.

(1) _____

(2) _____

(2 marks)

d. What is the general name given to each of these reactions?

_____

(1 mark)

e. Complete the following table for each of these two compounds to show the structure and the number of peaks that would be found in the spectra for ^{13}C NMR and low resolution ^{1}H NMR.

Compound	**Structure**	**Number of Peaks** ^{13}C NMR	**Number of Peaks** ^{1}H NMR
propan-1-ol			
propan-2-ol			

(6 x 1 = 6 marks)

Question 1 (continued)

f. Which of propan-1-ol and propan-2-ol would show a septet splitting pattern in a high resolution ^{1}H NMR spectrum? Give a reason for your answer.

_____

_____

_____

(2 marks)

g. Explain why the examination of the infra-red spectra of these two compounds would **not** be a suitable way of identifying them.

_____

_____

_____

(2 marks)

Question 2 (6 marks)

The essential amino acid **valine** is used in the production of stem cells.

a. Draw the structure of the zwitter ion of valine in the space below.

(2 marks)

b. Why is valine called “essential”?

_____

_____

(1 mark)

c. Draw the structure of the dipeptide formed when valine and alanine combine.

(2 marks)

d. In the structure above mark the peptide link.

(1 mark)

Question 3 (9 marks)

The ester **propyl propanoate** is a colourless liquid with a fruity odour and is used in perfumery. The reactions shown below can be used to produce propyl propanoate.

(1) propane reacts with chlorine to produce 1-chloropropane.

(2) 1-chloropropane reacts with hydroxide ions to produce propan-1-ol.

(3) propan-1-ol reacts with potassium dichromate to produce propanoic acid.

(4) propanoic acid reacts with propan-1-ol to produce propyl propanoate.

a. Draw the structural formula of each of the carbon compounds shown below.

Name	Structural Formula
propanoic acid	
propyl propanoate	

(2 x 1 = 2 marks)

b. Mark the ester functional group above in the structure of propyl propanoate.

(1 mark)

Question 3 (continued)

c. Write the chemical equation for one substitution reaction used in this synthesis.

_____

(1 mark)

d. Write the chemical equation for one oxidation reaction used in this synthesis.

_____

(1 mark)

e. Write the chemical equation for one condensation reaction used in this synthesis.

_____

(1 mark)

f. There are no chiral carbon atoms in propyl propanoate. Explain why.

_____

_____

(1 mark)

g. Draw the structure of an alcohol containing five (5) carbon atoms that **does** have a chiral carbon. Clearly mark the chiral carbon.

(2 marks)

Question 4 (11 marks)

Methanol can be produced from methane. The 2-step process is described by the equilibrium systems shown below.

(A) $CH_4\,(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$; $\Delta H = +205\ kJ\ mol^{-1}$

(B) $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$; $\Delta H = -109\ kJ\ mol^{-1}$

a. Name one possible source of the methane used in this process?

_____

(1 mark)

b. Name one possible use for the methanol produced?

_____

(1 mark)

c. What is the effect on the position of equilibrium when the pressure in reaction **(A)** is increased? Explain your answer.

_____

_____

_____

(2 marks)

d. What is the effect on the position of equilibrium when the pressure in reaction **(B)** is increased?

_____

(1 mark)

e. What is the effect on the position of equilibrium when the temperature in reaction **(A)** is increased? Explain your answer.

_____

_____

_____

(2 marks)

Question 4 (continued)

f. What is the effect on the position of equilibrium when the temperature in reaction **(B)** is increased?

_____

(1 mark)

g. Reactions **(A)**and **(B)** are slow under SLC. How could the best yield of each product be obtained while minimising the cost of the process?

_____

_____

_____

_____

_____

_____

_____

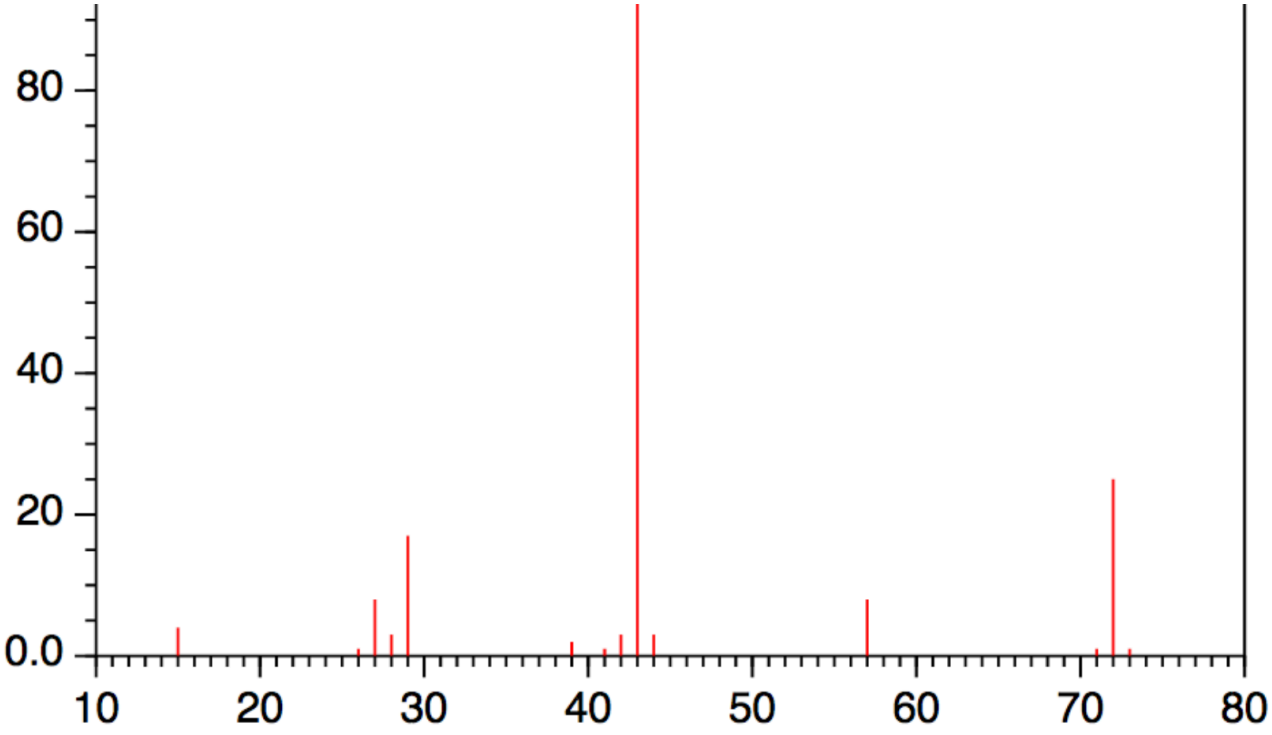
_____

(3 marks)

Question 5 (13 marks)

A chemistry student wishes to identify a colourless organic liquid with a distinctive odour using mass spectroscopy (MS), infra-red spectroscopy (IR) and nuclear magnetic resonance spectroscopy (NMR).

The mass spectrum is shown below.



https://bit.ly/3zQmnNQ

a. What is the mass of the molecular ion in this spectrum?

_____

(1 mark)

b. Give one possible formula for the molecular fragment with mass 15.

_____

(1 mark)

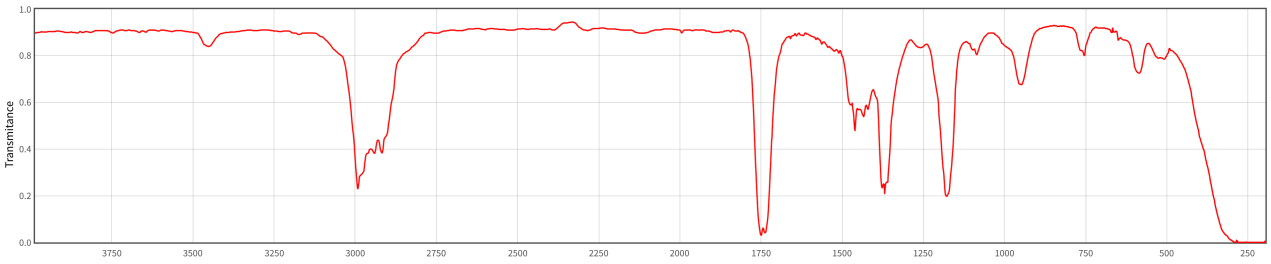
c. Give one possible formula for the most common molecular fragment.

_____

(1 mark)

Question 5 (continued)

The infra-red spectrum is shown below.



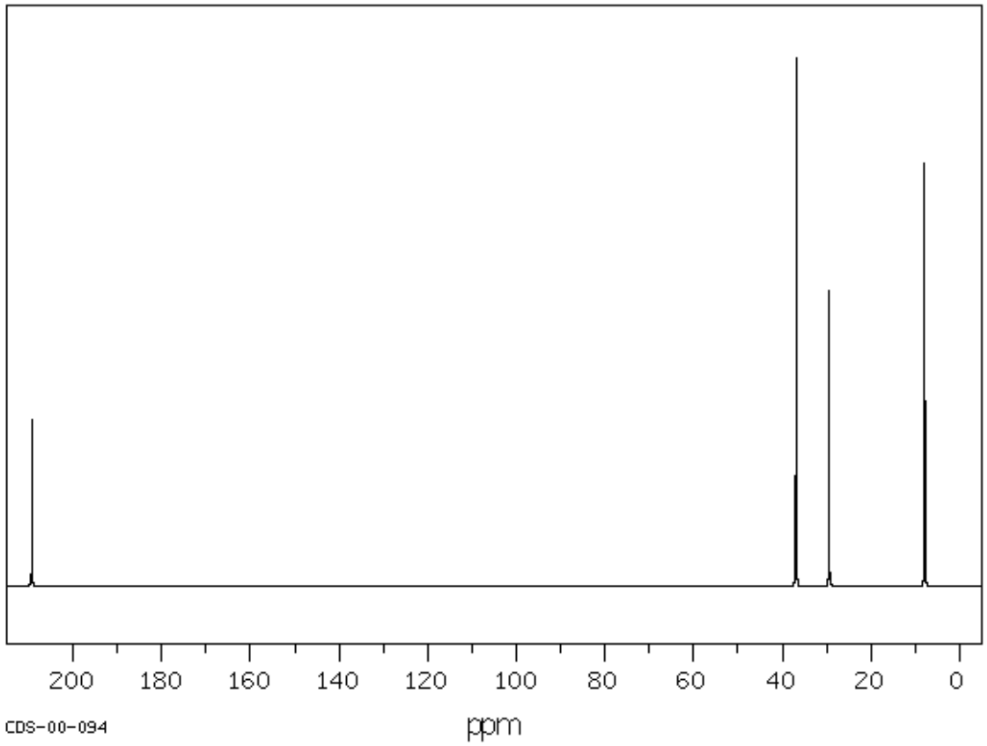
https://bit.ly/3iVARVy

d. What is the functional group shown by the absorption at 1750 cm^{-1}?

_____

(1 mark)

The 13C NMR spectrum is shown below.



https://bit.ly/37amsj6

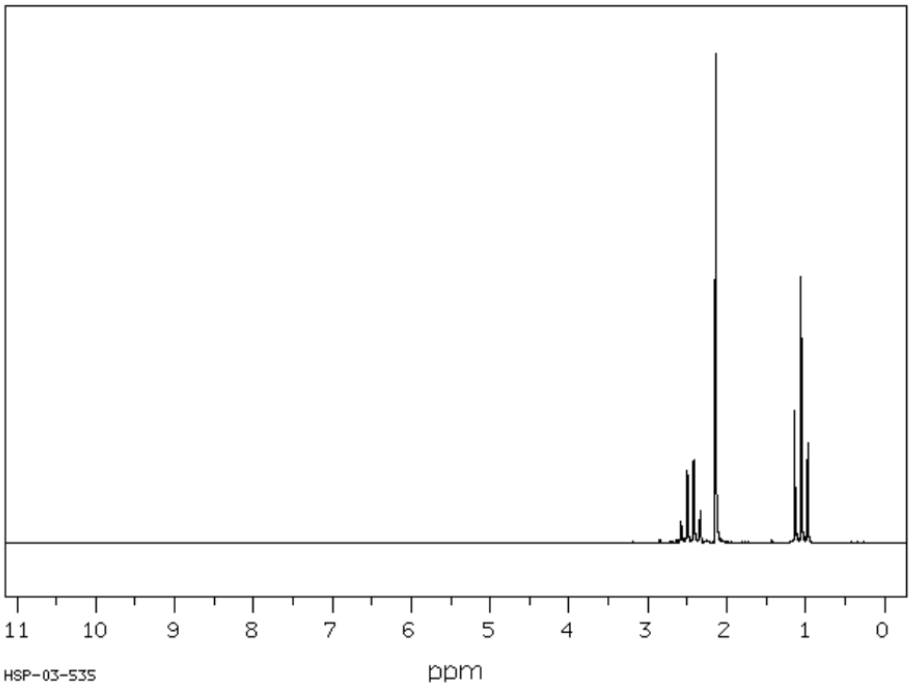
e. How many different carbon environments are shown in this spectrum?

_____

(1 mark)

Question 5 (continued)

The high resolution ^{1}H NMR spectrum is shown below.



https://bit.ly/3762eqJ

f. How many different hydrogen environments are shown in this spectrum?

_____

(1 mark)

Question 5 (continued)

g. Use all of the information you have obtained from **a.** to **f.** and the splitting shown in the high resolution ^{1}H NMR spectrum to identify the unknown carbon compound.
Give the name, molecular formula and structural formula.

Name _____

(1 mark)

Molecular Formula _____

(1 mark)

Structural Formula

(2 marks)

h. Explain how you used the splitting shown in the high resolution ^{1}H NMR spectrum to determine the structure of this molecule.

_____

_____

_____

_____

_____

_____

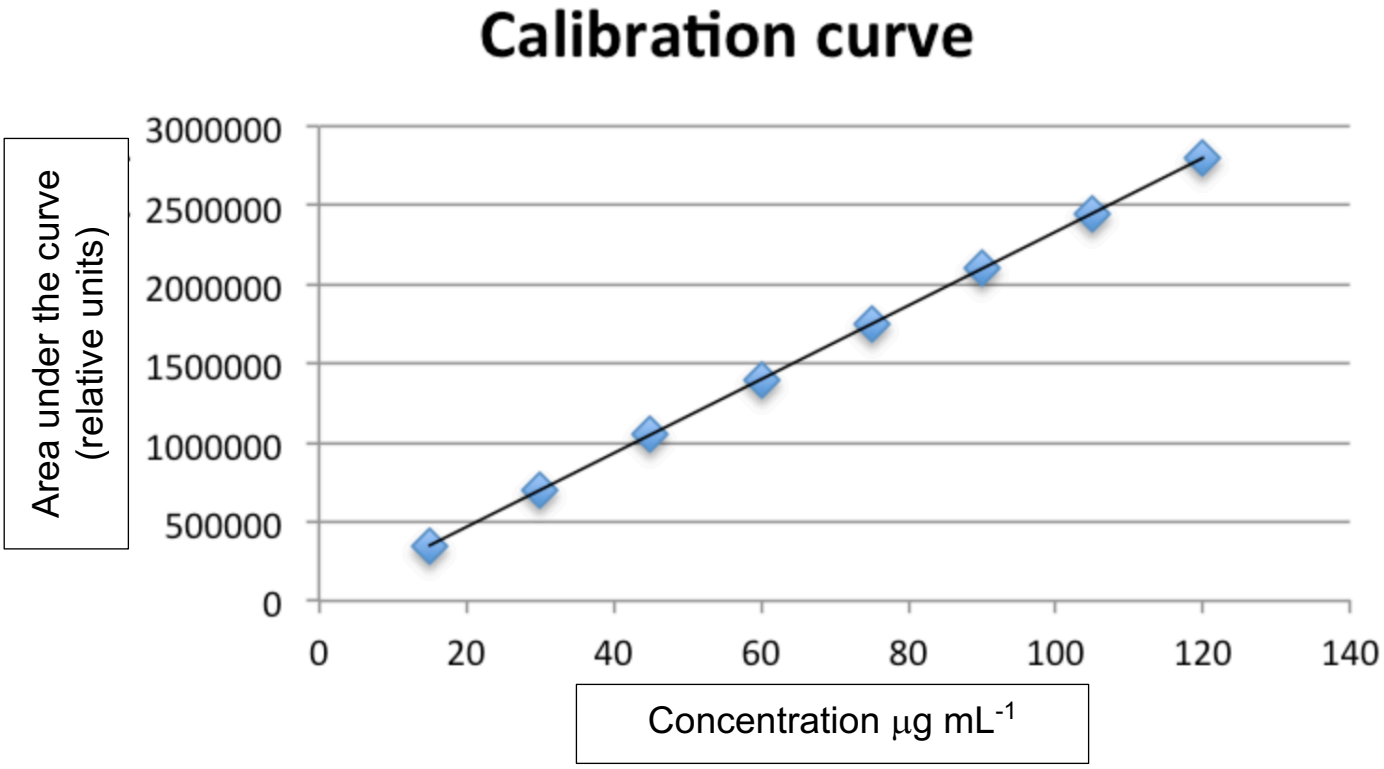
_____

_____

(3 marks)

Question 6 (8 marks)

When High Performance Liquid Chromatography (HPLC) is used to analyse a substance, a calibration curve must be constructed using standards solutions.



Modified from https://theory.labster.com/hplc-calibration-curve/

a. What is a standard solution?

_____

_____

_____

(1 mark)

Question 6 (continued)

b. Describe how the calibration curve is constructed.

(3 marks)

c. An unknown sample of a compound with a molecular mass of 200, has an area under the curve of 5×10^5 units. Calculate the number of mol of the unknown in 50 mL.

(4 marks)

Question 7 (7 marks)

Chocolate is a favourite snack food for many people

The NUTRITION INFORMATION for one brand of chocolate is shown below.

NUTRITION INFORMATION
SERVINGS PER PACKAGE: 7.2
SERVING SIZE: 25 g (approx. 4 squares)

	AVG QTY PER SERVING	% DAILY INTAKE* PER SERVING	AVG QTY PER 100g
ENERGY	492 kJ	6 %	1970 kJ
PROTEIN	1.3 g	3 %	5.3 g
FAT–TOTAL	5.4 g	8 %	21.5 g
-SATURATED	3.4 g	14 %	13.6 g
CARBOHYDRATE	15.7 g	5 %	62.6 g
-SUGARS	14.5 g	16 %	58.1 g
SODIUM	18 mg	1 %	74 mg

* Percentage Daily Intakes are based on an average adult diet of 8700kJ. Your daily intakes may be higher or lower depending on your energy needs.

a. Use the data above for PROTEIN, FAT–TOTAL and CARBOHYDRATE and the information from your Data Book to calculate the energy content of the four squares of chocolate shown.

_____

_____

_____

_____

(2 marks)

Question 7 (continued)

b. Explain why your answer in **a.** is lower than the value given in the NUTRITION INFORMATION.

_____

_____

_____

(1 mark)

The energy content of the chocolate shown could be determined using a bomb calorimeter.

c. 0.51 g of chocolate was burnt in a bomb calorimeter and produced a temperature rise of 2.14 ^{o}C. The combustion of 0.500 g of ethanol in the same calorimeter produced a temperature rise of 3.19 ^{o}C. Calculate the energy content of the 25 g of chocolate from these data.

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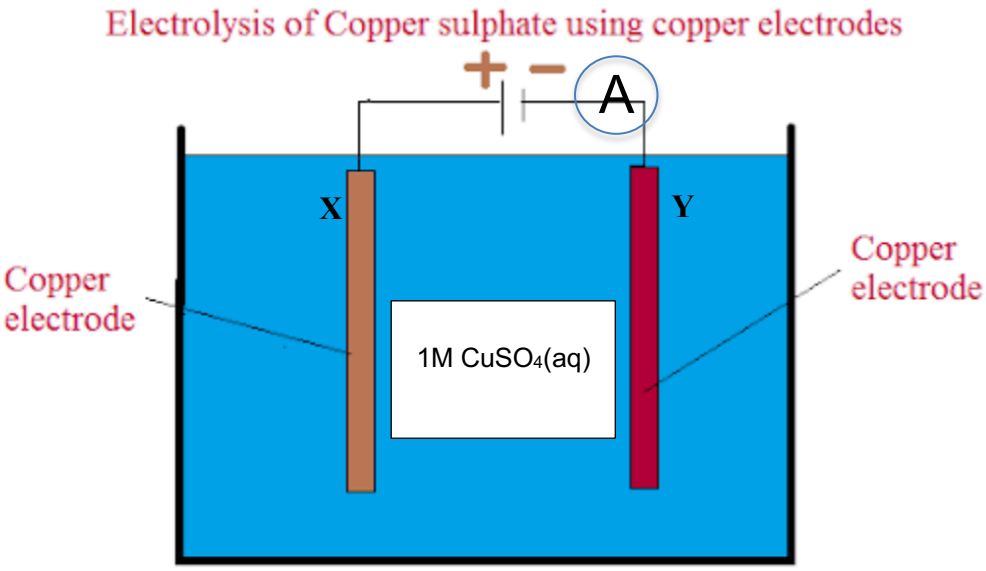
(4 marks)

Question 8 (10 marks)

The value of the Avogadro Constant, N_A can be determined experimentally by electrolysis using the cell shown below.



Modified from https://bit.ly/3ygRAcF

The electrolysis is done using a 1M aqueous solution of $CuSO_4$, a copper sheet for the positive electrode (**X**) and a copper sheet for the negative electrode (**Y**). The two electrodes are connected to a direct current power supply. An ammeter **A** measures the current through the circuit. The voltage is adjusted so that no visible gas is produced at either electrode.

a. A current of 1.5 A flows through the circuit for 8 minutes.
Calculate the quantity of electricity used.

_____

_____

(1 mark)

Next the electrodes are removed, dried and weighed. The mass of the positive electrode is found to have decreased by 0.241 g.

b. Calculate the number of mol of electrons used.

_____

_____

_____

(2 marks)

Question 8 (continued)

c. Use **these data** to calculate a value for the Avogadro Constant, N_A.
Show all working.

(4 marks)

The electrodes are replaced in the solution and the voltage slowly increased beyond that used in the first experiment. Eventually, a gas is observed to form at one of the electrodes.

d. At which electrode, **X** or **Y**, is gas first observed to form and what is the name of the gas?

(2 marks)

e. Write the partial ionic equation for the production of this gas.

(1 mark)

Question 9 (9 marks)

The fuel, ethanol, can be produced from glucose by fermentation.

a. Write the balanced equation for this reaction.

_____

(1 mark)

b. Calculate the percentage atom economy for this reaction.

_____

_____

_____

_____

_____

(2 marks)

c. Biodiesel produced from saturated fats obtained from animals usually has a higher melting point than biodiesel produced from plant oils. Suggest an explanation for this.

_____

_____

_____

_____

_____

(2 marks)

Question 9 (continued)

d. Explain why biodiesel is more viscous and has a higher freezing point than petrodiesel.

_____

_____

_____

_____

_____

(2 marks)

e. Draw a fully labelled diagram to illustrate the difference between an omega-3 fatty acid and an omega-6 fatty acid.

(2 marks)

End of question and answer book

2021 Kilbaha VCE Chemistry Trial Examination

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