# VCE CHEMISTRY 2018

# YEAR 12 TRIAL EXAM

## Units 3/4

## Reading time: 15 minutes

## Writing time: 2 hours 30 minutes

| *Section* | *Number of questions* | *Number of questions to be answered* | *Number of marks* |
|---|---|---|---|
| A | 30 | 30 | 30 |
| B | 10 | 10 | 100 |
| | | | **Total 130** |

**To download the Chemistry Data Book please visit the VCAA website:**
**http://www.vcaa.vic.edu.au/Documents/exams/chemistry/chemdata-w.pdf**

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**STUDENT NUMBER**

| | | | | | | | | | Letter |
|---|---|---|---|---|---|---|---|---|---|
| Figures | | | | | | | | | |
| Words | | | | | | | | | |

**Student Name........................................................................................**

## VCE Chemistry 2018 Year 12 Trial Exam Units 3/4

### Student Answer Sheet

Instructions for completing exam. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **30 Multiple Choice** questions to be answered by circling the correct letter in the table below.

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

# VCE Chemistry 2018 Year 12 Trial Exam Units 3/4

## SECTION A – Multiple Choice Questions

**(30 marks)**

*Section A consists of 30 multiple-choice questions.*
*Choose the response that is* ***correct*** *or* ***best answers*** *the question.*
*A correct answer scores 1, an incorrect answer scores 0.*
*No mark is awarded if more than one answer is supplied for a question.*
*Indicate your choice on the answer sheet provided.*

**Question 1**

One of the flu vaccines available in 2018 is known as Fluad. This vaccine contains an adjuvant – a compound that increases the immune system's response to the vaccine so that higher amounts of antibodies are generated, and longer-lasting protection provided.
The adjuvant in Fluad is squalene oil. The structure of squalene is represented in **Figure 1**.

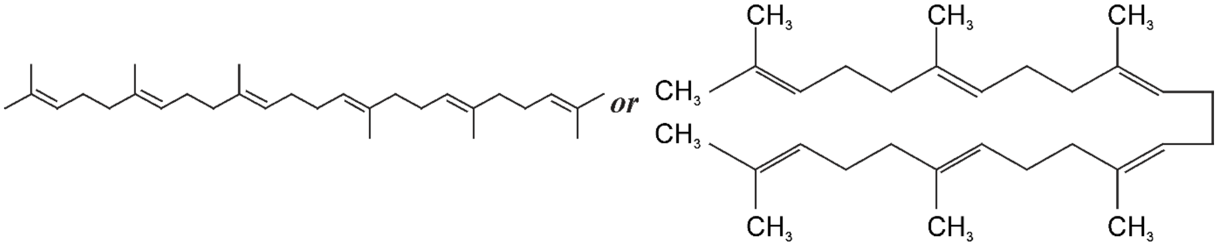


**Figure 1**

Which of the following descriptions of squalene molecules is **least** accurate?

**A.** Squalene molecules have no chiral carbons.
**B.** Squalene molecules are symmetrical.
**C.** Squalene molecules have 10 different hydrogen environments.
**D.** Squalene molecules have 14 different carbon environments.

**Question 2**

Camphor is a substance considered to have significant therapeutic benefits as an antiseptic, a decongestant and a local anaesthetic. Its molecular formula is $C_{10}H_{16}O$ and its heat of combustion is 5904 $kJ^{-1}$ $mol^{-1}$.
2.45 g of camphor is completely burnt in excess oxygen in a bomb calorimeter. The heat capacity of the calorimeter is 7.89 kJ $K^{-1}$ and the temperature after combustion is 33.88°C.
What was temperature in the calorimeter when the combustion reaction was sparked?

**A.** 12.1°C
**B.** 21.8°C
**C.** 26.0°C
**D.** 46.0°C

**Question 3**
In terms of enzyme activity, the induced fit model depends on the

**A.** active site independently changing shape so that the substrate will fit.
**B.** substrate independently changing shape, so it can fit the active site.
**C.** substrate binding to the active site and in doing so changing the shape of the active site.
**D.** active site changing the shape of the substrate as it binds to enable the required fit.

**Question 4**
Which of the following compounds does **not** have *cis* and *trans* isomers?

**A.** But-2-ene.
**B.** 1-chlorobut-2-ene.
**C.** 2-chlorobut-2-ene.
**D.** 2-methylbut-2-ene.

**Question 5**
0.49 g of a hydrocarbon was completely burnt in air. The heat produced raised the temperature of 200 g of water by 28.7°C. The standard enthalpy of combustion of the hydrocarbon is 2058 kJ $mol^{-1}$.
The relative molecular mass of the hydrocarbon is.

**A.** 42
**B.** 44
**C.** 58
**D.** 114

**Question 6**
Consider the general representation of a galvanic cell represented in **Figure 2**.

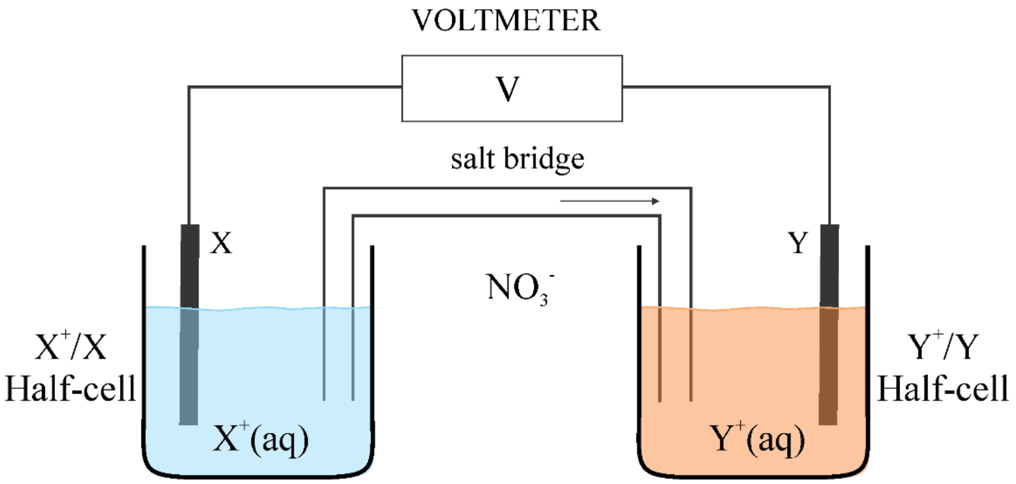


**Figure 2**

The half-equation for the reaction occurring at the negative electrode is

**A.** $X(s) \rightarrow X^+(aq) + e^-$
**B.** $X^+(aq) + e^- \rightarrow X(s)$
**C.** $Y(s) \rightarrow Y^+(aq) + e^-$
**D.** $Y^+(aq) + e^- \rightarrow Y(s)$

**Question 7**

Molecules of nitric oxide, NO, are important in the effective functioning of mammals. As a vasodilator, nitric oxide relaxes arteries, which allows blood to flow freely, and plays a critical role in blood pressure control and the circulatory system. NO molecules also act as an important signalling molecule in the nervous system.

Nitric oxide is produced in the body from one specific amino acid, by the catalytic action of nitric oxide synthases.

This amino acid is most likely to be

**A.** arginine.
**B.** asparagine.
**C.** histidine.
**D.** lysine.

**Question 8**

A galvanic cell made up of the $Ag^{+}$(aq) / Ag(s) and $Y^{3+}$(aq) / Y(s) half-cells under standard conditions generates 2.25 V more than a cell made up of the $Ag^{+}$(aq) / Ag(s) and $Pb^{2+}$(aq) / Pb(s) half-cells.

A galvanic cell made up of and Tl(aq) / Tl(s) and $Y^{3+}$(aq) / Y(s) generates 0.21 V less than a cell made up of $Pb^{2+}$(aq) / Pb(s) and $Y^{3+}$(aq) / Y(s).

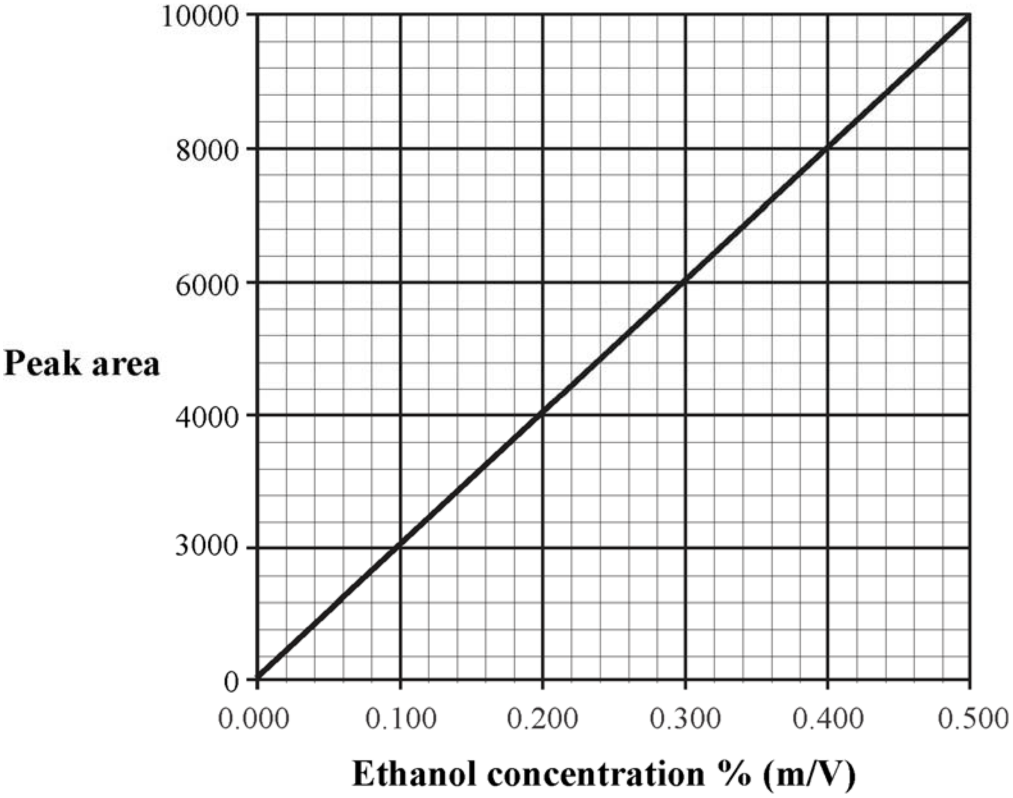
Based on this information, the strongest reductant present in the four half-cells is

**A.** Ag.
**B.** Pb.
**C.** Tl.
**D.** Y.

**Question 9**

The ethanol content of a fermentation mixture was determined by high performance liquid chromatography.

The calibration graph shown below was obtained by passing a set of known standards of ethanol through a high-performance liquid chromatograph and measuring peak areas at the retention time of ethanol.



**Graph 1**

A 20.0 mL sample of a fermentation mixture was added to a 500 mL volumetric flask and the solution made up to the calibration mark.

Samples of the diluted solution were run through the same chromatograph, and the peak area, at the retention time of ethanol, was recorded to be 8600.

The concentration of ethanol in the fermentation mixture, in mol $L^{-1}$, was closest to

**A.** 4.68
**B.** 2.34
**C.** 0.975
**D.** 0.234

**Question 10**

When one mL of 2-chloro-2-methylpropane is added to a sample of 0.10 M sodium hydroxide solution and reaction occurs, the pH of the solution

**A.** should decrease.
**B.** should increase.
**C.** should remain the same.
**D.** cannot be determined without more information.

**Question 11**
The energy profile in **Figure 3** represents the two steps in a reaction pathway from A to E.

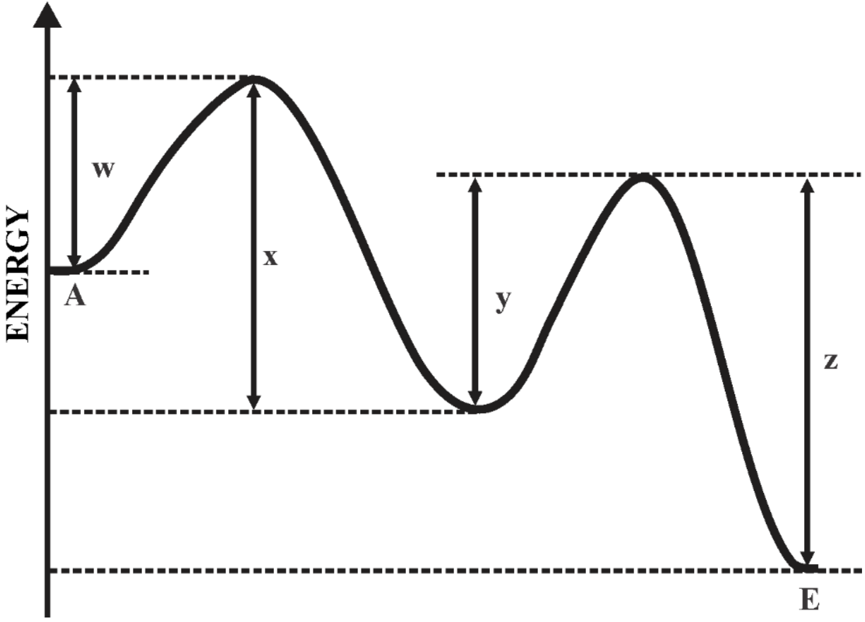


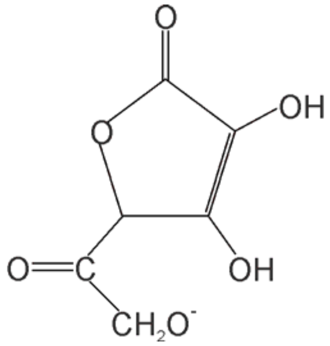
**Figure 3**

The overall energy change in the conversion of A to E is best represented by

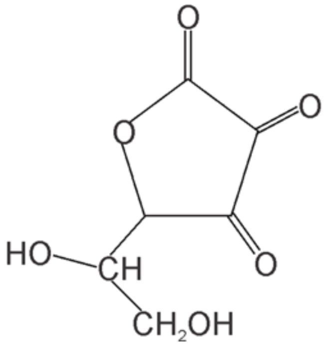
**A.** y + z – w – x
**B.** x + z – w – y
**C.** z – w + x – y
**D.** z – x

**Question 12**
Vitamin C, ascorbic acid, and its oxidised form dehydroascorbic acid can both be present in foods. Dehydroascorbic acid molecules simply have fewer hydrogen atoms than ascorbic acid molecules.
Which of the structures below is most likely to represent dehydroascorbic acid?

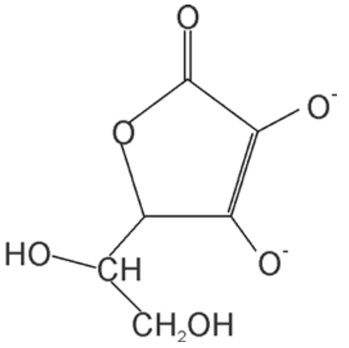
**A.**



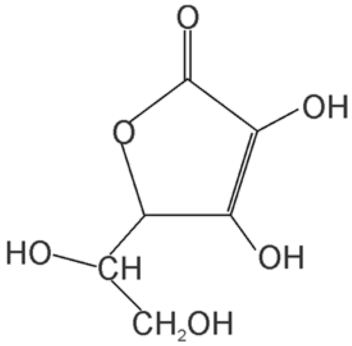
**B.**



**C.**



**D.**



**Question 13**
A racemic mixture is a mixture that contains equal amounts of enantiomers, i.e. a pair of stereoisomers. When placed in a polarimeter, enantiomers rotate polarised light by the same amount but in opposite directions.
Which of the following compounds might be expected to exist as a racemic mixture and so have no overall rotation of polarised light?

**A.** Butan-1-ol.
**B.** Butan-2-ol.
**C.** Methyl propan-2-ol.
**D.** Methyl propan-1-ol.

**Question 14**

Maxwell-Boltzmann curves are presented below in **Figure 4** for the same reaction under two different sets of conditions, 1 and 2.

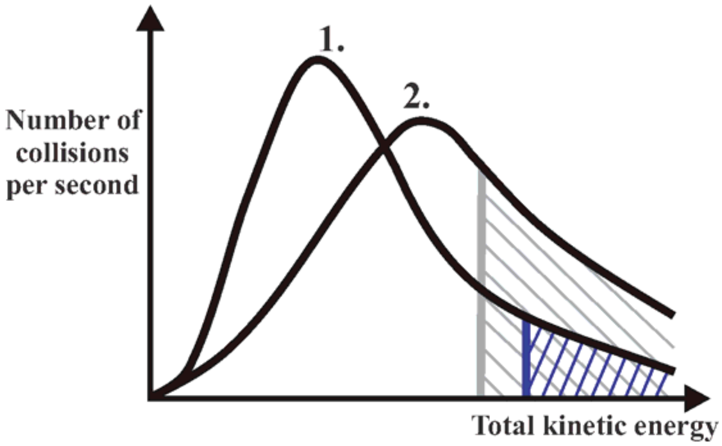


**Figure 4**

Compared to set of conditions 1. the reaction under set of conditions 2. involves

**A.** lower temperature and the presence of a catalyst.
**B.** lower temperature and the absence of a catalyst.
**C.** higher temperature and the presence of a catalyst.
**D.** higher temperature and the absence of a catalyst.

**Question 15**

Milk fresh from a cow does not contain lactic acid. However, over time, bacterial action can convert some lactose present in the milk to lactic acid, $CH_3CH(OH)COOH$.
In an analysis to determine the amount of lactic acid in a sample of milk with density 1.03 g mL$^{-1}$, 25.0 mL of the milk is titrated with 0.150 M NaOH(aq) to the phenolphthalein endpoint. An average titre of 13.2 mL of titrant was required.
The percentage, by mass, of lactic acid in the milk was

**A.** 0.692
**B.** 0.713
**C.** 0.733
**D.** 1.38

**Question 16**

Vitamin D helps us absorb calcium and phosphate from our diets and is essential for healthy bones. Low levels of vitamin D, associated with insufficient exposure to sunlight, can cause the skeletal disorder rickets. Given concerns associated with extended exposure to sunlight, vitamin D is added to some foodstuffs. Vitamin $D_3$ is animal-sourced and can be obtained from fish, whereas vitamin $D_2$ is plant-based.

Whilst they have similar structures, the melting temperatures of vitamin $D_2$ and vitamin $D_3$ are different.

Vitamin $D_2$: 114°C; vitamin $D_3$: 86°C

This difference is best explained by the

**A.** presence of an extra C=C double bond in vitamin $D_2$.

**B.** presence of extra H atoms in vitamin $D_2$.

**C.** structure of vitamin $D_3$ allowing its molecules to pack more tightly together.

**D.** the higher molar mass of vitamin $D_2$.

**Question 17**

NMR spectroscopy depends on the nuclear magnetic characteristics of atoms with an uneven number of protons or neutrons, e.g. $^1H$ and $^{13}C$. Such atoms can align with or against an applied magnetic field, with the alignment against the magnetic field dependent on energy absorption. The two alignments are at different nuclear spin energy levels as represented in the diagram in **Figure 5**.

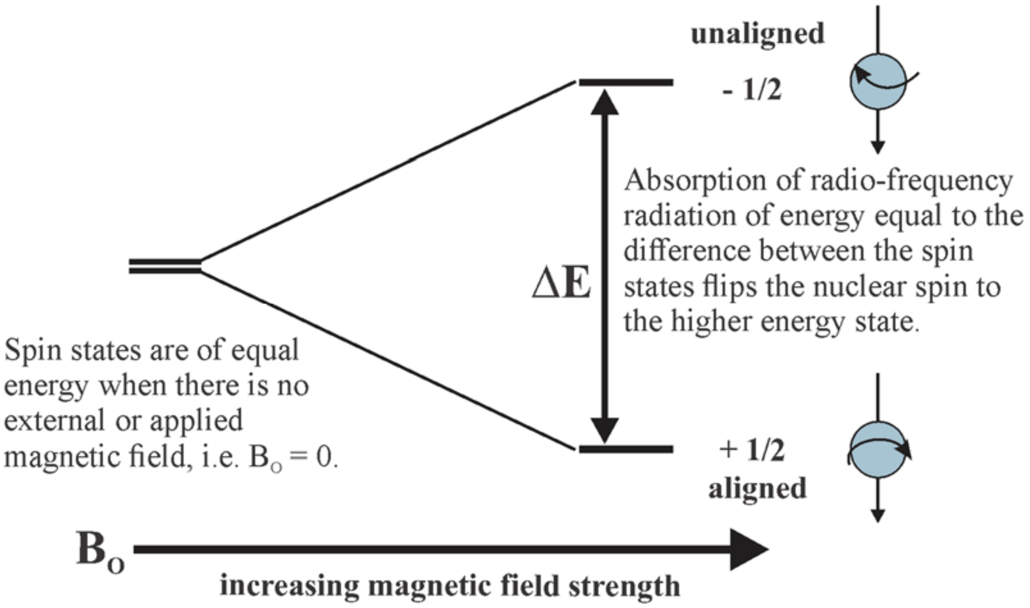


**Figure 5**

In NMR spectroscopy, a higher chemical shift value for a hydrogen or carbon atom in the molecules of a compound is consistent with

**A.** a smaller difference in nuclear energy spin levels.

**B.** a larger difference in nuclear energy spin levels.

**C.** a weaker magnetic field experience by the atoms.

**D.** stronger dispersion force attraction between the molecules of the compound.

**Question 18**

Excess acidified potassium dichromate is added to the same chemical amount of four different compounds. Which of these compounds will require the smallest amount of $K_2Cr_2O_7$ for complete reaction?

**A.** Propan-1-ol.
**B.** Propan-2-ol.
**C.** 2-methylpropan-1-ol.
**D.** 2-methylpropan-2-ol.

**Question 19**

Waste management has become an increasingly significant issue now that waste which was previously exported must be treated in Australia. At a meeting in April this year, federal and state environment ministers endorsed an ambitious target to make all Australian packaging recyclable, compostable or reusable by 2025.

Since plastic is our main packaging material, methods of converting plastic waste to oil are being considered. One such process is gasification, where waste plastic is heated with air or steam to produce synthesis gas, a mixture of CO and $H_2$, which can be used to produce petrodiesel in a process known as the Fischer-Tropsch process.

An unbalanced general equation for this process is

$$\_\_\_\_H_2 + \_\_\_ CO \rightarrow C_nH_{2n+2} + \_\_\_H_2O.$$

The coefficient of $H_2$ in this equation should be

**A.** n+1
**B.** 2n+1
**C.** 2n
**D.** 2n+2

**Question 20**

In an analysis of the concentration of ethanoic acid in a specific brand of commercial vinegar, the same method is followed using the same equipment and solutions multiple times. The *c*($CH_3COOH$) obtained from the analysis could best be described as

**A.** accurate.
**B.** precise.
**C.** accurate and precise.
**D.** accurate but not precise.

**Question 21**

Two students, Megan and Harry, separately standardise an approximately 0.1 M aqueous solution of hydrochloric acid by titrating 20 mL aliquots of 0.050 M $Na_2CO_3$(aq) with the acid to the methyl orange endpoint.

Ultimately, Harry calculated the *c*(HCl) to be 0.095 M whilst Megan determined it to be 0.098 M. Which of the following could best explain the difference in concentrations calculated?

**A.** Megan rinsed her pipette with water only.
**B.** Harry rinsed his pipette with water and then the sodium carbonate solution.
**C.** Megan consistently read from the bottom of the meniscus when taking burette readings.
**D.** Harry consistently read from the top of the meniscus when taking burette readings.

**Question 22**
**Table 1** shows the relative carbohydrate content in each 100 g serve and the glycaemic index of a few foods in a meal.

| **Food** | **Carbohydrate content g / 100 g** | **Glycaemic index** |
|---|---|---|
| Wholemeal bread – 84 g | 47 | 59 |
| Avocado – 50 g | 4 | 10 |
| Omelette – 200 g | 0 | - |
| Chips – 100 g | 20.1 | 85 |
| Watermelon – 150 g | 4 | 76 |

**Table 1**

The food which will have the greatest impact on blood sugar levels because of digestion of the food will be

**A.** avocado.
**B.** chips.
**C.** watermelon.
**D.** wholemeal bread.

**Question 23**
0.886 g of a compound of carbon, hydrogen and oxygen contains 0.0402 mol of carbon atoms and 0.0806 mol of hydrogen atoms.
The IR spectrum of the compound is given below in **Figure 6.**
*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2018).*

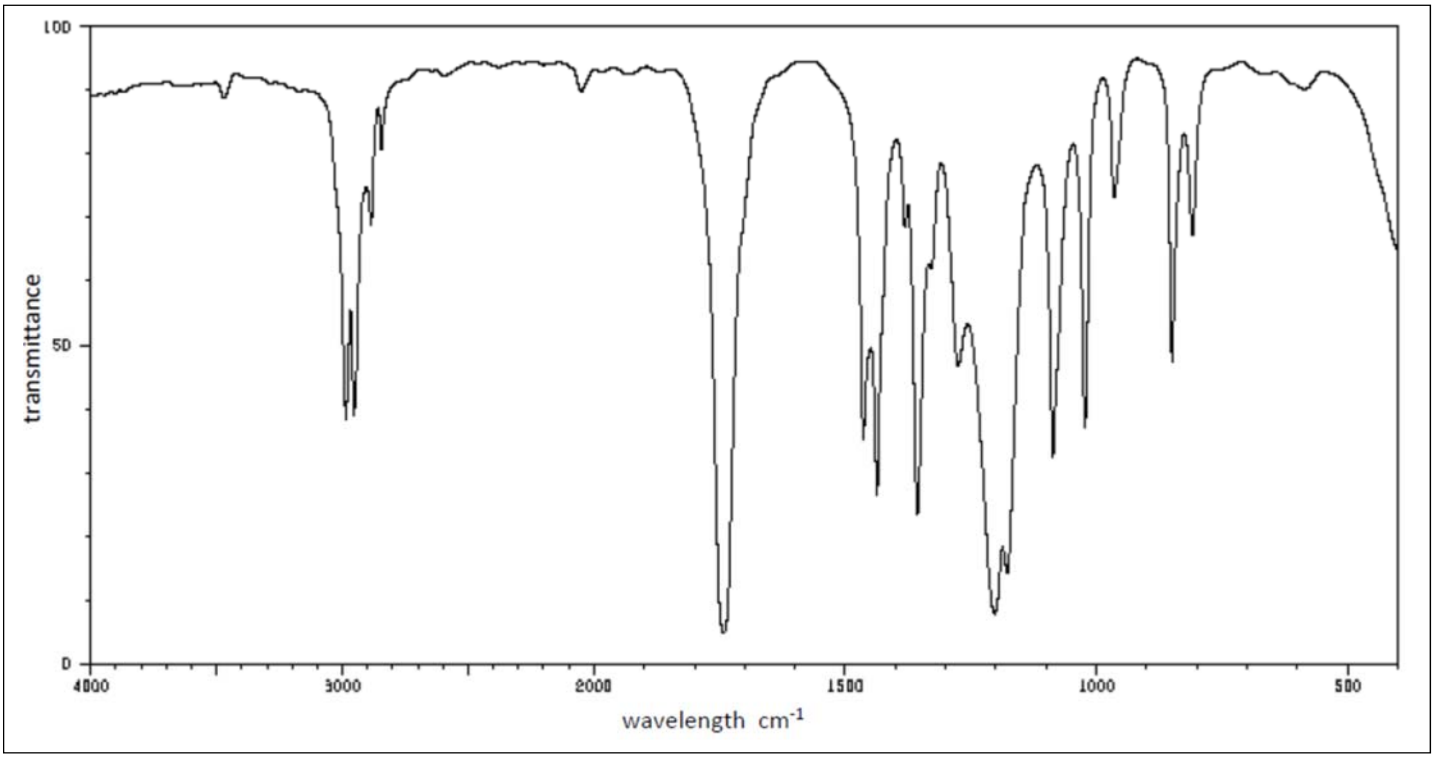


**Figure 6**

Which one of the compounds below is consistent with the data?

**A.** Butanoic acid.
**B.** Methyl propanal.
**C.** Methyl propanoate.
**D.** Butan-2-one.

**Question 24**

Part of a student's summary of the **chemistry of food** is shown in **Figure 7**.

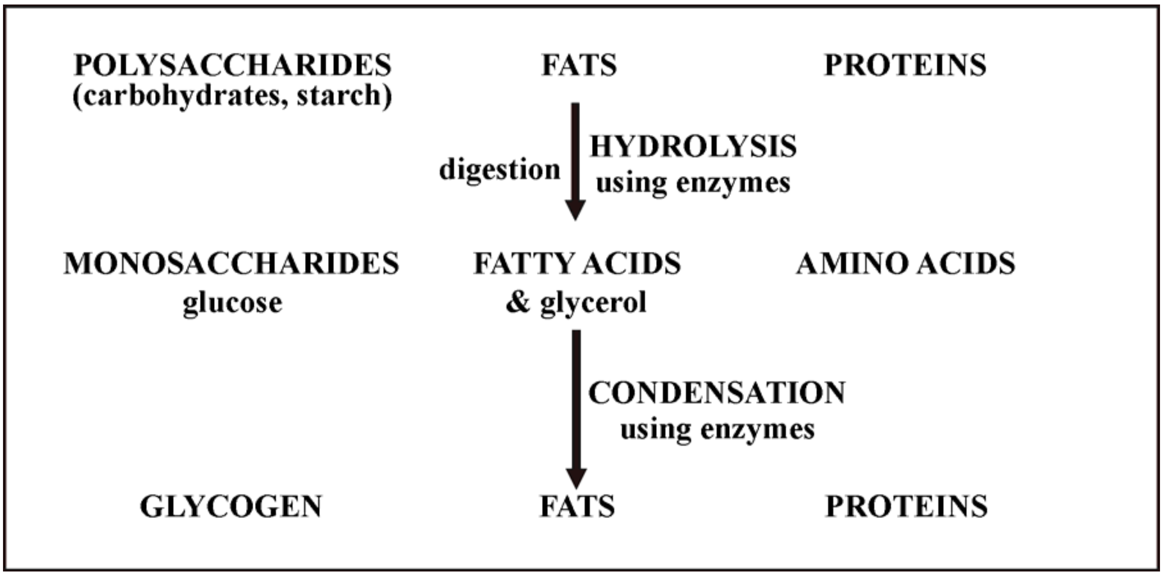


**Figure 7**

In a more detailed version of the summary in **Figure 7,** the associated **functional group changes** are shown.
How many **different** functional groups should appear on the more detailed summary?

**A.** Five.
**B.** Six.
**C.** Seven.
**D.** Nine.

**Question 25**

Palmitoyl-GHK is believed to be able to stimulate collagen production in the skin. More collagen usually means fewer wrinkles and younger looking skin. The structure of palmitoyl-GHK is represented in **Figure 8**.

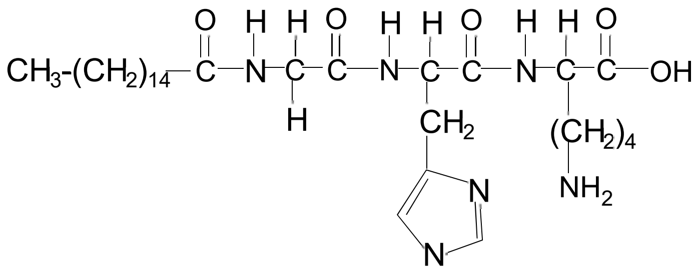


**Figure 8**

Aspartame is an artificial sweeter which is approximately 180 times as sweet as sucrose. Which of the following statements is an accurate deduction based on the structure of palmitoyl-GHK and aspartame?

**A.** Both palmitoyl-GHK and aspartame contain three different amino acids.
**B.** Both palmitoyl-GHK and aspartame release a carboxylic acid during hydrolysis.
**C.** Palmitoyl-GHK and aspartame may be used indirectly to produce biofuel.
**D.** Both palmitoyl-GHK and aspartame molecules assume an overall charge of +1 in alkaline solutions.

**Question 26**

A mixture of 120 mL of methane and 300 mL of oxygen is sparked – volumes are at 130°C and 110 kPa and the combustion reaction allowed to proceed to completion. The change in volume, in mL, at 130°C and 110 kPa, of greenhouse gases during the reaction was

**A.** a decrease of 40 mL.
**B.** zero.
**C.** an increase of 120 mL.
**D.** an increase of 240 mL.

**Question 27**

Whilst methanol plays a key role in FAME (fatty acid methyl ester) biofuels, it is also used in combination with petrol in blended fuels such as M15 which is 15 per cent, by volume, methanol.

Assuming petrol is pure octane, what amount of energy is contained in a 50 L tank of M15? (The densities of octane and methanol are 703 g $L^{-1}$ and 792 g $L^{-1}$ respectively.)

**A.** $1.4 \times 10^5$ kJ
**B.** $1.4 \times 10^6$ kJ
**C.** $1.6 \times 10^6$ kJ
**D.** $2.2 \times 10^6$ kJ

**Question 28**

A representation of chemical pathways from ethane and ethene is represented in **Figure 9**.

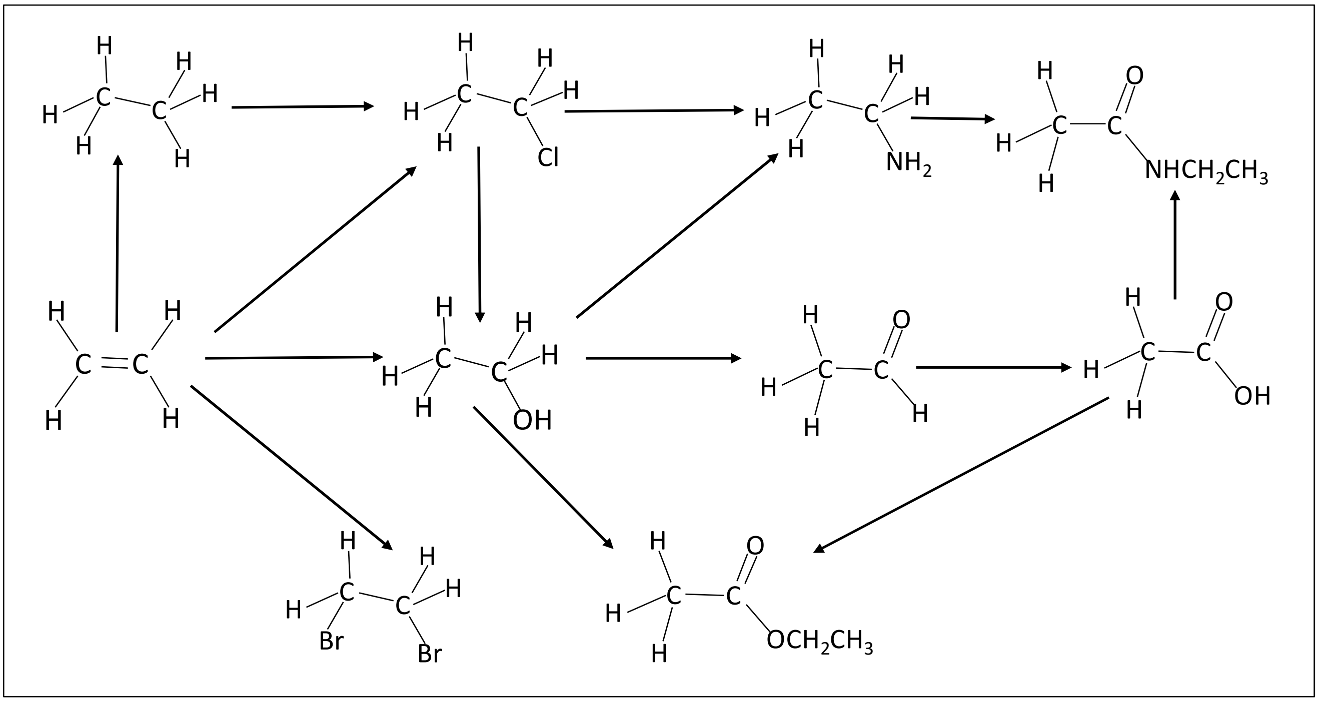


**Figure 9**

Which of the compounds listed below is **not** directly associated with this pathway?

**A.** Ammonia.

**B.** Hydrogen bromide.

**C.** Hydrogen chloride.

**D.** Sulfuric acid.

**Question 29**

Lithium batteries have a higher energy density than lithium ion batteries but are not rechargeable. However, lithium batteries can deliver a constant voltage over long periods of time and this makes them suitable for implanted devices such as heart pacemakers.

Some heart pacemakers are powered by lithium-iodide batteries. In these batteries, the positive electrode is a solid complex of molecular iodine. The electrolyte is solid lithium iodide in a nickel mesh.

The overall equation for the energy releasing reaction is $2Li(s) + I_2(s) \rightarrow 2LiI(s)$.

If a lithium battery is required to deliver an average current of 85.6 μA for 10 years what is the minimum amount of lithium it should contain?

**A.** 0.032 g

**B.** 0.200 g

**C.** 1.93 g

**D.** 24.6 g

**Question 30**
The electrolysis of a concentrated aqueous solution of sodium chloride occurs in a cell represented in **Figure 10**.
Salt solution is fed in at one electrode and water is fed in at the other electrode. Because of the electrolysis, a new compound is obtained from the cell and two gases are produced. The cell also contains a semi-permeable membrane which allows the transfer of cations but not anions.

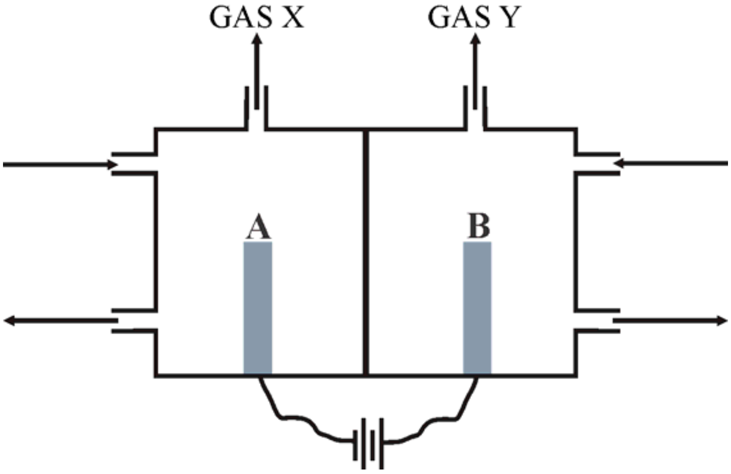


**Figure 10**

Which of the following statements is correct?

**A.** Gas X is $Cl_2$.
**B.** NaOH is produced at electrode A.
**C.** Excess NaCl is extracted from around electrode A.
**D.** Gas Y is $H_2$.

## End of Section A

# VCE Chemistry 2018 Year 12 Trial Exam Units 3/4

## SECTION B – Short Answer Questions

*Section B consists of 9 short answer questions.*
*You should answer all of these questions in the spaces provided.*
*The allotted* ***marks*** *are shown at the end of each part of each question.*

**Question 1 (11 marks)**
As part of an extended experimental investigation, the relationship between heats of combustion and molecular size is determined utilising the equipment set represented in **Figure 11**. The first four members of the homologous series of straight chain alcohols are to be investigated.

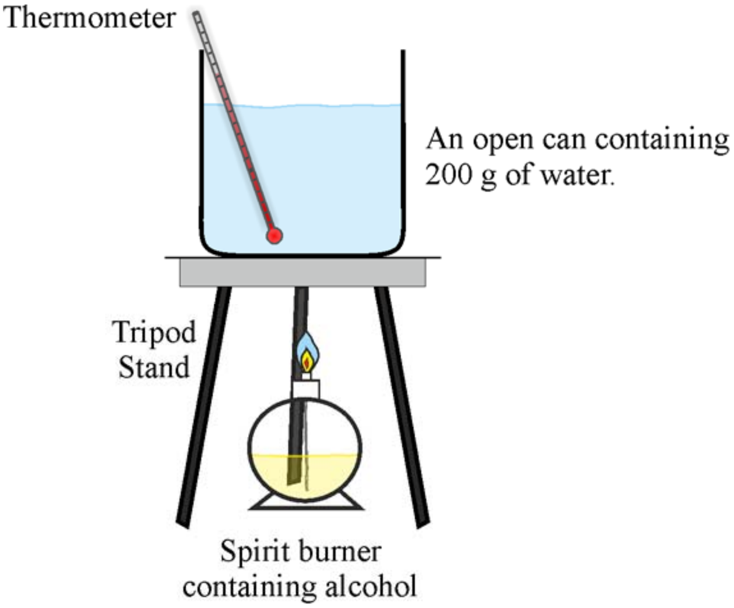


**Figure 11**

All four alcohols are investigated the same way. Each alcohol is in a different spirit burner and, once the wick is ignited, is used to heat the water in the can until its temperature has risen by approximately 20°C at which point the flame on the wick of the spirit burner is extinguished.

**a.** Identify the two main '**sets**' of measurements which must be recorded for each alcohol used.

**2 marks**

**b.** What is the independent variable in this experiment?

**1 mark**

**c.** State a variable that should have been controlled during the investigation.

**1 mark**

**d.** In the investigation of propan-1-ol, the combustion of 0.936 g of the alcohol caused the water to rise by 21.2°C. According to this data, what is the molar heat of combustion of propan-1-ol?

**2 marks**

**e.** Based on data collected during the investigation, the molar heats of combustion of the other three alcohols investigated from smallest to largest were calculated to be 395 kJ $mol^{-1}$, 871 kJ $mol^{-1}$, and 1653 kJ $mol^{-1}$. Explain the relationship between molecular size of the alcohols and heat of combustion in terms of the structural changes that occur during a combustion reaction.

**2 marks**

**f.** For all four alcohols, the calculated molar heats of combustion are lower than the standard values such as may be seen in an extended ***Table 11 of the VCE Chemistry Data Book***. Suggest a reason for this discrepancy and describe one way the equipment setup might be modified to provide more accurate results.

**1 mark**

**g.** Based on the data available to you, calculate the percentage efficiency of energy transfer from the alcohol to the water when ethanol was used in this investigation.

**1 mark**

**h.** Aside from a more efficient transfer of energy from the combustion to water, why is the use of a bomb calorimeter a more accurate way of determining molar heats of combustion?

**1 mark**

**Question 2 (10 marks)**

The equilibrium reaction between hydrogen and iodine to produce hydrogen iodide, in which all reactants and products were gaseous, was investigated experimentally.

Equal quantities of both reactants were initially added to an empty reaction vessel and the chemical amount of each species was determined at regular intervals.

At different points after the system had reached equilibrium, the volume of the reaction vessel was decreased, and the temperature was increased.

Data from the investigation are given in **Table 2**.

| Time (minutes) | $n(H_2)$ - mol | $n(I_2)$ - mol | $n(HI_2)$ - mol |
|---|---|---|---|
| 0.0 | 1.0 | 1.0 | 0.0 |
| 1.0 | 0.76 | 0.76 | 0.48 |
| 2.0 | 0.58 | 0.58 | 0.84 |
| 3.0 | 0.46 | 0.46 | 1.08 |
| 4.0 | 0.36 | 0.36 | 1.28 |
| 5.0 | 0.29 | 0.29 | 1.42 |
| 6.0 | 0.26 | 0.26 | 1.48 |
| 7.0 | 0.24 | 0.24 | 1.52 |
| 8.0 | 0.23 | 0.23 | 1.54 |
| 9.0 | 0.22 | 0.22 | 1.56 |
| 10.0 | 0.22 | 0.22 | 1.56 |
| 11.0 | 0.22 | 0.22 | 1.56 |
| 12.0 | 0.22 | 0.22 | 1.56 |
| 13.0 | 0.22 | 0.22 | 1.56 |
| 14.0 | 0.34 | 0.34 | 1.32 |
| 15.0 | 0.45 | 0.45 | 1.10 |

**Table 2**

**a.** Write a balanced equation for the equilibrium reaction.

**1 mark**

**b.** Discuss the trend in, and the significance of, the data changes up to the 10 minute mark.

**2 marks**

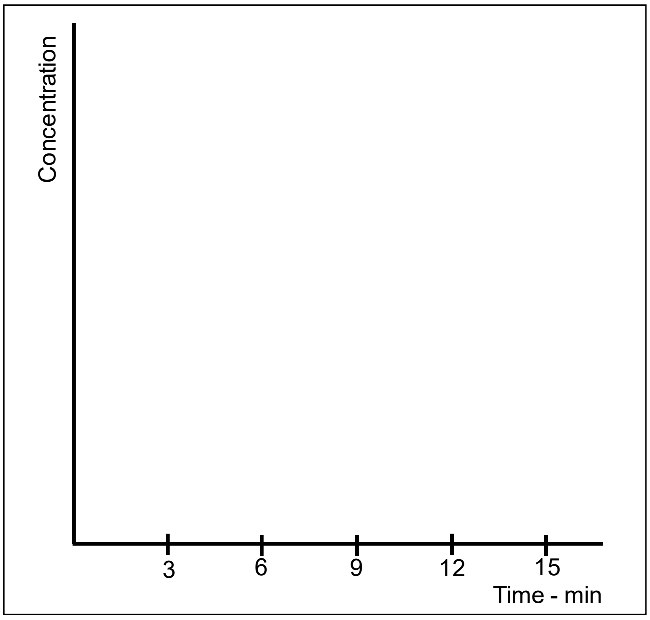
**c.** Work out the equilibrium constant for the reaction under the conditions that applied for the first 13 minutes.

**2 marks**

**d.** At the 10 minute mark, the volume of the reaction vessel was doubled and at the 13 minute mark the temperature was decreased. Explain the trends in the data following each of these changes.

**2 marks**

**e.** Use the axes given below to show a concentration-time graph for HI through the full 15 minutes of the investigation.



**3 marks**

**Question 3 (5 marks)**

In March 2018, peat fires near Cobden caused some residents in South West Victoria to evacuate their homes and it was considered that the fires could burn for months.

Peat is generated through the accumulation of partially decomposed plant debris in an anaerobic, watery environment. Peat is high in carbon content and porous. It is believed the largest peat fire, near the town of Cobrico, caught fire during the St Patrick's Day bushfires. Peat fires can be difficult to extinguish because they smoulder though a deposit rather than burn with an open flame.

Peat smoulders because of relatively low oxygen levels. The smoke from peat fires contains fine particles, water vapour and gases, one of which in particularly is associated with combustion in low oxygen environments.

**a.** Write a balanced equation for the production of this gas in a peat fire.

**1 mark**

**b.** Explain, using equilibrium principles, why this gas can be hazardous to life. Appropriate equations should be used.

**3 marks**

**c.** Explain, using equilibrium principles, how the effect of non-fatal exposure to this gas is usually reversed.

**1 mark**

**Question 4 (13 marks)**
In January 2018, Qantas carried out the world's first biofuel-powered flight between the US and Australia, running on about 24 tonnes of blended biofuel made from non-food mustard seed oil harvested from mustard plant seeds. Qantas claims saving 18000 kg in carbon dioxide emissions – approximately a 7 per cent saving.
**Table 3** provides results from the analysis of petrodiesel, B100 biodiesel, derived from mustard seed oil, and B10 – a blend of 10 percent mustard seed oil biodiesel and 90 per cent petrodiesel.

| **Property** | **Units** | **Petrodiesel** | **B100** | **B10** |
|---|---|---|---|---|
| Density (15 °C) | g $mL^{-1}$ | 0.843 | 0.888 | 0.847 |
| Viscosity (40 °C) | cs $s^{-1}$ | 3 | 7.3 | 3.2 |
| Calorific value | kJ $g^{-1}$ | 45 | 39 | 44 |
| Water content | mg $kg^{-1}$ | 45 | 500 | 71 |

**Table 3**

The fatty acid composition of mustard oil is around 60 percent monounsaturated - erucic and oleic, 21 per cent polyunsaturated - alpha-linolenic (α-linolenic) and linoleic, and 12 per cent saturated.
The chemical formula of alpha-linolenic (α-linolenic) acid is given in the ***Table 9 of the VCE Chemistry Data Book***. Gamma-linolenic acid (γ-linolenic acid), a fatty acid with recognised anti-inflammatory properties, is represented by the structure shown in **Figure 12**.

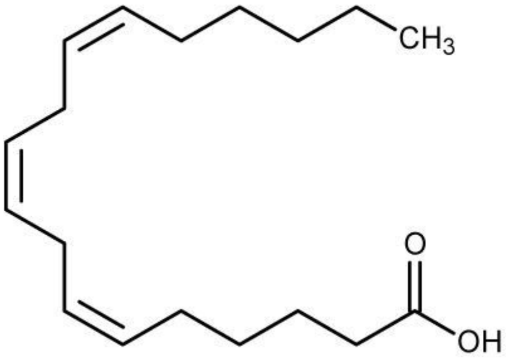


**Figure 12**

**a.** What is the essential structural difference between α-linolenic and γ-linolenic acids?

**1 mark**

**b.** Provide an equation – using semi-structural formula – representing the formation of biodiesel produced by transesterification of a fat containing oleic and linoleic acids in 1:2 ratio.

**3 marks**

**c.** Qantas states that the 10 % B10 blend fuels saved 18000 kg in $CO_2$ emissions. Does this mean that 18000 kg less $CO_2$ was produced during combustion of the fuel in the engines than if pure petrodiesel had been used? Explain.

**2 marks**

**d.** Traces of water are collected in petrodiesel tanks due to condensation. To prevent these traces being a problem in the ignition phase, a small amount of a surfactant is added to the petrodiesel to dissolve this water.

**i.** What does the ability of the surfactant to dissolve water in petrodiesel suggest about the structure of the surfactant molecules?

**1 mark**

**ii.** Explain why the water content of the blended fuel increases as the proportion of biodiesel increases.

**1 mark**

**e.** The mustard oil seeds from which biodiesel was produced are obtained from the plant *Brassica carinata*, which is described as water efficient and can be grown on fallow ground or between crop cycles. After the mustard seeds are ground up and the oil extracted, the leftover material can be used as high protein animal feed. Why are these properties significant?

**1 mark**

**f.** The cold filter plugging point (CFPP) is the lowest temperature at which diesel type fuel will give trouble-free flow in certain fuel systems. Which would you expect to have the higher CFPP, petrodiesel or B100? Explain.

**1 mark**

**g.** What mass of B100, in tonne, would be needed to provide the same energy as 500 L of petrodiesel? Density of petrodiesel is 0.832 g $mL^{-1}$.

**2 marks**

The structures of erucic acid and its geometric isomer brassidic acid are represented below in **Figure 13**.

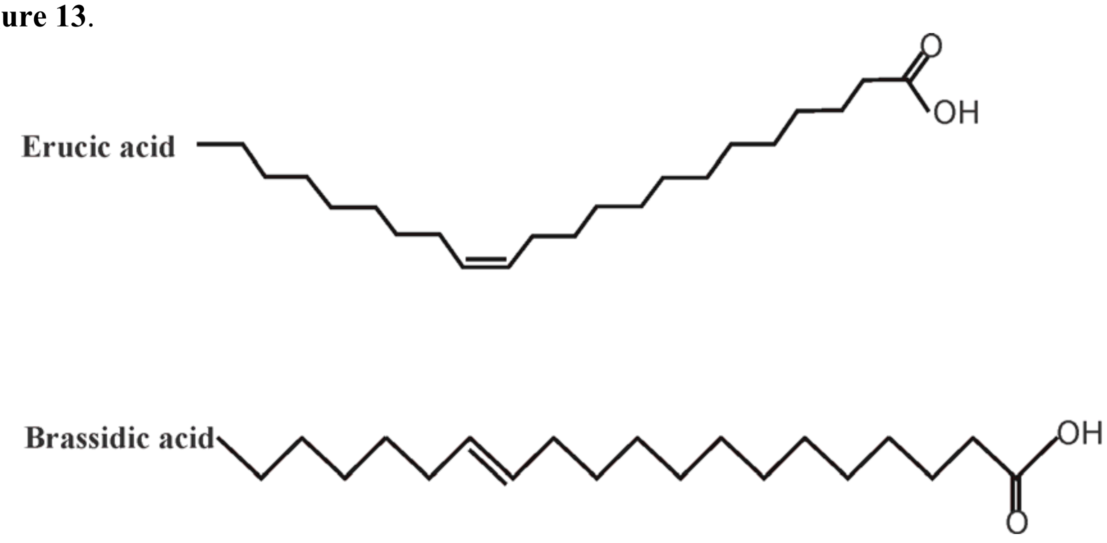


**Figure 13**

**h.** Which compound has the higher melting temperature? Explain.

**1 mark**

**Question 5 (9 marks)**
Avocadoes are a highly nutritious food containing many vitamins and minerals.
They contain more potassium than bananas and consumption of avocadoes has been linked to improved heart health.

**a.** Avocadoes also contain lutein and zeaxanthin, two compounds which in the body protect photoreceptor cells in the retina from free radical damage. Based on this role in the body, how may lutein and zeaxanthin be classified?

**1 mark**

**b.** The most abundant compound in avocadoes is the monounsaturated fatty acid, oleic acid. This fatty acid could be extracted from avocado oil and used to produce a useful fuel. Write a balanced equation for the combustion of that fuel.

**1 mark**

**c.** A particular type of avocado contains 17.2 g of carbohydrate but in terms of nutrition is said to have a net carbohydrate of 3.65 g. What does this imply about the carbohydrates present in the avocado?

**2 marks**

**d.** Avocadoes and avocado oil contain another substance CoQ10 (coenzyme Q10) which exists in two forms, ubiquinol and ubiquinone, the structures of which are represented in **Figure 14**.

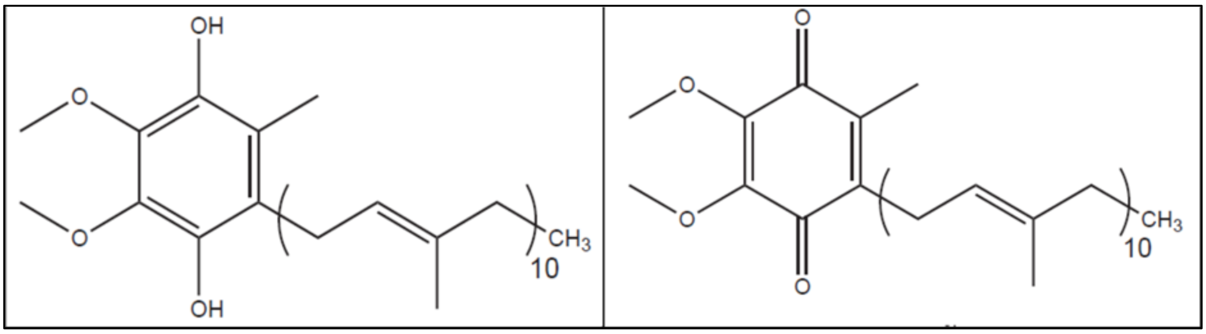


**Figure 14**

**i.** What is the main structural difference between the two substances and what does this suggest about the fact that CoQ10 supplements contain ubiquinol rather than ubiquinone?

**1 mark**

**ii.** Is CoQ10 fat soluble or water soluble? Explain.

**1 mark**

**e.** One of the vitamins present in avocadoes is vitamin K. Describe how vitamin derived coenzymes play significant roles in ensuring biochemical reactions occur at appropriate rates.

**2 marks**

**f.** Explain how the activity of an enzyme is related to its structure.

**1 mark**

**Question 6 (12 marks)**

The oxidation of the ethanol from alcoholic beverages to ethanal requires the presence of the enzyme '*alcohol dehydrogenase*' (ADH). Ethanal, commonly known as acetaldehyde, is a nasty tasting, even toxic, substance and is generally quickly oxidised in the presence of *acetaldehyde dehydrogenase*. The symptoms of hangovers associated with excessive consumption of alcoholic beverages are due largely to ethanal toxicity.

Alcohol dehydrogenase by itself is not effective as an enzyme in the oxidation of ethanol. It requires the presence of the coenzyme NAD+ (nicotinamide adenine dinucleotide) which during the process is converted to NADH.

**a.** Write a balanced half-equation for the oxidation of ethanol to ethanal and explain why 'dehydrogenase' is an appropriate name for the enzyme involved.

**2 marks**

**b.** Describe the role of NAD+ in the conversion of ethanol to ethanal and explain the chemical change it undergoes via an appropriate half-equation.

**2 marks**

In efficient metabolism of ethanol, the ethanal (acetaldehyde) produced is oxidised to ethanoic acid in the presence of acetaldehyde dehydrogenase and NAD+. In the presence of Coenzyme A (CoA), ethanoic acid is converted to acetyl-SCoA so the acetyl group is carried to the citric acid cycle where it is ultimately oxidised for energy production.

A simplified semi-structural representation of acetylSCoA is shown in **Figure 15**.

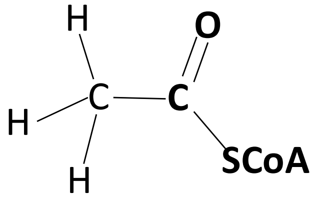


**Figure 15**

**c.** Give the formula of an acetyl radical.

**1 mark**

Antabuse is a medicine that may be prescribed for recovering alcoholics to help them avoid alcohol consumption. It contains disulfiram, a compound which is an aldehyde dehydrogenase inhibitor. As such it prevents the enzyme working and any alcohol consumption results in ethanal build up in the blood stream. The associated side effects act as a strong deterrent to future consumption of alcoholic beverages. The molecular structure of disulfiram is represented in **Figure 16**.

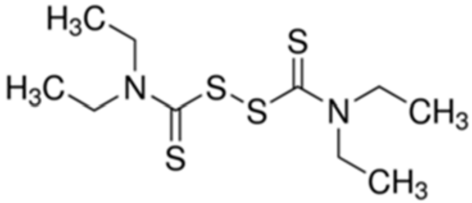


**Figure 16**

**d.** What is the molecular formula of disulfiram?

**1 mark**

**e.** Describe what you would expect to see, with respect to signals, on the $^1$H NMR spectrum of disulfiram.

**2 marks**

**f.** A standard drink is any volume of an alcoholic beverage that contains 10.0 g of ethanol. This is the amount of ethanol the liver of an average adult can process in one hour. Any ethanol above this amount circulates in the blood until it can be processed. The density of pure ethanol is 0.785 g mL$^{-1}$.
A 750 mL bottle of wine contains 14.5 per cent alcohol by volume. What is the minimum time, in hours, that it would take a healthy liver to process all the ethanol in a 190 mL glass of the wine?

**2 marks**

**g.** Bioethanol and ethanol in wine are both produced by fermentation using yeast which secretes the catalyst *catalase*. Write a balanced equation for the fermentation reaction and explain why this reaction can become less effective over time.

**2 marks**

**Question 7 (11 marks)**

'Reality check on a half-billion-dollar brown coal hydrogen project'.
This headline appeared soon after a plan to produce hydrogen from brown coal at Loy Yang A Power Station, was revealed in early April 2018. The production of hydrogen from brown coal is effectively a three-step process.

1. Oxidation of the coal to produce its own gasification agent, $CO_2$.
2. Gasification in which the gasification agent reacts with additional coal to produce CO.
3. Reaction between CO and $H_2O$ to produce $H_2$ in a reaction known as the water gas shift reaction.

**a.** Gasification is an endothermic reaction requiring 3.1 kJ of energy for each gram of CO produced. What is the minimum mass of brown coal which must react in the partial oxidation of coal to enable the production of 0.50 mol of CO in the gasification reaction? The heat of combustion of brown coal is 10 MJ $kg^{-1}$.

**2 marks**

**b.** The 'reality check' in the headline was referring to both economic and environmental concerns. It has been suggested that a sophisticated carbon capture and storage (CCS) process could alleviate a significant environmental concern. Use the 'overall' equation for the process to identify this key environmental concern and identify two issues which would need to be dealt with for CCS to be feasible.

**2 marks**

**c.** Hydrogen from the project is to be shipped to Japan for industrial use. Identify two key properties of hydrogen which need to be considered when transporting hydrogen and describe related safety issues.

**2 marks**

**d.** Write a balanced half-equation for the reaction occurring at the negative (-) electrode during the operation of a hydrogen-oxygen fuel cell which contains an alkaline electrolyte.

**1 mark**

**e.** $H_2$ can also be produced by electrolysis. An investigation showed that the electrolysis of pure deionised water is too slow.

**i.** Explain why the electrolysis of pure deionised water is extremely slow.

**1 mark**

**ii.** Describe an environmentally responsible way of producing $H_2$ by electrolysis and provide a half-equation for the reaction occurring at the cathode.

**2 marks**

**f.** Explain why using hydrogen-oxygen fuel cells to generate electricity is more efficient than the standard combustion → steam → turbine → generator method in a coal fired power station.

**1 mark**

**Question 8 (9 marks)**
A deadly nerve agent called a Novichok received much media coverage in 2018 following an incident in the UK. Nerve agents disrupt the body's nervous system. Electric impulses travel from neuron to neuron in the nervous system by the release of a neurotransmitter. A common neurotransmitter is acetylcholine, which must be broken down after the message is passed along to prevent neurons firing continuously which would cause continuous muscle contraction. Acetylcholine is broken down by the enzyme and synthesised courtesy of the enzyme *acetylcholinesterase* also known as *acetylcholine hydrolase*.

**a.** The structural formula of acetylcholine is represented in **Figure 17**.

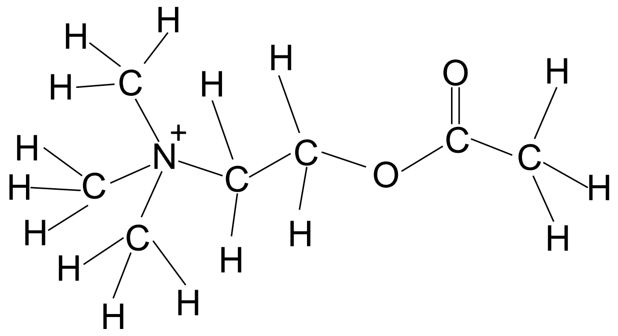


Figure 17

One of the products of the hydrolysis of acetylcholine is the choline ion.

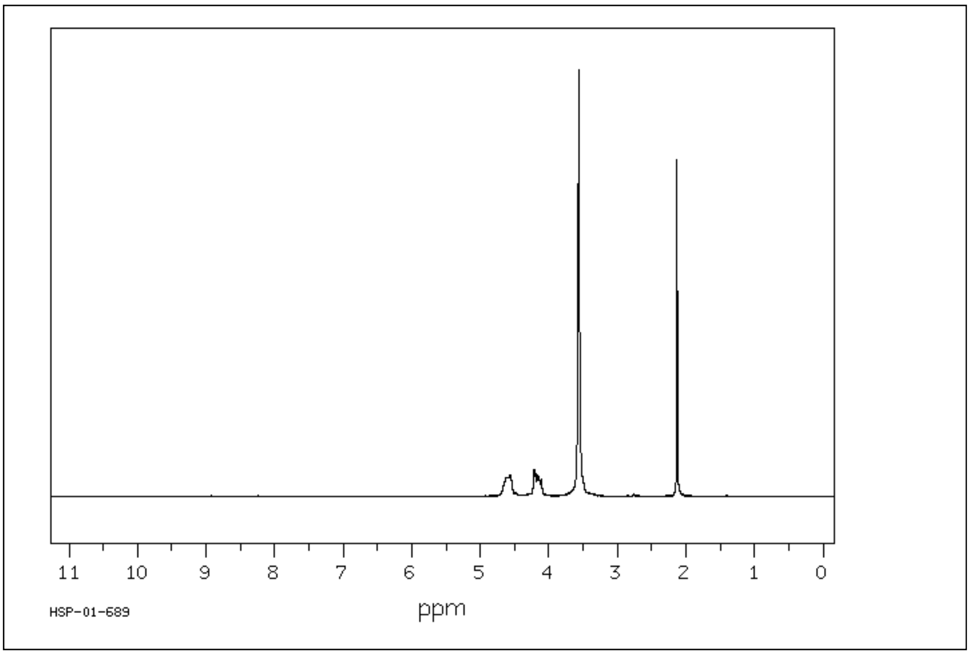
**i.** Give the semistructural formula of the choline ion.

**1 mark**

**ii.** Choline salts are classified as quaternary ammonium salts. Suggest a reason for the use of the term of quaternary in this context and describe a different context in which the term quaternary applies in VCE Chemistry.

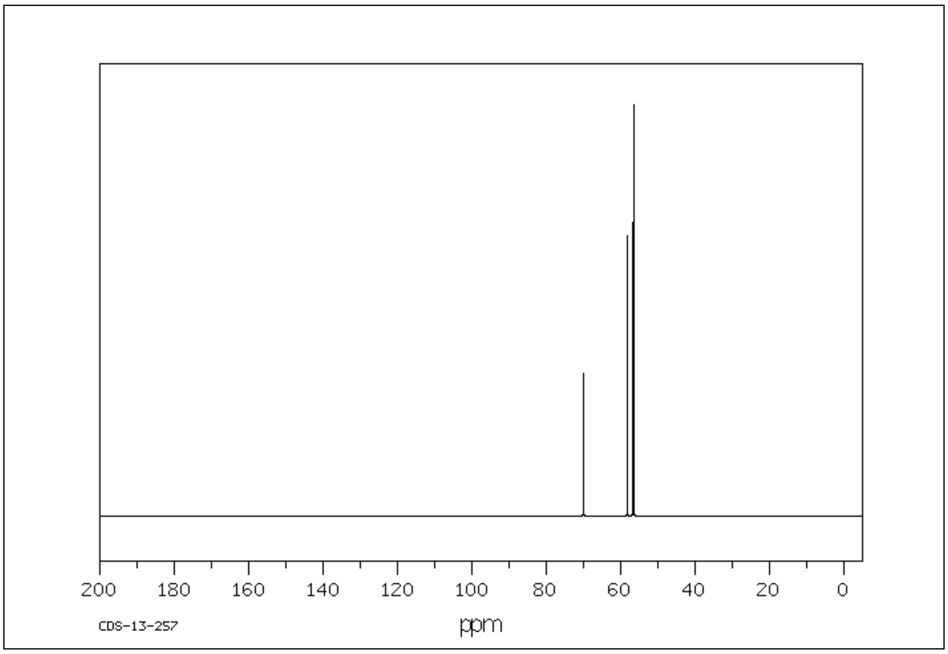
**1 mark**

**b.** The three spectra shown below are related to the hydrolysis of acetylcholine. Each spectrum refers to a different compound.
*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2018).*



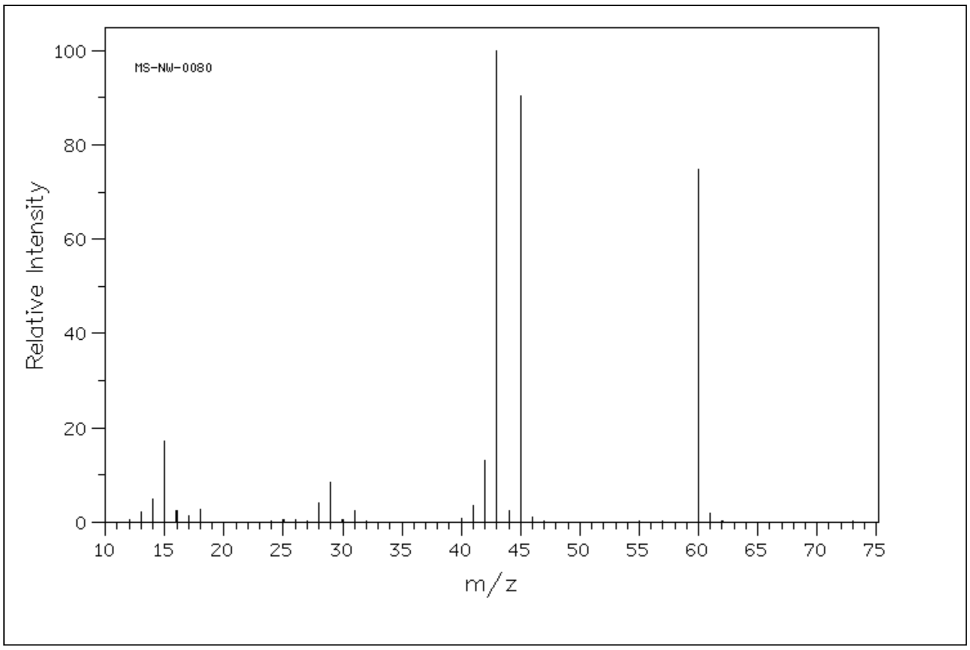
**Spectrum 1**

*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2018).*



**Spectrum 2**

*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2018).*



**Spectrum 3**

**i.** Identify the compound associated with each spectrum explaining why that spectrum is specific to the compound identified.

**3 marks**

Spectrum 1:

Spectrum 2:

Spectrum 3:

**ii.** Explain the significance of the peak at relative intensity 100 on **Spectrum 3** and give the formula of the species causing that peak.

**1 mark**

**c.** Nerve agents contain compounds that bind to serine in *acetylcholinesterase* preventing the breakdown of acetylcholine. Build-up of acetylcholine (acetylcholine chloride) can cause convulsions, paralysis and respiratory collapse.
Explain, in terms of enzyme structure, why the nerve agent reduces the ability of *acetylcholinesterase* to break down acetylcholine.

**1 mark**

**d.** One antidote for nerve agent poisoning is pralidoxime chloride. The formula of the pralidoxime ion is $C_7H_9N_2O^+$.
The recommended dose of this antidote for adults is 30 mg/kg administered intravenously over 20 minutes, repeated 20 minutes later.
At what rate in, mol / hour, must this antidote be administered to an 82.5 kg adult?

**2 marks**

**Question 9 (11 marks)**

Challenged with the task of determining the percent efficiency of electroplating a steel plate with copper, two students, Clarisse and Masud, each set up a simple electrolytic cell, using $CuSO_4(aq)$ as the electrolyte and pure copper as one electrode.

Required to assess the impact of one variable on cell efficiency, the students decide to use different currents for the same time and weigh the steel plate before and after the electrolysis. Some of the data recorded by the students is listed in **Table 4**.

| Student | Current (Amps) | Time (min) | Change in mass of plate |
|---|---|---|---|
| Clarisse | 1.45 | 15.0 | 0.395 g |
| Masud | 1.15 | 15.0 | 0.326 g |

**Table 4**

**a.** **Figure 18** is a representation of the cell. Give the electrode signs and provide appropriate species in the boxes provided.

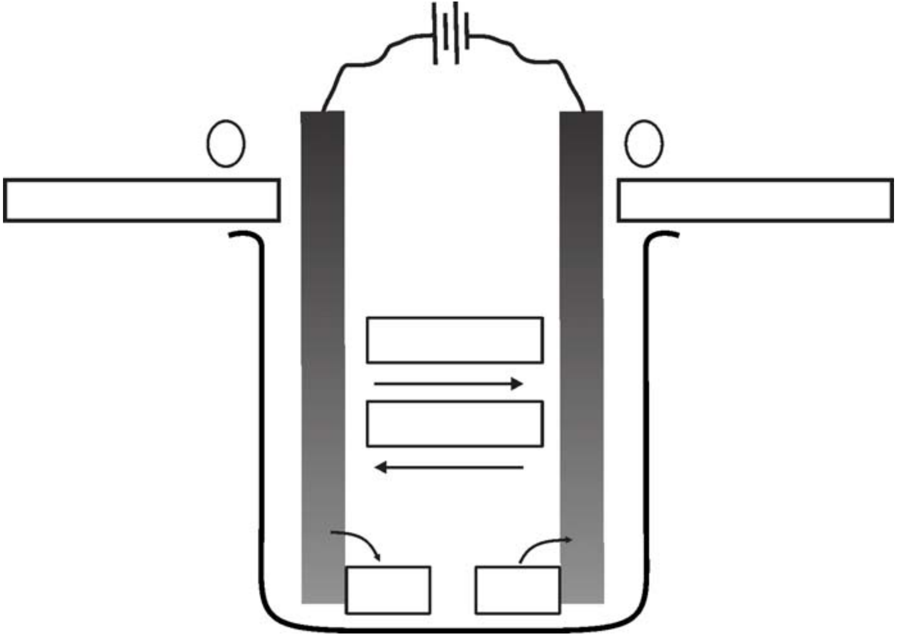


**Figure 18**

**3 marks**

**b.** Based on the recorded data what were the (i) independent, and (ii) dependent variables.

**1 mark**

**c.** List **three** variables which must have been controlled if a valid comparison of the data present is to be made.

**1 mark**

**d.** Determine the percentage efficiency of the cell used by Clarisse.

**3 marks**

**e.** Masud calculates the efficiency of his cell to be higher than that of Clarisse's cell. Suggest a possible technique variation that would explain this difference.

**1 mark**

**f.** Explain why the electrolyte concentration might be expected to remain constant during the plating procedure.

**1 mark**

**g.** Comment on the suggestion that 'during the analysis, results obtained by weighing the copper electrode, rather than the steel electrode, before and after passing the current may have been more accurate'.

**1 mark**

**Question 10 (9 marks)**
Redox flow batteries are a developing energy storage option. Like other electrochemical cells, these contain electrolyte solutions and positive and negative electrodes. Unlike other batteries, the electrolyte in the solvent methane sulfonic acid, $CH_3SO_3H$, is stored externally in tanks and pumped past the electrodes.

**Figure 19** shows the general structure of a zinc-cerium redox-flow battery. One electrode is Zn, the other is a graphene oxide – graphite composite.

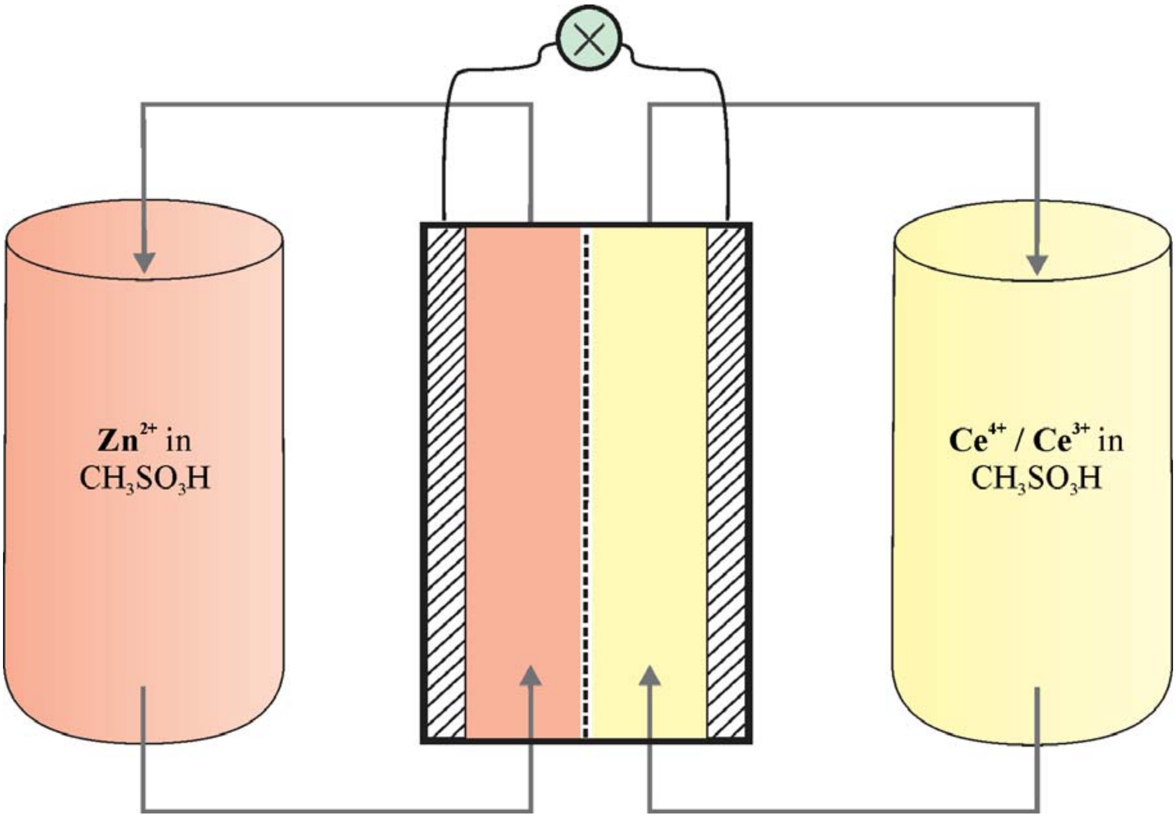


**Figure 19**

Methane sulfonic acid, $CH_3SO_3H$, is a good solvent used in many industrial electrochemical processes.

**a.** Cerium(III) is a weaker reductant than zinc. State the sign of each electrode over which each electrolyte is pumped and write balanced half-equations for the reactions at these electrodes when the cell is discharging.

**2 marks**

**b.** Would you expect to see any change to the electrodes when the cell is recharging? Explain.

**1 mark**

**c.** Under standard conditions, the zinc-cerium cell generates 2.20 V. What is the standard electrode potential of the $Ce^{4+}/Ce^{3+}$ half-cell?

**1 mark**

**d.** Redox flow batteries have been described as a cross between a conventional rechargeable battery and a fuel cell. Is this a fair description? Explain.

**1 mark**

**e.** Methane sulfonic acid is used as a catalyst in many organic processes. One instance of its use is in the final step of the production of an organic compound from chloroethane. No other organic compounds are supplied during the production of the compound. The $^1$H NMR and mass spectra of this compound are shown in **Figures 20 and 21**.

*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology June 2018).*

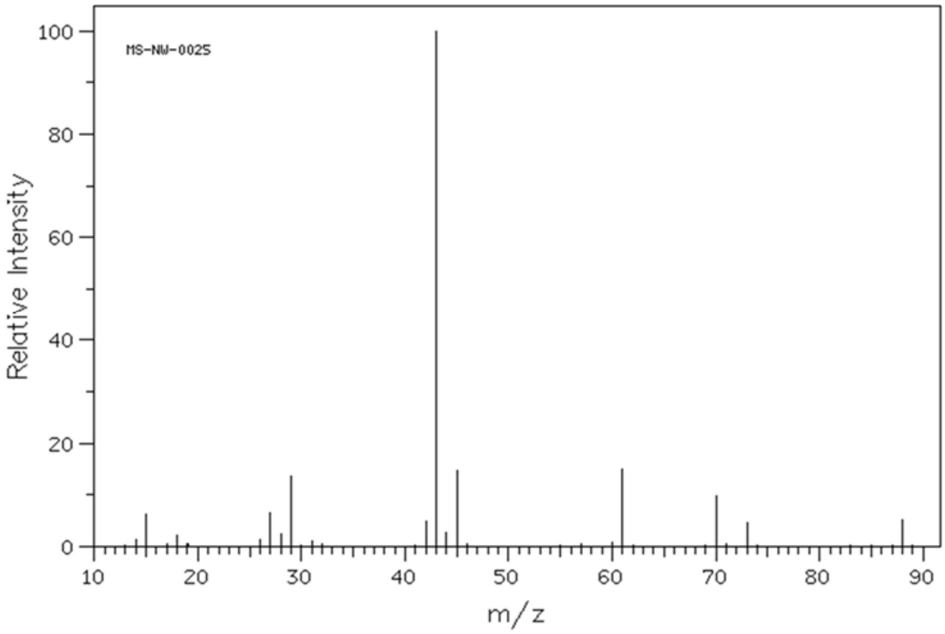


**Figure 20**

*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology June 2018).*

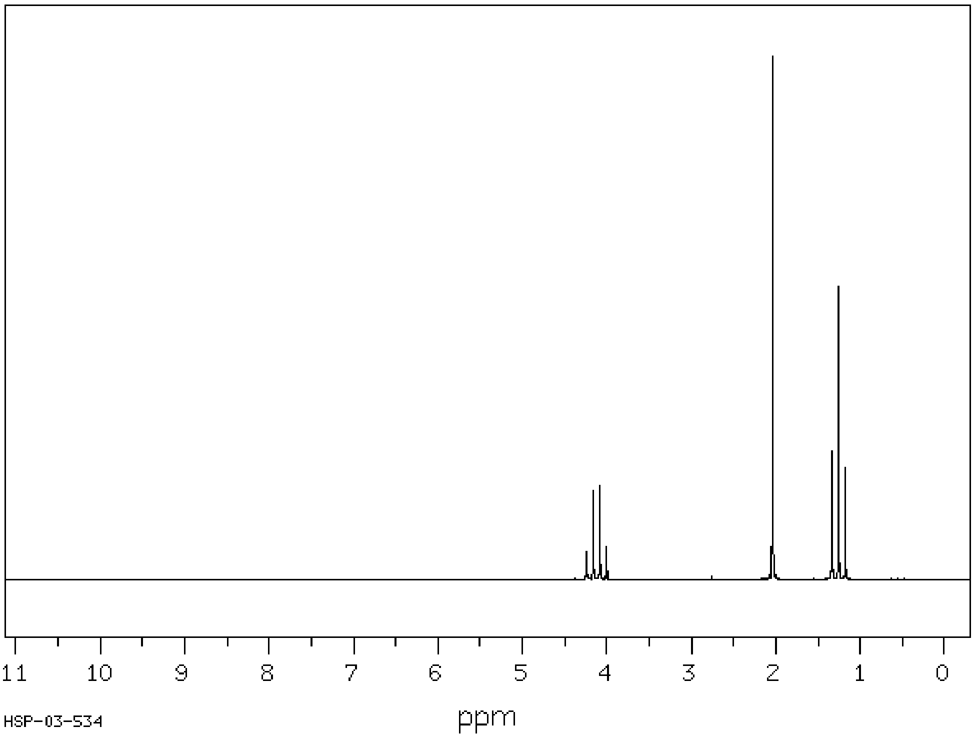


**Figure 21**

**i.** Use your knowledge of organic reaction pathways emanating from chloroethane, and the information which may be deduced from the two spectra to identify the compound produced using methanesulfonic acid as the catalyst.

**3 marks**

*SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology June 2018).*

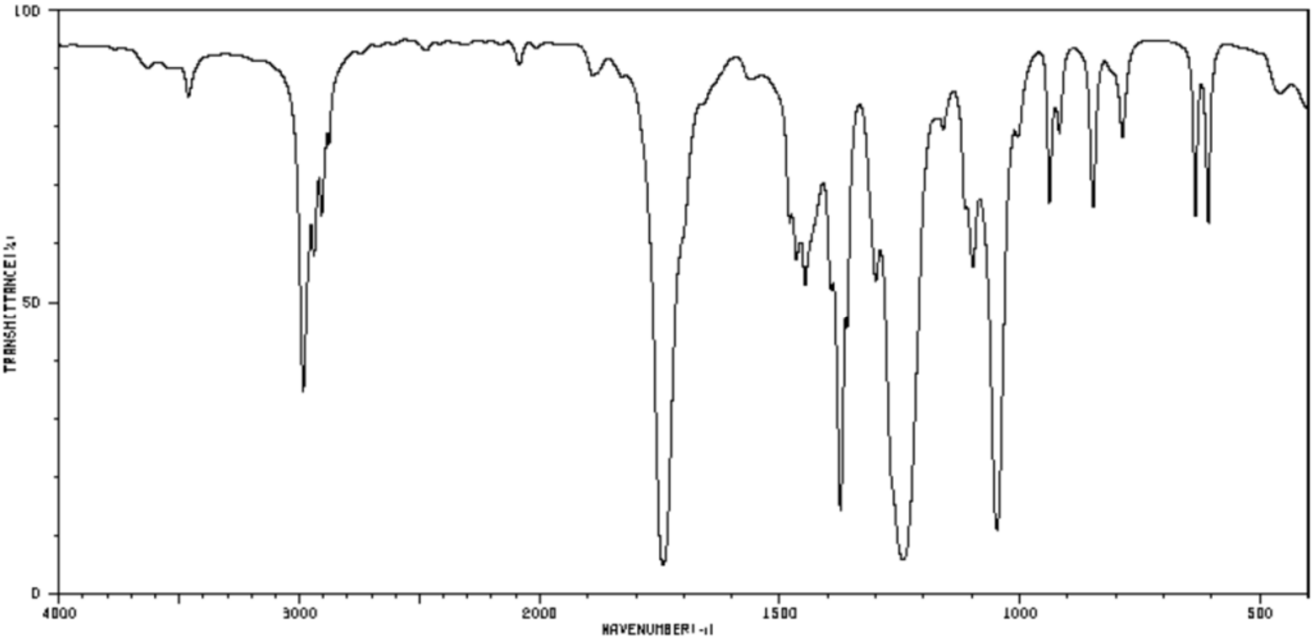


**Figure 22**

**ii.** The IR spectrum of this organic compound is shown in **Figure 22**. Indicate the bonds associated with three significant peaks on this spectrum.

**1 mark**

## End of Section B

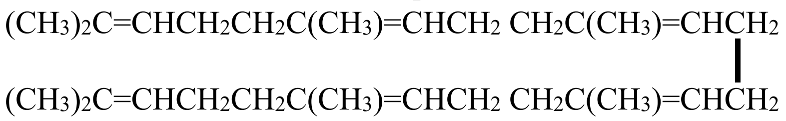
## End of Trial Exam

# Suggested Answers

# VCE Chemistry 2018 Year 12 Trial Exam Units 3/4

## SECTION A – Multiple Choice Answers

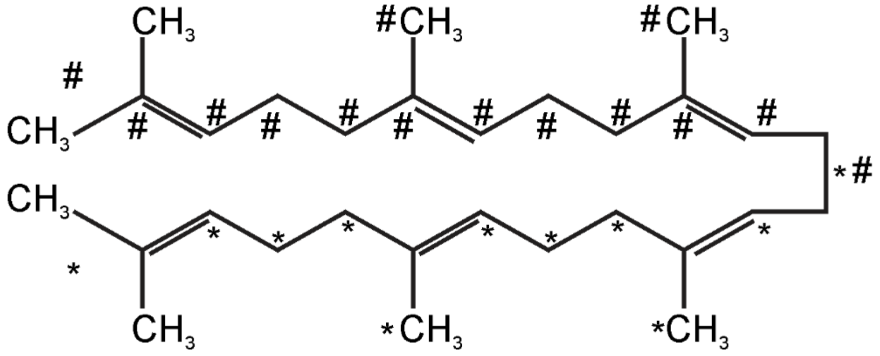
**Q1. C** The semi-structural formula of squalene is



$$\begin{array}{l}(CH_3)_2C{=}CHCH_2CH_2C(CH_3){=}CHCH_2\ CH_2C(CH_3){=}CHCH_2\\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad |\\ (CH_3)_2C{=}CHCH_2CH_2C(CH_3){=}CHCH_2\ CH_2C(CH_3){=}CHCH_2\end{array}$$

The are no C atoms bonded to four different atom groups, hence **no chiral carbons**.

**Squalene molecules are symmetrical** as emphasised by the skeletal structure.



Squalene molecules have **11 hydrogen environments** – indicated by * on the skeletal structure.

Squalene molecules have **14 carbon environments** – indicated by # on the skeletal structure.

**Q2. B** $n(C_{10}H_{16}O) = 2.45\ g / 152\ g\ mol^{-1}$

$= 0.0161$ mol

Energy released from combustion of camphor $= 0.0161\ mol \times 5904\ kJ\ mol^{-1}$

$= 95.2$ kJ

$\Delta T = 95.2\ kJ / 7.89\ kJ\ K^{-1}$

$= 12.1$ K (12.1 °C) - temperature changes are the same in °C and K.

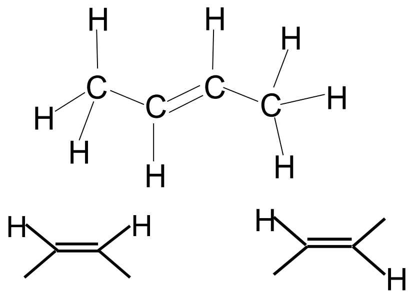
Initial temperature $= 33.88 - 12.1$

$= 21.8$ °C

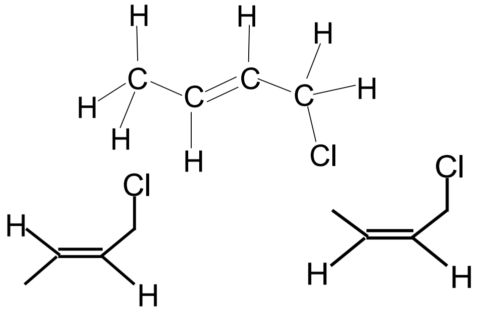
**Q3. C** The induced fit model of enzyme activity refers to the situation when **exposure to a substrate (reactant) causes the active site of the enzyme to change to a shape complementary to that of the substrate** to allow the interaction necessary for reaction to occur.

**Q4. D**

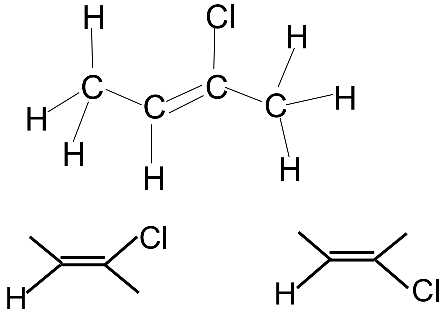
**But-2-ene**



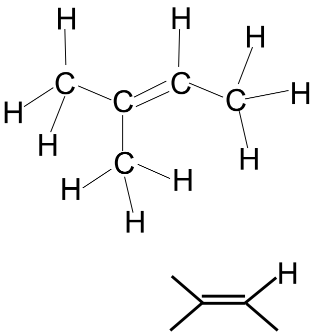
**1-chlorobut-2-ene**



**2-chlorobut-2-ene**



**2-methylbut-2-ene**



**Q5. A** Energy released during combustion $= 4.18\ \text{J g}^{-1}\text{°C}^{-1} \times 200\ \text{g} \times 28.\ 7\text{°C}$

$= 2.40 \times 10^4$ J

= 24.0 kJ

$n$(hydrocarbon) burnt = 24.2 kJ / 2058 kJ mol$^{-1}$

= 0.0117 mol

$M$(hydrocarbon) = $m$ / $n$ = 0.49 / 0.0117

= 42 g mol$^{-1}$

**Relative molecular mass = 42**

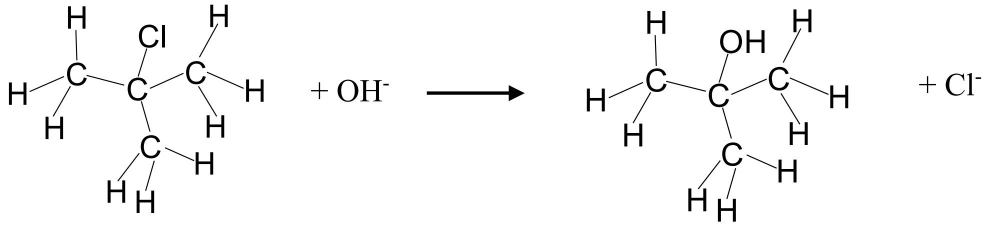
**Q6. C** The key piece of information is the direction of movement of the anion, $NO_3^-$(aq). In all electrochemical cells, anions move towards the anode which, in galvanic cells, is the **negative** electrode.
In all cells, the anode is the site of oxidation of the reductant which, in the $Y^+$(aq) / Y(s) half-cell, is Y(s).
The half-equation at the negative electrode is $Y(s) \rightarrow Y^+(aq) + e^-$

**Q7. A.** The amino acid is most likely to be the one with the greatest proportion of nitrogen atoms. Visual inspection of amino acid structures from the ***VCE Chemistry Data Book (Table 17)*** suggest **arginine.**
Proportions by mass of N – [$m$(N) / $M$(amino acid)] × 100
**Arginine** – (56/174) × 100 = **32 %**
Asparagine – (28/132) × 100 = 21 %
Histidine – (42/155) × 100 = 27 %
Lysine – (28/146) × 100 = 19 %

**Q8. D** According to electrochemical series in ***Table 2 of the VCE Chemistry Data Book***.
*E*° ($Ag^+$/Ag) = 0.80 V
*E*° ($Pb^{2+}$/Pb) = -0.13 V
*E* ($Ag^+$/Ag // $Pb^{2+}$/Pb) = 0.80 – (-0.13) = 0.93 V
According to the information in the question we can deduce
*E* ($Ag^+$/Ag // $Y^{3+}$/Y) = 0.93 + 2.24 = 3.17 V
Since *E*° ($Ag^+$/Ag) = 0.80 V, then *E*°($Y^{3+}$/Y) must be either 3.17 + 0.80 i.e. 3.87 which would place it above $F_2$(g)/$F^-$(aq) on the table of electrode potentials, or 0.80 – 3.17 = **-2.37 V.**
*E*°($Y^{3+}$/Y) = *E*° ($Ag^+$/Ag) – *E*(cell) = 0.80 – 3.17
= -2.37 V
So, expand the electrochemical series to
*E*° ($Ag^+$/Ag) = 0.80 V
*E*° ($Pb^{2+}$/Pb) = -0.13 V
*E*° ($Y^{3+}$/Y) = -2.37 V
*E*°($Pb^{2+}$(aq)/Pb(s) //$Y^{3+}$(aq/Y(s)) = -0.13 – (-2.37)
= 2.24 V
*E*($Tl^+$(aq)/Tl(s) //$Y^3$ (aq)/Y(s)) = 2.24 – 0.21 V
= 2.03 V
*E*°($Tl^+$/Tl) is either 2.03 more or 2.03 less than *E*° ($Y^{3+}$/Y), i.e. -0.34 V or -4.40 V. The latter is unlikely since it would place $Tl^+$(aq)/Tl(s) below $Li^+$(aq)/Li(s).
So, *E*°($Tl^+$/Tl) = -0.34.
Electrochemical series becomes
*E*° ($Ag^+$/Ag) = 0.80 V
*E*° ($Pb^{2+}$/Pb) = -0.13 V
*E*°($Tl^+$/Tl) = -0.34 V
*E*° ($Y^{3+}$/Y) = -2.37 V
**Strongest reductant is Y**

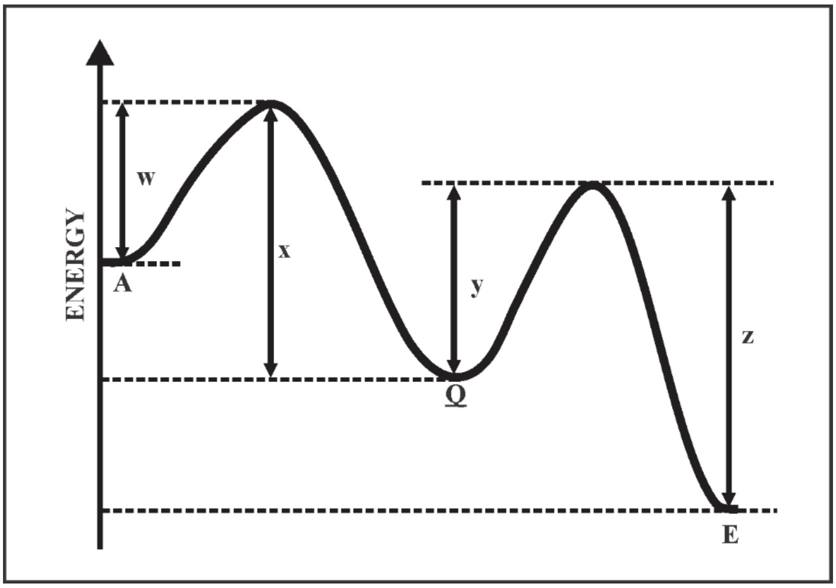
**Q9. B** *c*(ethanol) in dilute mixture = 0.430 % (m/V)
*c*(ethanol) in original fermentation mixture = (500/20) × 0.430
= 10.8 % (m/V)
= 10.8 g in 100 mol
*m*($CH_3CH_2OH$) in 100 mL = 10.8g / 46.0 g $mol^{-1}$
= 0.234 mol
***c*($CH_3CH_2OH$) = 2.34 mol $L^{-1}$**

**Q10. A** In NaOH(aq), 2-chloromethylpropane will be converted to methylpropan-2-ol



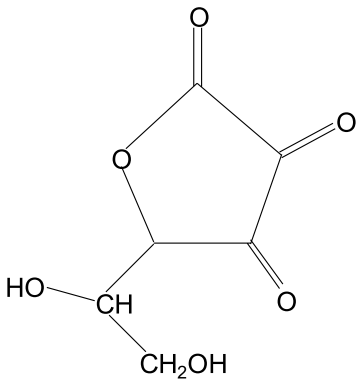
As the [$OH^-$] decreases due to the reaction, the **pH will decrease**.

**Q11. B** Consider the two stages of the conversion of A to E.

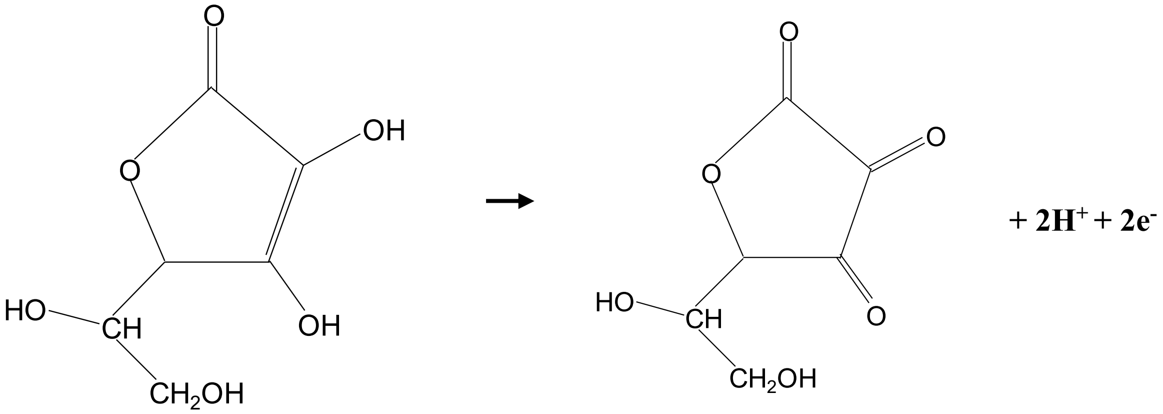


Energy change A → Q = **x – w**
Energy change Q → E = **z – y**
**Total energy change A → E = x – w + z -y**
**<u>= x + z – w – y</u>**

**Q12. B** The structure of ascorbic acid is given in the ***Table 17 of the VCE Chemistry Data Book***.
The loss of hydrogen in the oxidation to dehydroascorbic acid indicates that $H^+$ ions will be released during the oxidation. In the oxidation half-equation, the charge on the $H^+$ ions will be balanced by electrons so the overall charge on ascorbic acid remains zero.
The only structure consistent with the half-equation will be

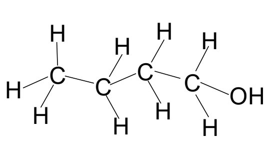
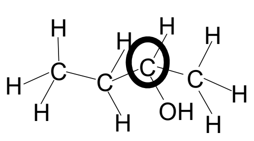
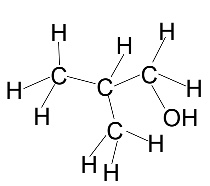
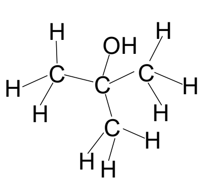


The half-equation for the oxidation is

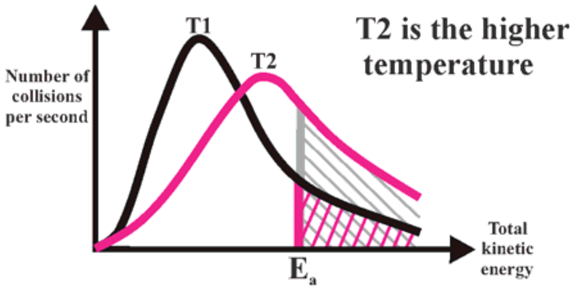


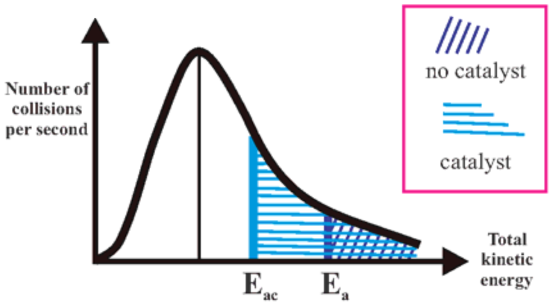
or $C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e^-$

**Q13. B** To exist as a racemic mixture the substance must have two stereo isomers resulting from one chiral centre.
Only butan-2-ol has a chiral centre, i.e. a carbon bonded to four different atoms or groups of atoms.

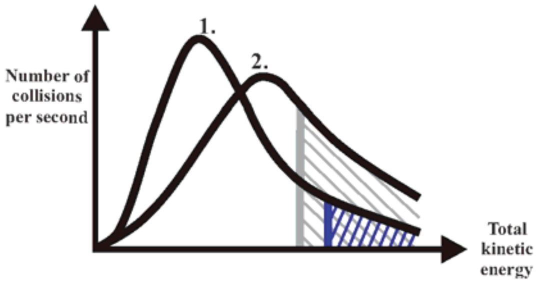





**Q14. C** The effect of an increase in temperature on reaction rate and a catalyst on reaction is represented in the Maxwell-Boltzmann distribution curves shown below.





These curves are combined in the curves for conditions 1. and 2., i.e.



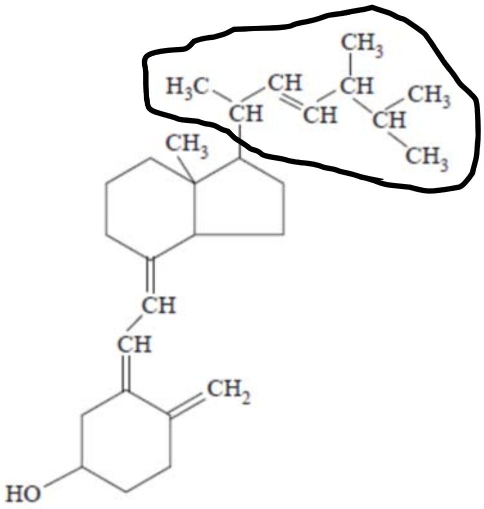
So, the conditions at 2. **involve a higher temperature and the presence of a catalyst**.

**Q15. A** Equation for titration reaction

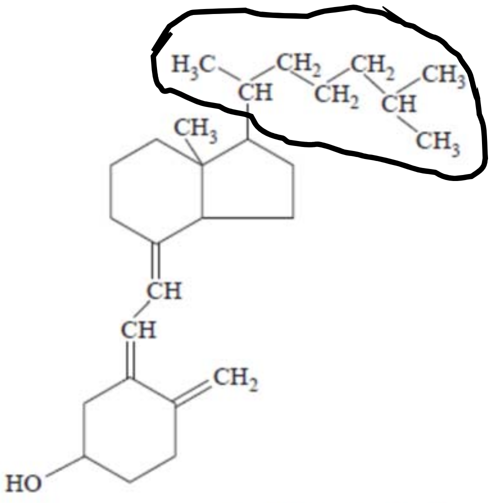
$CH_3(OH)COOH(aq) + NaOH(aq) \rightarrow CH_3(OH)COONa(aq) + H_2O(l)$

$n(NaOH)$ used $= 0.150$ mol $L^{-1} \times 13.2\times10^{-3}$ L
$= 1.98\times10^{-3}$ mol
m(lactic acid) $= 1.98\times10^{-3}$ mol $\times$ 90.0 g mol$^{-1}$
$= 0.178$ g
m(milk) $= 25.0$ mL $\times$ 1.03 g mL$^{-1}$
$= 25.8$ g
% lactic acid $= (0.178 / 25.8) \times 100$
$= 0.692$ % (m/m)

**Q16. D** The structures of vitamin $D_2$ and vitamin $D_3$ are shown in Table 10 in the ***VCE Chemistry Data Book***. The difference between structures is in the hydrocarbon chains attached to the ring structure.



vitamin $D_2$ (ergocalciferol)



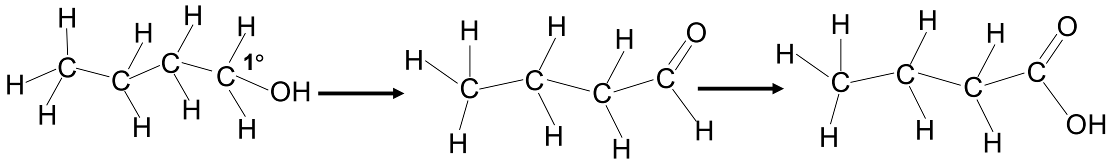
vitamin $D_3$ (cholecalciferol)

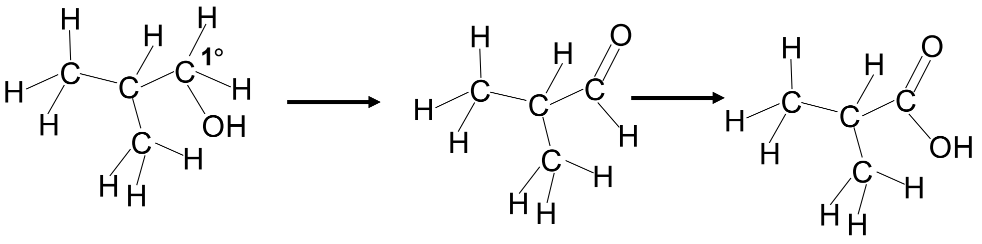
The formulae of the respective side chains are $\mathbf{C_9H_{17}}$ and $\mathbf{C_8H_{17}}$.
The extra carbon atom in vitamin $D_2$ means that its intermolecular dispersion force attraction will be stronger and its melting temperature higher.

**Q17. B** The chemical shift of a H or C atom in a molecule on a $^1H$ or $^{13}C$ NMR spectrum is determined by the relative strength of the external magnetic field experienced by the atoms. Exposure to the magnetic field is reduced by the shielding effect of electrons surrounding the atom in the bonded state. This shielding effect is reduced by the presence of more electronegative atoms in the molecule which means the nuclei are exposed to a stronger magnetic field. Consequently, the **energy gap between the two nuclear spins states increases** and **so does the chemical shift**.

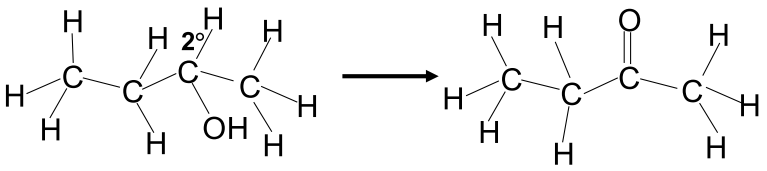
**Q18. D** In the presence of acidified dichromate,

- primary alcohols – **propan-1-ol** and **methylpropan-1-ol** – are oxidised to **aldehydes** and carboxylic acids

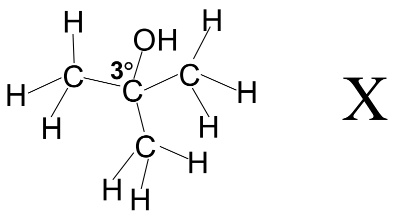




- secondary alcohols – **propanol-2-ol** – are oxidised to ketones



- tertiary alcohols – **methylpropan-2-ol** – are not oxidised



Hence methylpropan-2-ol will require the least amount of acidified dichromate.

**Q19. B** $\_\_\_\_H_2 + \_\_\_ CO \rightarrow C_nH_{2n+2} + \_\_\_\_H_2O$

$\_\_\_\_H_2 + \mathbf{n}\ CO \rightarrow C_nH_{2n+2} + \_\_\_\_H_2O$

$\_\_\_\_H_2 + \mathbf{n}\ CO \rightarrow C_nH_{2n+2} + \mathbf{n}\ H_2O$

Total number of H atoms on right $= 2n+2 + 2n$

$= \mathbf{4n+2}$

Number of H atoms required on left $= 4n + 2$

Number of $H_2$ molecules required on left $= (4n+2) / 2$

$= 2n+\mathbf{1}$

Overall equation

$\mathbf{2n+1}\ H_2 + \mathbf{n}\ CO \rightarrow C_nH_{2n+2} + \mathbf{n}\ H_2O$

**Q20. B** The accuracy of the determined *c*($CH_3COOH$) depends on how close it is to the true value.

The precision depends on the reproducibility of the data collected under the same conditions.

It **cannot be claimed** that the result **is accurate** because there may be a flaw in the technique or a significant systematic error.

However, **multiple repetition** of the same experimental technique under the same conditions should eliminate any random error and provide **results that are close together, i.e. precise.**

**Q21. A** The equation for the reaction is

$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

The c(HCl) is determined via the calculation sequence

$V(Na_2CO_3) \times c(Na_2CO_3) \rightarrow n(Na_2CO_3) \times 2 \rightarrow n(HCl) \div V(HCl) \rightarrow c(HCl)$

Rinsing the pipette with water only, rather than with water followed by sodium carbonate solution – the correct technique - will mean that the calculated n($Na_2CO_3$) will be higher than the true value because of dilution by residual water in the pipette. This means the calculated n(HCl) and subsequently c(HCl) will be too high.

Alternatively, the lower concentration of $Na_2CO_3$ in the pipette will lead to a smaller V(HCl) in the titre which leads to a higher calculated c(HCl).

This means Megan's calculated value of the c(HCl) will be higher than Harry's calculated value.

Since the V(HCl) reacting is determined by subtracting the initial burette reading from the final burette reading, it cannot be determined how reading from the top rather than the bottom of the meniscus -the preferred technique - impacted on Harry's calculated result.

**Q22. D.** The glycaemic index of a food effectively represents the rate of hydrolysis of carbohydrates in food to glucose since it is a scale which ranks foods according to their effect on blood sugar levels over a 2-hour period after consumption.

However, the glycaemic index does not take into account the variation in relative amount of carbohydrate in each food in a meal.

The actual amount of carbohydrate in each food in the meal has been added to the table as shown below.

| Food | Carbohydrate content g / 100 g | **Actual amount of carbohydrate g** | Glycaemic index |
|---|---|---|---|
| Wholemeal bread – 84 g | 47 | **39.5** | 59 |
| Avocado – 50 g | 4 | **2.0** | 10 |
| Omelette – 200 g | 0 | **0** | - |
| Chips – 100 g | 20.1 | **20.1** | 85 |
| Watermelon – 150 g | 4 | **6** | 76 |

Although the 'chips' have the highest glycaemic index it does not have the greatest impact on blood sugar levels in **that** meal because there is almost twice as much carbohydrate available from the wholemeal bread. This, considered in conjunction with the relative glycaemic indices, shows that wholemeal bread has the highest glycaemic load in the meal.

Glycaemic load (GL) of a food stuff can be calculated via

**GL = (GI x amount of carbohydrate) / 100**

**Wholemeal bread** = 59 × 39.5 / 100 = **23**

Avocado = 10 x 2.0 / 100 = 0.20

Chips = 85 × 20.1 / 100 = 17

Watermelon = 76 × 6 / 100 = 4.6

**Q23. C** Use the composition data to determine the empirical formula of the compound

***m*(O)** = *m*(sample) – [*m*(C) + *m*(H)]
= 0.886 – [0.0402×12.0 + 0.0806×1.0]
= 0.886 – [0.483 + 0.0806]
= 0.322 g

*n*(O) = 0.322 / 16.0
= 0.0201 mol

**Mole ratio**

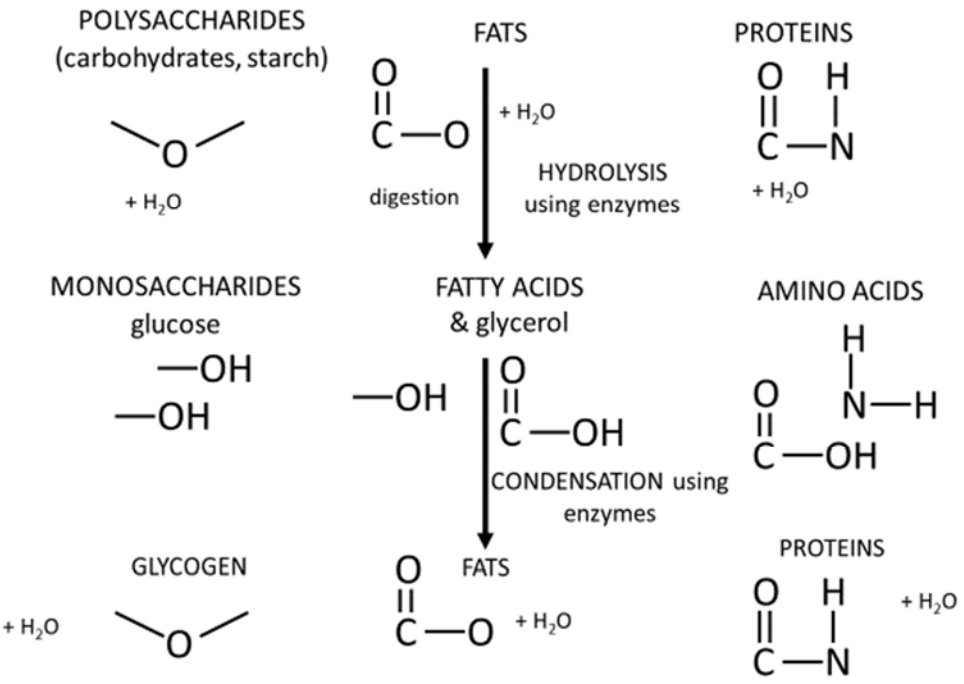
| C | : | H | : | O |
|---|---|---|---|---|
| 0.0402 | : | 0.0806 | : | 0.0201 |
| **2** | **:** | **4** | **:** | **1** |

**Empirical formula $C_2H_4O$**

Molecules of all the alternatives
- butanoic acid ($CH_3CH_2CH_2COOH$),
- methyl propanal [$(CH_3)_2CHCHO$],
- methyl propanoate ($CH_3CH_2COOCH_3$) and
- butan-2-one ($CH_3CH_2COCH_3$)

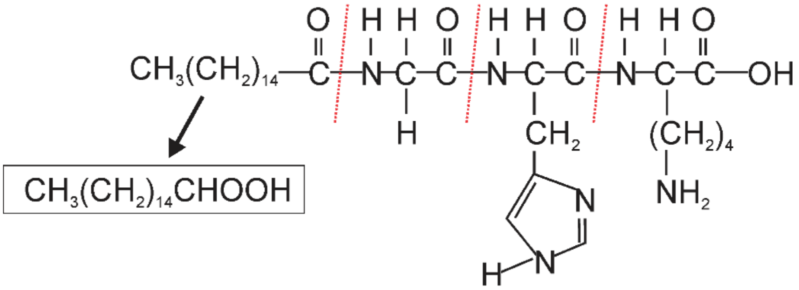
all contain 4 carbon atoms, so the **molecular formula of the compound is $C_4H_8O_2$**
This is consistent with only **butanoic acid** and **methyl propanoate.**
**IR spectrum does not show a peak in the absorption band 2500-3500 $cm^{-1}$ for OH(acid)**. It does show a peak in the absorption band 1720-1840 $cm^{-1}$ for C=O esters. Compound is **methyl propanoate**.

**Q24. B** A more detailed version of the summary diagram showing functional group changes is given below

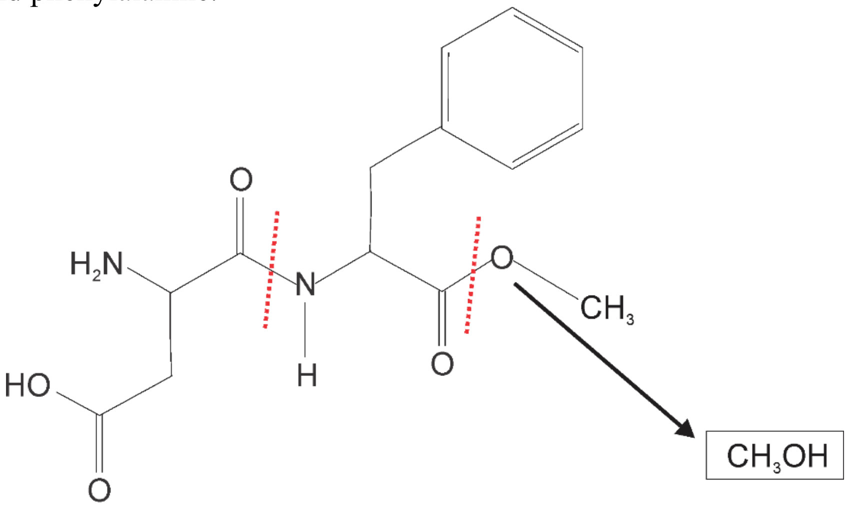


There are total of **six** functional groups involved – hydroxyl, ether(glycoside), ester, carboxyl, amide (peptide) and amino.

**Q25. C** Hydrolysis of **Palmitoyl-GHK** will release **palmitic acid, $CH_3(CH_2)_{14}COOH$** and **three amino acids** – glycine, histidine and lysine - *identified from Table 17 in* ***VCE Chemistry Data Book****.*



Hydrolysis of **Aspartame** will release **methanol, $CH_3OH$**, and **two amino acids** – aspartic acid and phenylalanine.



Under appropriate conditions, **palmitic acid can react with methanol to produce** methyl palmitate – a **biodiesel.**

$$CH_3(CH_2)_{14}COOH + CH_3OH \rightarrow CH_3(CH_2)_{14}COOCH_3 + H_2O$$

In alkaline conditions **palmitoyl-GHK and Aspartame will assume a charge of -1 as both have a single carboxyl group that can be deprotonated**, but no acid side chains on their amino acid side chains.

**Q26. D** The equation for the complete combustion of methane is

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Since 1 mol $CH_4$ reacts with 2 mol $O_2(g)$ to give 1 mol $CO_2(g)$ and 2 mol $H_2O(g)$, then since all volumes are measured at the same temperature and pressure the volume ratio for reaction is the same as the mole ratio in the equation.

So, 120 mL $CH_4$ reacts with 240 mL $O_2$ to give 120 mL $CO_2$ and 240 mL $H_2O$

$CH_4$, $CO_2$ and $H_2O$ are all greenhouse gases.

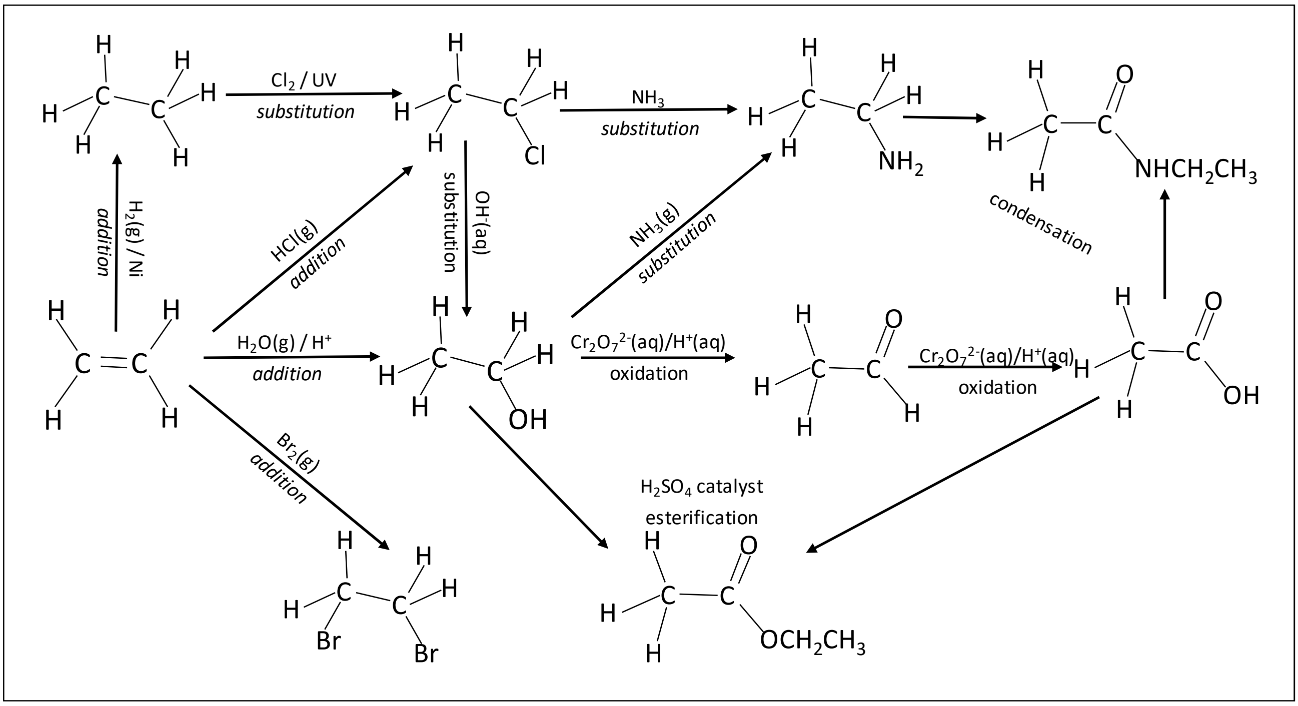
Initial volume greenhouse gases $= V(CH_4)$
$= 120$ mL

Final volume greenhouse gases $= V(CO_2) + V(H_2O)$
$= 120$ mL + 240 mL
$= 360$ mol

Change in volume of greenhouse gases is an **increase of 240 mL**.

**Q27. C** According to Table 11 of the ***VCE Chemistry Data Book***, the heats of combustion of the compounds in M15 are
Methanol 22.7 kJ $g^{-1}$
Octane 47.9 kJ $g^{-1}$
M15 is 15 % methanol and 85 % octane
$V(CH_3OH)$ in 50 L M15 = 0.15 × 50 = 7.5 L
$m(CH_3OH) = d \times V = 792 \text{ g L}^{-1} \times 7.5 \text{ L}$
$= 5940 \text{ g}$
$V(C_8H_{18})$ in 50 L M15 = 0.85 × 50 = 42.5 L
$m(C_8H_{18}) = d \times V = 703 \text{ g L}^{-1} \times 42.5 \text{ L}$
$= 2.99\times10^4 \text{ g}$
Total energy contained $= 5940 \text{ g} \times 22.7 \text{ kJ g}^{-1} + 2.99\times10^4 \text{ g} \times 47.9 \text{ kJ g}^{-1}$
$= 1.35\times10^5 \text{ kJ} + 1.43\times10^6 \text{ kJ}$
$= \mathbf{1.6\times10^6 \text{ kJ}}$

**Q28. B** HBr is not part of the pathway, as indicated in the detailed summary below.



**Q29. C** $Q = It$

$I = 85.6\ \mu A = 85.6 \times 10^{-6}\ A$

$t = 10.0$ years

$= 10.0 \times 365 \times 24 \times 60 \times 60$ seconds

$= 3.15 \times 10^{8}\ s$

$Q = 3.15 \times 10^{8} \times 85.6 \times 10^{-6}$

$= 2.70 \times 10^{4}\ C$

$n(e^-) = Q / F = 2.70 \times 10^{4} / 96500$

$= 0.280$ mol

Oxidation half-equation $Li \rightarrow Li^+ + e^-$

$n(Li) = 0.280$ mol

$m(Li) = 0.280\ mol \times 6.9\ g\ mol^{-1}$

= **1.93 g**

**Q30. B** Species present in an aqueous solution of sodium chloride are $Na^+(aq)$, $Cl^-(aq)$ and $H_2O(l)$. According to the power supply notation**, electrode *A*** is **(-)** and **electrode *B*** *i*s **(+)**.

The products of the electrolysis of NaCl(aq) can be deduced from the electrochemical series

| | |
|---|---|
| $Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ | *1.36 V* |
| $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ | *1.23 V* |
| $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ | *-0.83 V* |
| $Na^+(aq) + e^- \rightarrow Na(s)$ | *-2.71 V* |

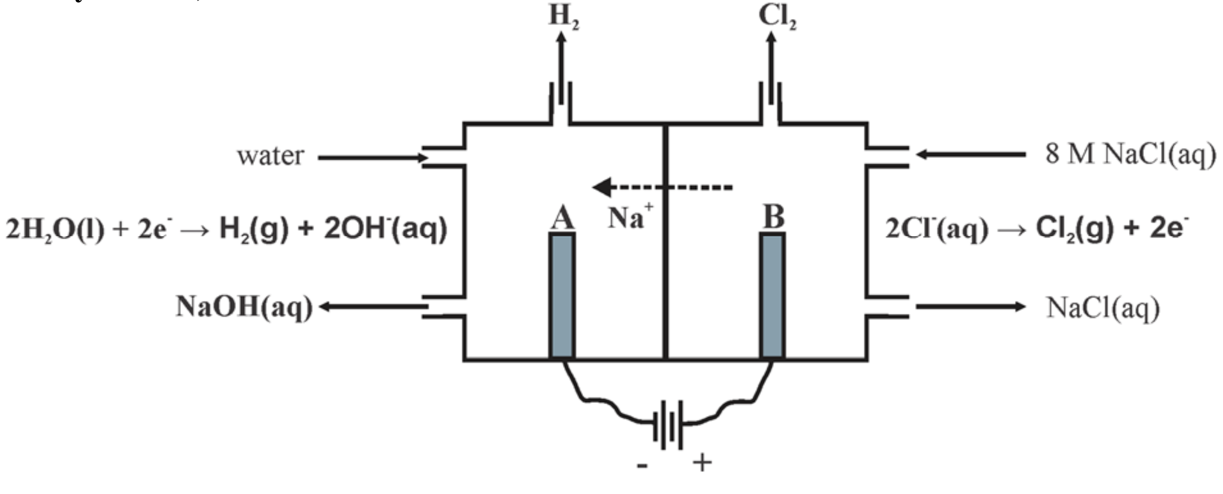
$H_2O(l)$ will be reduced at the cathode, which is the negative electrode in electrolysis. At the anode – the positive electrode - depending on the $c(Cl^-)$, $H_2O(l)$ and/or $Cl^-(aq)$ will be oxidised. Under standard conditions, $O_2(g)$ will be produced, at high $c(Cl^-)$, $Cl_2(g)$ will be produced. This reflects the relative similarities in the reducing strengths of $H_2O(l)$ and $Cl^-(aq)$.

Half-equations for the electrolysis of 8 M NaCl(aq) are

(+) electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(-) electrode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2e^-$

So, the compound extracted from the half of the cell containing the (-) electrode is **sodium hydroxide**, NaOH**.**



## SECTION B – Short Answer (Answers)

**Question 1 (11 marks)**

**a.** Mass of spirit of burner before heating the water & mass of spirit burner after heating water for all four alcohols. ❶
Temperature change of the water in the can. ❶

**b.** Molecular mass / molar mass of the alcohols. ❶
The independent variable is the one varied during the investigation and the different alcohols have different have different molar masses / molecular sizes.

**c.** One of. ❶
Volume (mass) of water being heated.
Distance between burner and water container.
Length of wick extended from burner.
Amount of stirring of water.
Controlled variables are factors which are kept as constant as possible to ensure the best outcome of the relationship between the dependent variable – heat of combustion – and independent variable – molecule size – is produced.

**d.** Energy absorbed by water $= 4.18 \text{ J g}^{-1} \text{ °C}^{-1} \times 200 \text{ g} \times 21.2 \text{ °C}$
$= 1.77\times10^{4} \text{ J}$ ❶
$n(CH_3CH_2CH_2OH) = 0.936 \text{ g} / 60.0 \text{ g mol}^{-1}$
$= 1.56\times10^{-2} \text{ mol}$
Molar heat of combustion $= 1.77\times10^{4} \text{ J} / 1.56\times10^{-2} \text{ mol}$
$= 1.14\times10^{6} \text{ J mol}^{-1}$
$= \mathbf{1.14\times10^{3} \text{ kJ mol}^{-1}}$ ❶

**e.** During the combustion of the alcohols the **total energy released depends on the total number of C-C and C-H bonds which are broken and the total number of C=O and O-H bonds formed**. The **energy released reflects the difference between the energy released when C=O and O-H bonds are formed and the energy used in breaking C-C and C-H bonds.** ❶ The **larger the alcohol molecules, the greater the numbers of C-C and C-H bonds broken and C=O and O-H bonds formed and the larger the amount of energy released in the combustion of one mole of the alcohol.** ❶

**f.** The **equipment set up does not maximise the transfer of energy released by combustion of the alcohol to the water**, hence the calculated energy absorbed by the water is less than the energy released during combustion.
Possible modifications could be
- **putting a lid on the container** to reduce heat loss from the water *or*
- adding a protective shield around the burner to **reduce heat loss to the surroundings**. ❶

**g.** % efficiency = [(calculated heat of combustion) / (actual* heat of combustion)] × 100
= (871 / 1360) × 100
= **64.0** % ❶
(* - from ***VCE Chemistry Data Book***)

**h.** The calorimeter incorporates energy absorbed by the reaction bomb material, the stirrer and thermometer. This is not accounted for in the experimental technique used. ❶

**Question 2 (10 marks)**

**a.** $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ ❶

**b.** The **concentrations of $H_2$ and $I_2$ decrease and the concentration of HI increases until there is no change after 9.0 minutes**. The data also shows that **the rate of the forward reaction decreases with time since the changes in amounts of amount of $H_2$ and $I_2$ reacting, and HI produced, become increasingly smaller**. ❶ This is consistent with the decreasing number of reactant collisions as the $[H_2]$ and $[I_2]$ are decreasing. However**, as the [HI] is increasing, the rate of the reverse reaction is increasing until the point is reached, around 9.0 minutes, when the rates of the forward and reverse reactions are equal and there is no further change in amounts of reactants or product as the system has reached equilibrium.** ❶

**c.** $K = [HI]^2 / [H_2][I_2]$ ❶

$= (n(HI)/V)^2 / \{ (n(H_2)/V) \times (n(I_2)/V)$

$= n(HI)^2 / \{n(H_2) \times n(I_2)\}$

$= 1.56^2 / (0.22 \times 0.22)$

$=$ **50.3** ❶

*There are the same number of particles on both sides of the equilibrium, so*

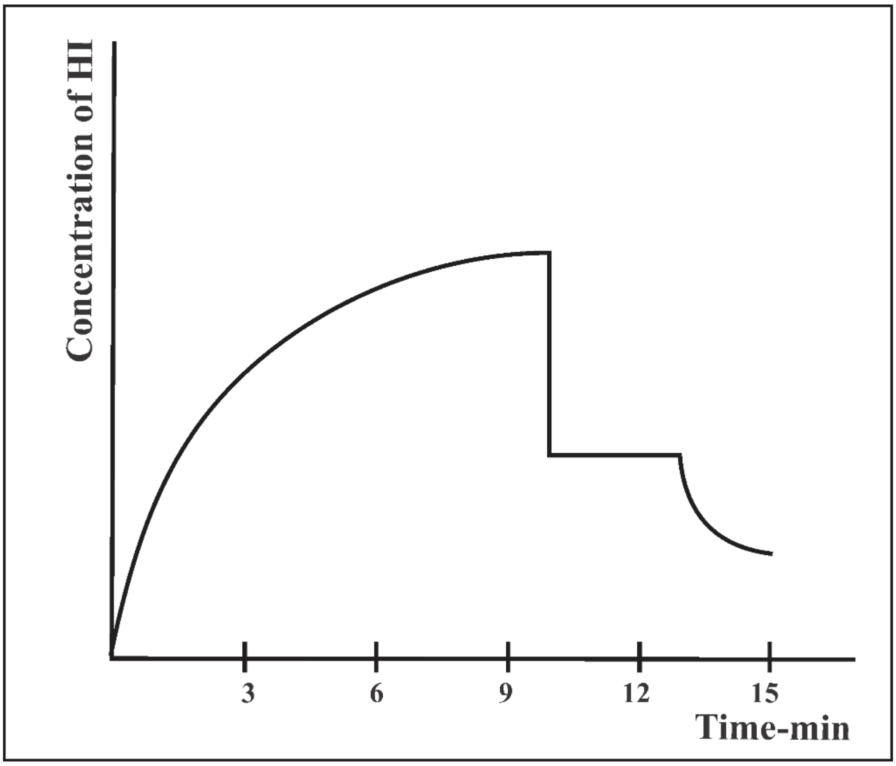
**i.** the actual volume of the container is not needed to calculate $K_c$ since V effectively cancels out.

**ii.** K does not have any units.

**d.** The **volume increase would cause all concentrations to decrease and decrease the total pressure**. However, because there are the **same number of particles on both sides of the equilibrium it cannot shift to compensate for these changes**, hence the **amounts of reactants and products present do not change**. ❶

The **decrease in temperature** would cause the system to compensate by **favouring the exothermic reaction**. According to the data changes following the temperature decrease, this was the **reverse reaction**. ❶

**e.**



The **[HI] starts at zero and increases as the system heads to equilibrium** at the 9 minute mark. The **rate of increase falls as the [$H_2$] and [$I_2$] decrease**. [HI] is constant between 9 and 10 minutes. ➊

At the **10-minute** mark the **[HI] halves due to the volume doubling and remains at that new level up to the 13-minute mark.** ➊

Between **13 minutes and 15 minutes the [HI] decreases as the reverse reaction is favoured by the temperature decrease.** ➊

**Question 3 (5 marks)**

**a.** $2C(s) + O_2(g) \rightarrow 2CO(g)$ *or* $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ ➊

**b.** Exposure to CO can affect the capacity of haemoglobin in the blood to carry $O_2$ to cells in the body.

**Oxygen combines with haemoglobin via an equilibrium** represented by the equation:

**$Hb(aq) + O_2(g) \rightleftharpoons HbO_2(aq)$**. ➊

However, **haemoglobin combines more readily with CO than $O_2$ and so in the presence of CO, a competing equilibrium**, represented by the equation below, is set up.

**$Hb(aq) + CO(g) \rightleftharpoons HbCO(aq)$.** ➊

The **Hb/CO equilibrium has a much higher equilibrium constant than the Hb/$O_2$ equilibrium and so in the presence of CO, $HbO_2$ is forced to release its $O_2$**, according to

**$HbO_2(aq) + CO(g) \rightleftharpoons HbCO(aq) + O_2(g)$.** ➊

Consequently, CO is carried to the cells by haemoglobin rather than the necessary $O_2$.

**c.** Non-fatal CO poisoning is treated by **breathing pure oxygen, which causes the equilibrium**

**$HbO_2(aq) + CO(g) \rightleftharpoons HbCO(aq) + O_2(g)$**

**to shift to the left and the carriage of $O_2$ to the by Hb is enhanced.** ➊

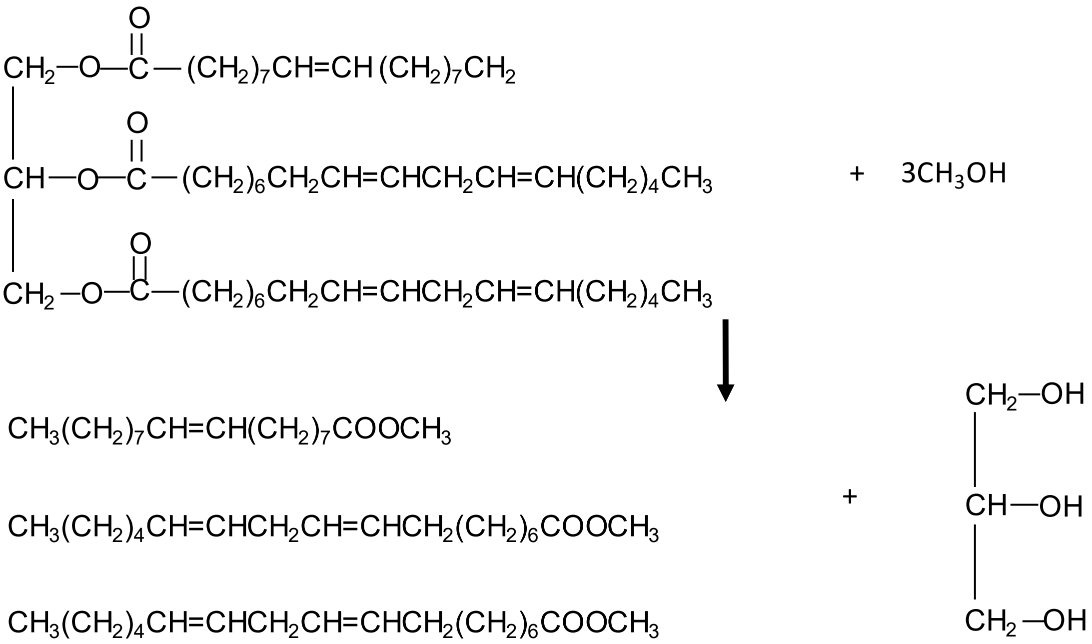
**Question 4 (13 marks)**

**a.** Both **α-linolenic** and **γ-linolenic acids** are polyunsaturated fatty acids with 3 C=C double bonds. The key structural difference is the **location of the 3 C=C double bonds (or the 3 CH=CHCH$_2$ moieties) in the hydrocarbon chain**. The **omega classification** is dependent on **location of the C=C double bond furthest from the carboxyl group.** ❶

**α-linolenic acid** –
$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$ is **Omega-3** (ω-3)

**γ-linolenic acid** –
$CH_3CH_2CH_2CH_2CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH_2CH_2CH_2COOH$ is **Omega-6** (ω-6)

**b.**



❶ for correct fat structure
❶ for correct number of methanol molecules.
❶ for three correct methyl ester formulae.

**c.** **No.** CO$_2$ is produced from the combustion of both the biodiesel and petrodiesel components of the blended fuel used in the flight. However, **the biodiesel produced from mustard seed oil is effectively sourced from plants and the CO$_2$ emissions from its combustion are offset by the CO$_2$ absorbed from the atmosphere during photosynthesis in the growth of the mustard plant**. ❶ However, for **petrodiesel**, a fossil fuel oil, there is **no offset for CO$_2$ emissions during its combustion**. ❶ So, using biodiesel as an alternative to petrodiesel does not result in additional CO$_2$ being added to the atmosphere.

**d.** **i.** The surfactant molecules must have a polar region – to bond with the polar water molecules, and a non-polar region – to bond with the non-polar petrodiesel molecules. ❶

**ii.** **Biodiesel** molecules each have a **polar ester group to which water molecules can bond**. So, the **more biodiesel molecules present the greater the amount of water that can be present**. ❶

**e.** The **production of the biofuel has no effect on land available for food production** and **is produced more cheaply due to lower water costs, and the offset effect of income from the sale of leftover material as animal feed**. ❶

**f.** The CFPP reflects the attraction between fuel molecules. So, the stronger the intermolecular attraction, the higher the CFPP. **B100**, which is pure biodiesel, will have the **higher CFPP** because due to the presence of the **polar ester group** in each molecule it has **stronger intermolecular attraction** than petrodiesel. ❶

**g.** $m$(petrodiesel) = 500 L × 832 g $L^{-1}$
= $4.16 \times 10^5$ g
Energy released from petrodiesel = $4.16 \times 10^5$ g × 45 kJ $g^{-1}$
= $1.87 \times 10^7$ kJ ❶
$m$(B100) = $1.87 \times 10^7$ kJ / 39 kJ $g^{-1}$
= $4.80 \times 10^5$ g
= **0.48 t** ❶

**h.** **Brassidic acid** has the higher melting temperature.
Both acids have the same molecular formula and one carboxyl functional group. So, the **determining factor in the intermolecular attraction is the arrangement around the C=C double bond**. **Erucic acid has a *cis* arrangement and brassidic acid has a *trans* arrangement**. The **kink caused by the *cis* arrangement in erucic acid prevents its molecules packing together as effectively or as strongly as brassidic acid molecules**. ❶

**Question 5 (9 marks)**

**a.** Since the compounds prevent free radical damage they act as **antioxidants**. ❶

**b.** The fuel would be the biodiesel methyl oleate, **$C_{17}H_{33}COOCH_3$**. ❶
Combustion equation.
**$C_{17}H_{33}COOCH_3(l) + 27O_2(g) \rightarrow 19CO_2(g) + 18H_2O(g / l)$** ❶

**c.** Much of the carbohydrate in avocadoes must be cellulose, and other dietary fibre which is not digested due to lack of appropriate enzymes. ❶

**d.** **i.** Ubiquinol contains **two hydroxyl groups** which in ubiquinone has been **converted to two carbonyl groups**.
Ubiquinol in the diet can **act as an antioxidant** as the **(C)-OH is oxidised to C=O.** ❶

**ii.** **Fat soluble due to the long non-polar hydrocarbon tail** which enables significant dispersion force attraction with non-polar fat molecules. ❶

**e.** Many enzymes **are proteins which need some temporary modification of their tertiary structure** to show enzyme action. ❶ **Coenzymes interact with the active site modifying it to enable the substrate to bond to it so that the bond breaking necessary for reaction is activated.** ❶

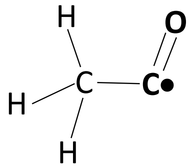
**f.** Enzymes are proteins. For enzyme activity to occur, the **substrate molecule(s) must be able to interact with the active site**. The active site is determined by the **tertiary structure** of the protein. ❶

**Question 6 (12 marks)**

**a.** $CH_3CH_2OH(aq) \rightarrow CH_3CHO(aq) + 2H^+(aq) + 2e^-$ ❶
The oxidation of ethanol involves the loss of hydrogen, consistent with the '*alcohol dehydrogenase*' name of the enzyme. ❶

**b.** NAD+ acts as the **oxidant** ❶ and is reduced – gaining hydrogen - according to
**$NAD^+(aq) + H^+(aq) + e^- \rightarrow NADH(aq)$** ❶

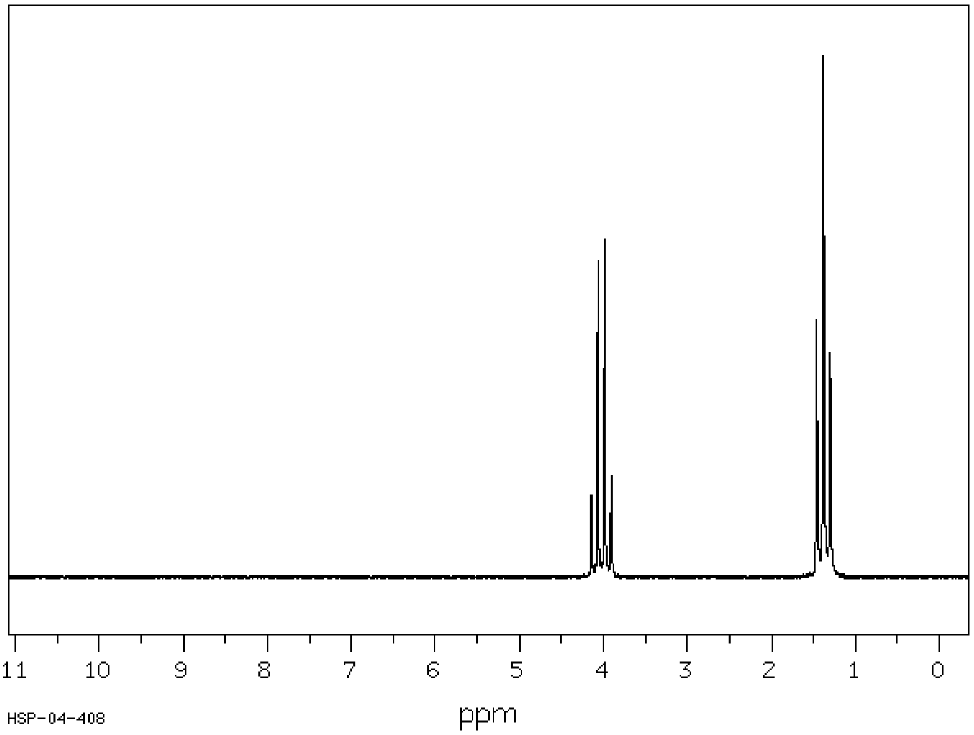
**c.** **$CH_3CO\bullet$**



❶

**d.** **$C_{10}H_{20}N_2S_4$ ….** from $(CH_3CH_2)_2NS_4N(CH_2CH_3)_2$ ❶

**e.** Disulfiram is a symmetrical molecule with four equivalent $CH_3CH_2$- groups.
The $^1H$ NMR spectrum will contain **two sets of signals** split into a **triplet** (H on $CH_3$) ❶and a **quartet** (H on $CH_2$) ❶ according to the n+1 rule.



**f.** $V$(ethanol) in 190 mL glass of wine = (14.5/100) × 190
= 27.6 mL
$m$(ethanol) in 190 mL glass of wine = $V$(ethanol) × $d$(ethanol)
= 27.6 mL × 0.785 g $mL^{-1}$
= 21.6 g ❶
Time to process ethanol in 190 mL glass of wine = 21.6 g / 10.0 g per hour
= **2.16 hours** ❶

**g.** **$C_6H_{12}O_6(aq) \rightarrow CH_3CH_2OH(aq) + 2CO_2(g)$** ❶
**Fermentation is an exothermic reaction** and if the heat produced cannot dissipate the catalyst may become ineffective since **catalyse is an enzyme and enzymes, like all proteins, can denature at high temperatures**, and in the presence of ethanol, **causing the active site** to be less effective. ❶

**Question 7 (11 marks)**

**a.** *m*(CO) produced in gasification = $0.50 \text{ mol} \times 28.0 \text{ g mol}^{-1}$
= 14 g
Energy required = $14 \text{ g} \times 3.1 \text{ kJ g}^{-1}$
= 43.4 kJ ❶
Brown coal - $10 \text{ MJ kg}^{-1} \rightarrow 10\times10^3 \text{ kJ in } 1000 \text{ g} \rightarrow 10 \text{ kJ g}^{-1}$
*m*(brown coal) needed= $43.4 \text{ kJ} / 10 \text{ kJ g}^{-1}$
= **4.4 g** ❶

**b.** Overall equation for the process, obtained by adding together equations 1., 2., and 3. is
**$2C(s) + O_2(g) + 2H_2O(g) \rightarrow 2H_2(g) + 2CO_2(g)$.**
The **$CO_2$ produced** in the process is a **greenhouse gas** which if possible should not be released into atmosphere. ❶
For CCS to be feasible
- a **suitable storage location for this $CO_2$ must be identified** (deep geological formations deep underground).
- since **$CO_2$ would be stored under pressure the location must be remain leakproof** under this pressure.
- the **location must not be subject to natural phenomena which could lead to release of $CO_2$.** ❶

**c.**
1. **Hydrogen is flammable** – must be **stored in an airtight container away from any possible ignition sources.** ❶
2. **Hydrogen is a gas** – must be **stored under pressure in well maintained pressurised containers.** ❶

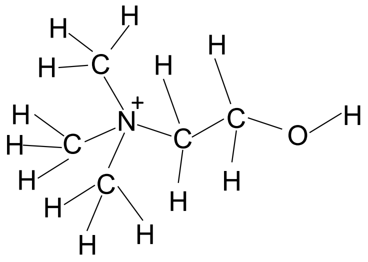
**d.** Negative electrode is the site of oxidation of the fuel, $H_2(g)$, in an alkaline environment.
**$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$** ❶

**e.**
- **i.** Electrolysis requires electrolytic and electronic conduction. **The lack of ions, other than minimal amounts of $H^+(aq)$ and $OH^-(aq)$ in pure water minimises electrolytic conduction.** ❶
- **ii.** Use **electrical energy obtained from solar cells to drive the electrolysis of a dilute aqueous solution of sodium chloride.** ❶
  Cathode reaction: **$2H_2O(l) + 2e^-(aq) \rightarrow H_2(g) + 2OH^-(aq)$** ❶

**f.** In a **coal fired power station, energy is lost at each energy transformation so that only about 30 per cent of the chemical energy is converted to usable electric energy. Fuel cells are far more efficient because the direct conversion of chemical energy to electrical energy occurs in a single step.** ❶

**Question 8 (9 marks)**

**a.** **i.** **$(CH_3)_3N^+CH_2CH_2OH$** ❶

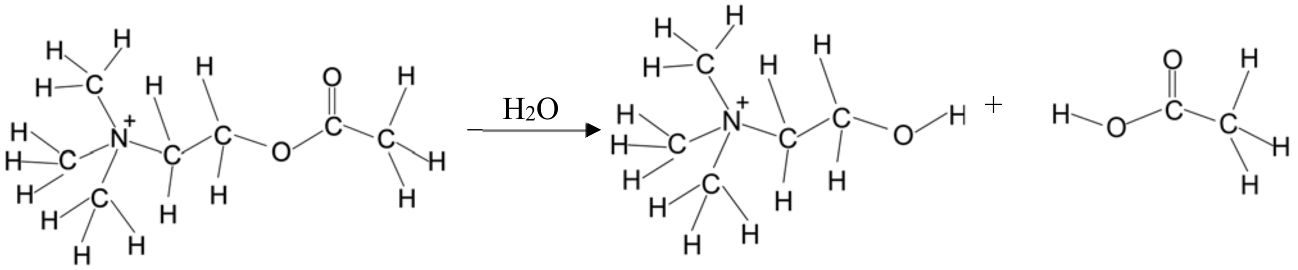


Products of hydrolysis were $(CH_3)_3N^+CH_2CH_2OH$ and $CH_3COOH$, i.e. the ester group in acetylcholine was converted to a hydroxyl and a carboxyl group.

**ii.** **Quaternary** reflects the fact the **nitrogen atom is bonded to four different carbon atoms**, just as in the ammonium ion, the nitrogen atom is bonded to four hydrogen atoms.

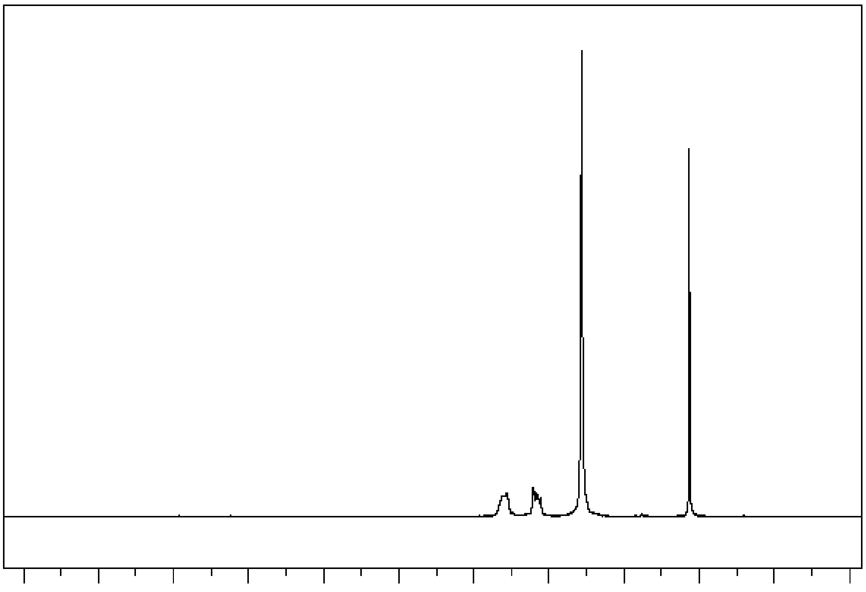
The in-course context was the **quaternary structure** of **proteins.** ❶ The quaternary structure refers to the combination of two or more protein chains linked together and is present in complex proteins such as haemoglobin.

**b.** The hydrolysis of acetylcholine occurs according to the chemical equation.



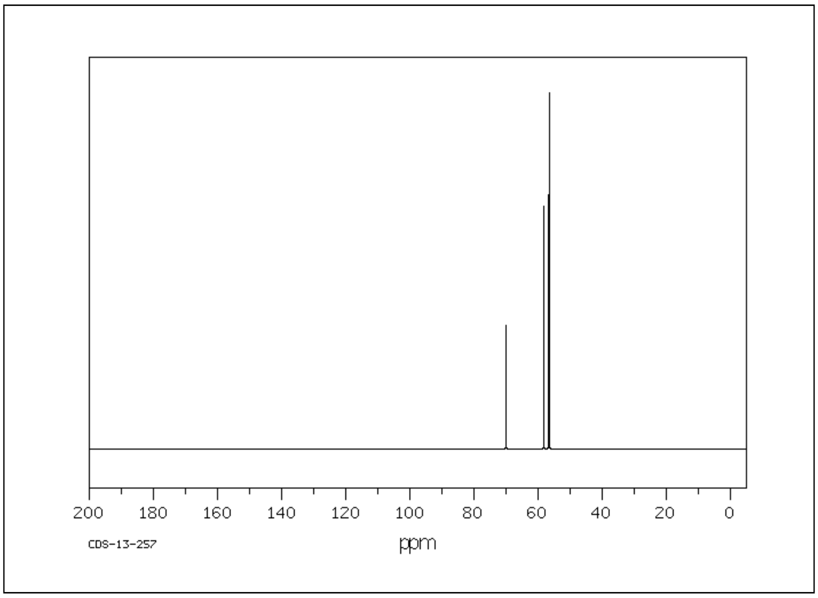
acetylcholine choline ethanoic acid

**i.** **Spectrum 1.**



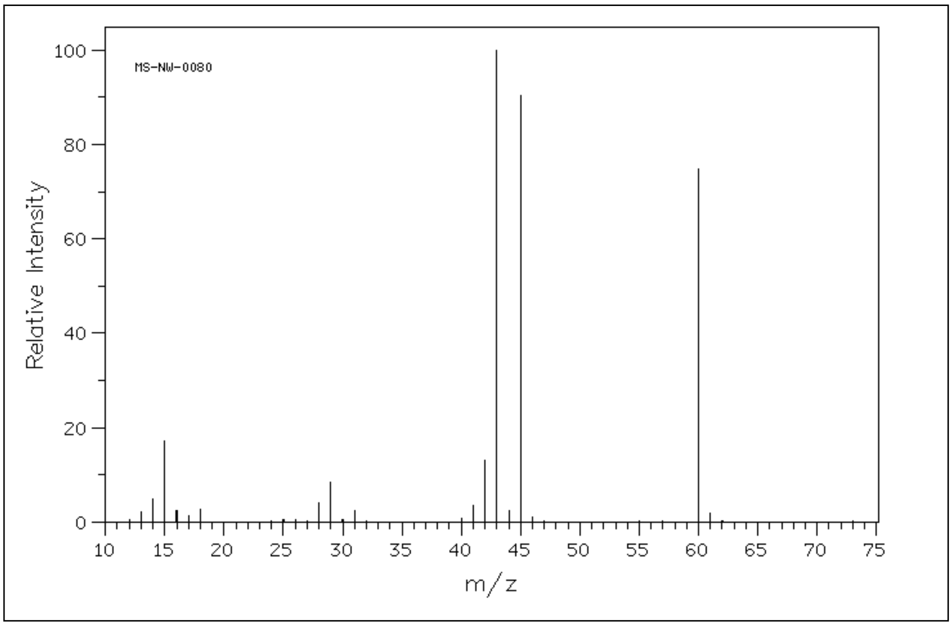
This is the $^{1}H$ **NMR spectrum of acetylcholine** – it is only species with **four different hydrogen environments**. ❶

**Spectrum 2.**



This is the $^{13}C$ **NMR spectrum of choline** – it is only species with **three different carbon environments.** ❶

**Spectrum 3.**



This is the **mass spectrum of ethanoic acid** (acetic acid) – **the parent peak at m/z = 60 corresponds with the molecular mass of $CH_3COOH$.** ❶

**ii.** The peak with relative intensity at m/z = 43 is the **base peak** and is associated with the **most abundant species** resulting from fragmentation in the mass spectrometer.
Species formula – $[CH_3CO]^+$ ❶

**c.** **Compounds in nerve agents binding to serine** in *acetylcholinesterase* would **disrupt** its **tertiary structure** and so **interfere with the active site on the enzyme**. ❶ This would reduce the ability of the enzyme to break down acetylcholine.

**d.** Pralidoxime chloride: $C_7H_9N_2OCl$

$m(C_7H_9N_2OCl)$ required in 20 minutes $= 30 \text{ mg kg}^{-1} \times 82.5 \text{ kg}$

$= 2.5\times10^3 \text{ mg} = 2.5 \text{ g}$

$n(C_7H_9N_2OCl)$ required in 20 minutes $= 2.5 \text{ g} / 172.5 \text{ g mol}^{-1}$

$= 1.4\times10^{-2} \text{ mol}$ ❶

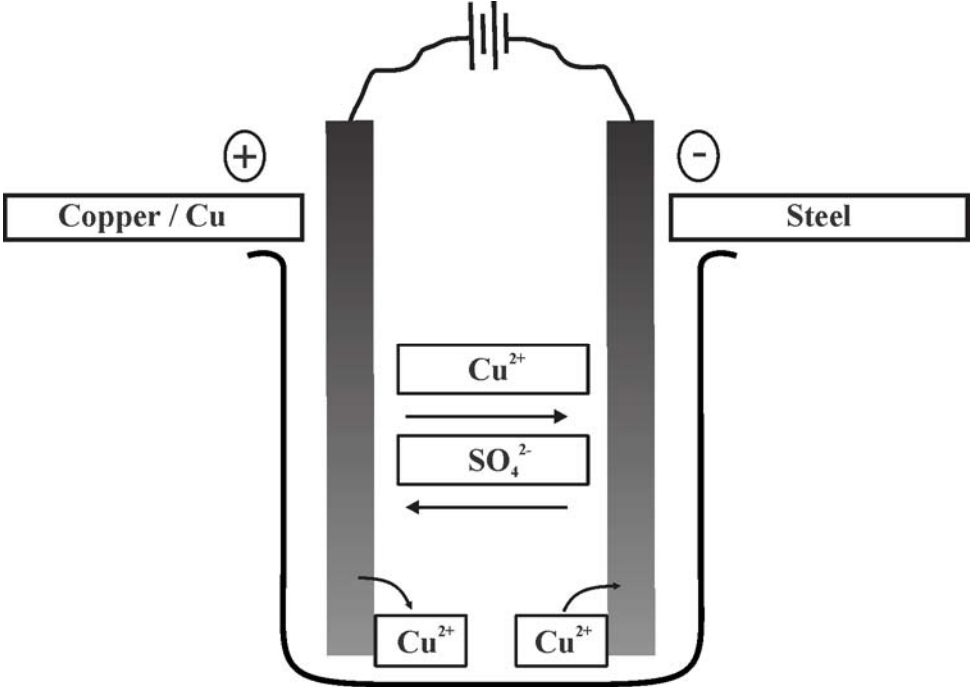
$n(C_7H_9N_2OCl)$ required in 60 minutes $= 1.4\times10^{-2} \text{ mol} \times 3$

$= 4.3\times10^{-2} \text{ mol}$

Rate administered = **$4.3\times10^{-2}$ mol / hour** ❶

**Question 9 (11 marks)**

**a.**



❶ for correct electrode signs.

❶ for correct labelling of electrodes.

❶ for correct species identification in electrolyte.

**b.** Independent variable – **current**.

Dependent variable – **mass of Cu deposited** / change in mass of plate. ❶

**c.** Three from

Electrolyte concentration, electrode surface area, distance between electrodes, voltage, temperature and time. ❶

**d.** % efficiency = [actual m(Cu) deposited / theoretical m(Cu) deposited] × 100

Reduction half-equation = $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

Clarisse: Actual m(Cu) deposited = 0.395 g

$Q = It = 1.45 \times 15 \times 60 = 1.3\times10^3 \text{ C}$

$n(e^-) = Q/F = 1.3\times10^3 / 96500 = 0.014 \text{ mol}$ ❶

Theoretical m(Cu) deposited $= ½ \times 0.014 \times 63.5$

$= 0.43 \text{ g}$ ❶

% efficiency = (actual mass / theoretical mass) × 100

= (0.395 / 0.43) × 100

= 92 % ❶

**e.** Possible reasons.
- Masud did not dry the copper plated electrode prior to weighing. ❶
- Clarisse accidentally removed some of the deposited copper when drying the copper plated electrode.
- Some of the copper deposited on Masud's electrode was oxidised during drying.

**f.** $Cu^{2+}$(aq) is simultaneously produced at the anode and consumed at the cathode. ❶

**g.** In the original analysis, some of copper produced at the steel electrode may not stick to the electrode or may be accidently removed during drying, making the recorded change in the electrode mass lower than the mass of copper oxidised from the anode. Whilst this would be less of an issue if the copper anode was weighed before and after the electrolysis the **results obtained would not be a true experimental outcome.** ❶

**Question 10 (9 marks)**

**a.** During the discharge the strongest oxidant is reacting with the strongest reductant. Since $Ce^{3+}$(aq) is a weaker reductant than Zn(s) then $Ce^{4+}$(aq) must be a stronger oxidant than $Zn^{2+}$(aq).
During discharge Zn(s) is oxidised at the **(-) electrode – Zn**, whilst $Ce^{4+}$(aq) is reduced at the **(+) electrode – graphene oxide – graphite composite.** So **$Zn^{2+}$(aq) is pumped over the (-) electrode** and **$Ce^{4+}$(aq)/$Ce^{3+}$(aq) is pumped over the (+) electrode.** ❶
**(-) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$**
**(+) $Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$** ❶

**b.** **During recharging Zn(s) is deposited on the (-) electrode** due to
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ ❶

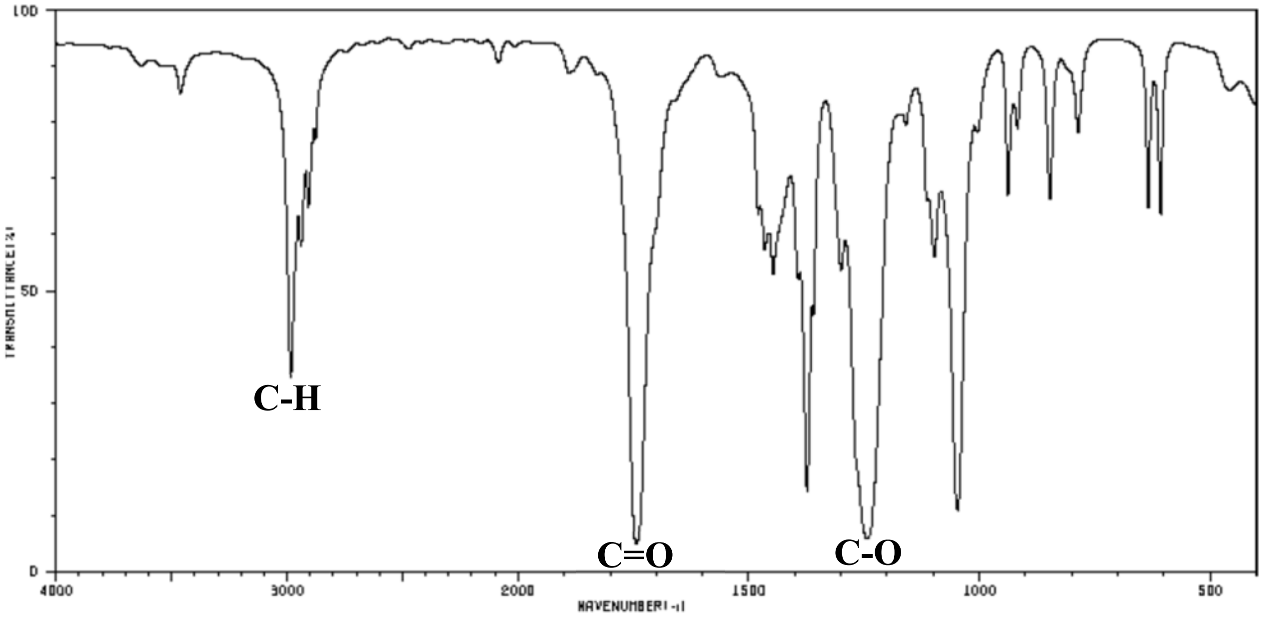
**c.** 2.20 V = $E°$(oxidant half-cell) - $E°$(reductant half-cell) = $E°(Ce^{4+}/Ce^{3+})$ - $E°(Z^{2+}/Zn)$
= $E°(Ce^{4+}/Ce^{3+})$ – (-0.76) – *from* ***Table 2 of the VCE Chemistry Data Book***
= $E°(Ce^{4+}/Ce^{3+})$ + 0.76
$E°(Ce^{4+}/Ce^{3+})$ = 2.20 – 0.76
= **1.44 V** ❶

**d.** In a conventional rechargeable battery all the reactants are within the cell. However, in the **redox flow battery the reactants are stored outside the outside and pumped in as required as happens in fuel cells**. However, **electrical recharging is not characteristic of fuel cells**. ❶

**e.** **i.** General reaction pathway from $CH_3CH_2Cl$ with no other organic compounds involved is
**$CH_3CH_2Cl \rightarrow CH_3CH_2OH \rightarrow CH_3CHO \rightarrow CH_3COOH \rightarrow CH_3COOCH_2CH_3$**
The **mass spectru**m shows **parent ion peak at *m*/*z* = 88.0** and **base peak at *m*/*z* = 43.0.** ❶
The **$^1$H NMR spectrum** shows **three hydrogen environments** with a **quartet, singlet, triplet** splitting pattern.
This data is consistent with the ester **ethyl ethanoate $CH_3COOCH_2CH_3$** ❶
**$M_r$ ($CH_3COOCH_2CH_3$) = 88.0**
- ***m*/*z* =43.0** is consistent with **$CH_3CO^+$ fragment**
- **three different hydrogen environments**
- **quartet, triplet** is consistent with **$-CH_2CH_3$** ❶

Also, signal at $\delta$ = 2.0 ppm is consistent with C**H**$_3$COOR,
signal at $\delta$ = 4.0 ppm is consistent with RCOOC**H**$_2$R.

**ii.** Use ***Table 14 in the VCE Chemistry Data Book*** to identify peaks for C-H, C-O and C=O(esters) bonds.



❶ for all 3 correct

## End of Suggested Answers