NAME: _____

VCE® Chemistry

UNITS 3 & 4 Practice Written Examination

Reading time: 15 minutes
Writing time: 2.5 hours

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of Questions*	*Number of questions to be answered*	*Number of marks*
A	**30**	**30**	**30**
B	**10**	**10**	**90**
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- One scientific calculator is allowed in this examination.

Materials supplied

- Question and Answer Book of 29 pages.
- The VCAA Chemistry Databook will be provided.

Instructions

- Write your **student name** in the space provided above on this page.
- All written responses must be in English.
- Place the Answer Sheet for Multiple-Choice Questions inside the front cover of this book.
- Hand in your examination Question and Answer Booklet to your teacher.
- You may keep the Data Book.

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

SECTION A Multiple-Choice Questions

Instructions for Section A
Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

Which option below best describes a class of renewable fuels?

- **A.** Octane extracted from crude oil
- **B.** Methane extracted from coal seam gas
- **C.** Electricity generated from a coal power plant
- **D.** Ethanol produced from the fermentation of corn starch

Question 2

The number of carbon and hydrogen environments respectively, that would be produced by the compound pentan-3-ol is

- **A.** 2 and 3
- **B.** 3 and 4
- **C.** 3 and 2
- **D.** 3 and 3

Question 3

When magnesium metal is added to a solution of nitric acid, hydrogen gas is formed. Which set of reaction conditions would produce hydrogen at the fastest rate?

- **A.** A strip of magnesium metal and a 2.0 M solution of HCl at 25°C
- **B.** Powdered magnesium metal and a 1.0 M solution of HCl at 25°C
- **C.** Powdered magnesium metal and a 2.0 M solution of HCl at 25°C
- **D.** A strip of magnesium metal and a 1.0 M solution of HCl at 25°C

Question 4

An equilibrium reaction involving nitrogen dioxide and dinitrogen tetraoxide is represented below:

$$N_2O_4 \rightleftharpoons 2NO_2(g)$$

This reaction is endothermic.

What conditions below would produce the greatest yield of NO_2?

A. Low Temperature and Low Pressure

B. High Temperature and Low Pressure

C. Low Temperature and High Pressure

D. High Temperature and High Pressure

Question 5

The net cell reaction when a car battery is recharging is shown below:

$$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq)$$

When the cell is discharging, the half equation occurring at the anode is

A. $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$

B. $PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

C. $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$

D. $PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^-$

Question 6

The systematic name of the compound $CH_3CHOHCH_2CH_2Cl$ is

A. 1-chlorobutan-3-ol

B. 1-chloro-3-hydroxybutanol

C. 4-chlorobutan-2-ol

D. chlorobutanol

Question 7

The best description for a dependent variable is

A. a variable that is selected.

B. a variable that is manipulated.

C. a variable that is measured.

D. a variable that is affected by the independent variable.

Question 8

Which of the following statements about renewable fuels is **correct**?

A. Ethanol is a renewable fuel that does not produce any carbon dioxide.

B. Methane is a renewable fuel.

C. Renewable fuels are generally replenished at a sustainable rate.

D. Renewable fuels do not have any impact on the environment.

Question 9

The amount of energy released by the combustion of 10.0 kg of fuel, in a mixture of 85% octane and 15% ethanol by mass is

A. 453 MJ

B. 48550 MJ

C. 45.3 MJ

D. 407 MJ

Question 10

What statement below best describes what happens when a catalyst is added to a chemical reaction?

A. The yield of the products will increase.

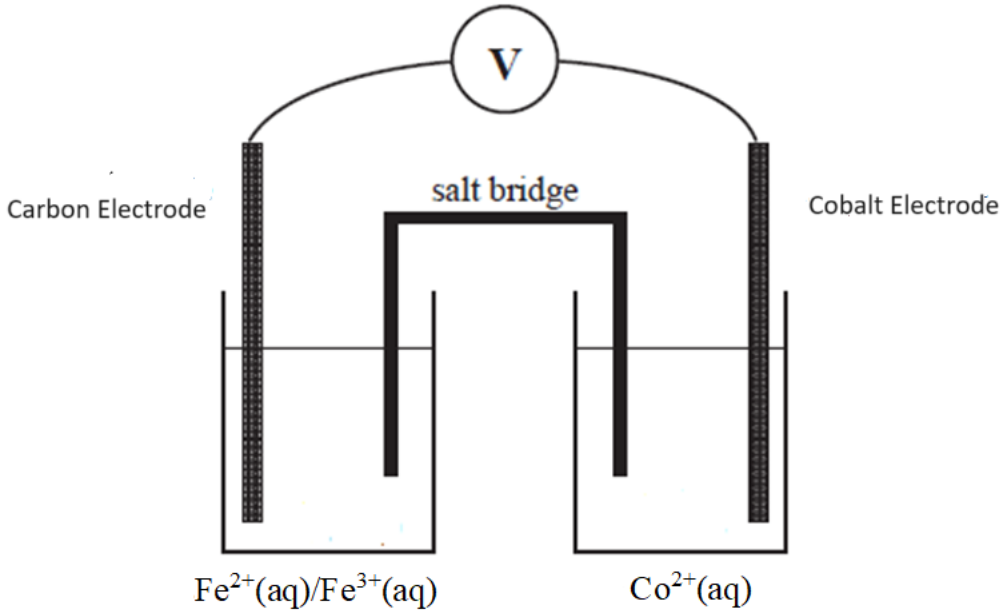
B. The activation energy is lowered.

C. The number of collisions per unit time will increase.

D. The enthalpy change of the forward reaction is reduced.

Use the following information to answer Questions 11-13.

A galvanic cell is set up under standard conditions. As the cell operated, it was observed that the cobalt electrode increased in size. The cell is shown below:



Question 11

The correct cell voltage when this cell operates under standard conditions is

A. 1.05 V

B. 0.49 V

C. 0.59 V

D. 1.50 V

Question 12

The correct half equation that occurs at the cathode in this cell is

A. $Co^{2+}(aq) + 2e^- \rightarrow Co(s)$

B. $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$

C. $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

D. $Co(s) \rightarrow Co^{2+}(aq) + 2e^-$

Question 13

The best explanation for why a carbon electrode, and not a zinc electrode, is used in the Fe^{2+}/Fe^{3+} half-cell is

A. carbon in the form of graphite provides electrons to the circuit.

B. a zinc electrode would be oxidised.

C. carbon acts as a catalyst in this cell.

D. in galvanic cells, only carbon can be used as an inert electrode.

Question 14

Validity is best defined as

A. testing a variable as stated in your experimental aim.

B. the ability to minimise experimental errors.

C. obtaining an experimental value close to the true value.

D. achieving results that are very close in value.

Question 15

In HPLC, the component that exits the column last is

A. most attracted to the mobile phase and has the shortest retention time.

B. least attracted to the mobile phase and has the shortest retention time.

C. most attracted to the stationary phase and has the longest retention time.

D. least attracted to the stationary phase and has the longest retention time.

Question 16

The semi-structural formula of glycine is a basic solution is

A. H_2NCH_2COOH

B. $H_3N^+CH_2COO^-$

C. $H_2NCH_2COO^-$

D. $H_3N^+CH_2COOH$

Question 17

Which of the following molecules would have the highest boiling point?

A. butane

B. butanoic acid

C. butan-1-ol

D. butan-2-ol

Use the following information to answer Questions 18-19.

The following equation shows the production of sulfur trioxide.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K = 86\ M^{-1}\ at\ 1000K$

Question 18

If a small amount of $O_2(g)$ was added to the system at equilibrium, the value of K and the concentration of sulphur dioxide gas would respectively

A. remain the same and decrease.

B. increase and decrease.

C. increase and remain the same.

D. both remain the same.

Question 19

The concentration of SO_3 gas at 1000K given $[SO_2] = 0.035M$ and $[O_2] = 0.520M$ is

A. 1.251 M

B. 0.234 M

C. 0.0545 M

D. 0.0116 M

Question 20

The mass of iron from an Fe^{2+} solution that could be deposited on a platinum electrode if a current of 4.0A was applied for 45 minutes, is closest to

A. 0.052 g

B. 0.104 g

C. 6.24 g

D. 3.13 g

Question 21

The oxidation number of the manganese atom in the compound $NaMnO_4$ is

A. +2

B. +7

C. -1

D. +6

Question 22

The volume, in L, of nitrogen gas N_2 present when 15.2g is placed in a sealed container at standard laboratory conditions, is closest to

A. 13.46

B. 189.0

C. 6.731 L

D. 27.02

Question 23

The correct number of structural isomers for C_5H_{12} is

A. 2

B. 3

C. 4

D. 5

Question 24

What class of organic compound is formed when butan-2-ol is oxidised using acidified dichromate solution?

A. Carboxylic acid

B. Aldehyde

C. Ketone

D. Ester

Question 25

Which compound listed below contains a chiral carbon?

A. 2-methylpropan-1-ol

B. 2-methylpropan-2-ol

C. butan-1-ol

D. butan-2-ol

Question 26

When a triglyceride undergoes a hydrolytic reaction during digestion, the products of this are likely to be

A. water and glycerol.

B. glycerol and three fatty acids.

C. water and three fatty acids.

D. glycerol and methanol.

Question 27

Methanol can be used in a fuel cell using KOH in the electrolyte. Which of the following statements below is correct?

A. Methanol is reduced at the cathode and hydroxide ions are produced at the cathode.

B. Methanol is oxidised at the anode and hydroxide ions are produced at the anode.

C. Methanol is oxidised at the anode and hydroxide ions are consumed at the anode.

D. Methanol is reduced at the cathode and hydroxide ions are consumed at the cathode.

Question 28

Consider the following equilibrium reaction to produce hydrogen gas.

$$CO(g) + H_2O(l) \rightleftharpoons CO_2(g) + H_2(g) \quad \Delta H = -41\ kj\ mol^{-1}$$

If all other conditions are kept constant, which statement best describes what happens to both the rate and the yield if the pressure is increased?

A. The rate will increase, and the yield of hydrogen gas will also increase.

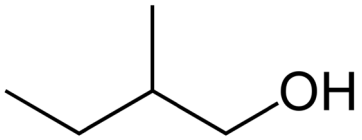
B. The rate will increase, and the yield of hydrogen gas will not change.

C. The rate will decrease, and the yield of hydrogen gas will not change.

D. The rate will decrease, and the yield of hydrogen gas will also decrease.

Question 29

The molar mass of the compound below is closest to



A. 88 g mol^{-1}

B. 64 g mol^{-1}

C. 87 g mol^{-1}

D. 74 g mol^{-1}

Question 30

A student was conducting an experiment where they needed to weigh out an accurate amount of sodium carbonate. Which of the following responses best describes a systematic error that could occur?

A. Some of the sodium carbonate powder spilled when transferring it into a beaker.

B. Sodium hydroxide powder was accidentally weighed instead of sodium carbonate.

C. The weight balance consistently gave a value that was 0.020g lower than the correct value.

D. The student wrote down 1.71g instead of 1.77g as shown on the display.

END OF SECTION A

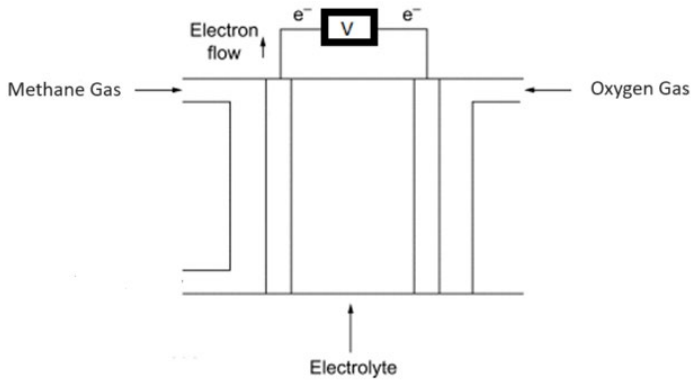
SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Write using a black or blue pen.
To obtain full marks for your responses you should:
- give simplified answers with an appropriate number of significant figures, to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.
- Ensure chemical equations are balanced and that formulas for individual substances include an indication of state, for example, $H_2(g)$; $NaCl(s)$.

Question 1 (10 marks)

Methane can be used in fuel cells to produce electrical energy directly, without the need to undergo direct combustion. Below is a diagram of a methane fuel cell. In this particular fuel cell, the electrolyte contains nitric acid $HNO_3(aq)$ and carbon dioxide is produced.



a. Explain the purpose of the nitric acid in the electrolyte. 1 mark

b. Identify the polarity of the electrode on the right side of the diagram on the previous page. 1 mark

c. Write the half equation for the cathode reaction. 1 mark

d. Write the half equation for the anode reaction. 1 mark

e. Hence, write the overall equation for this fuel cell. 1 mark

f. State **one** method of producing methane so it is considered a renewable fuel. Explain why this way of producing methane would be considered renewable. 2 marks

g. In another type of fuel cell known as a solid oxide fuel cell, oxygen will undergo the following half equation.

$$O_2 + 4e^- \rightarrow 2O^{2-}$$

Calculate the mass of oxygen gas that would be consumed in the above fuel cell if it produced a current of 4.0A for a total of 5.5 hours.

3 marks

Question 2 (12 marks)

The Haber Process is an industrial process to produce ammonia gas. Consider the following equation for the production of ammonia gas.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -ve$$

a. Is this reaction exothermic or endothermic? Explain the importance of knowing whether a reaction is endothermic or exothermic, with reference to the yield of the products. 2 marks

In a particular scenario, equilibrium was quickly achieved at 600K.

b. A mixture of 4.00 mol of $H_2(g)$ and 2.00 mol of $N_2(g)$ was placed in a 4.00 L evacuated, sealed vessel, and kept at 600 K until equilibrium was reached. At equilibrium, the vessel was found to contain 2.00 mol of $NH_3(g)$.

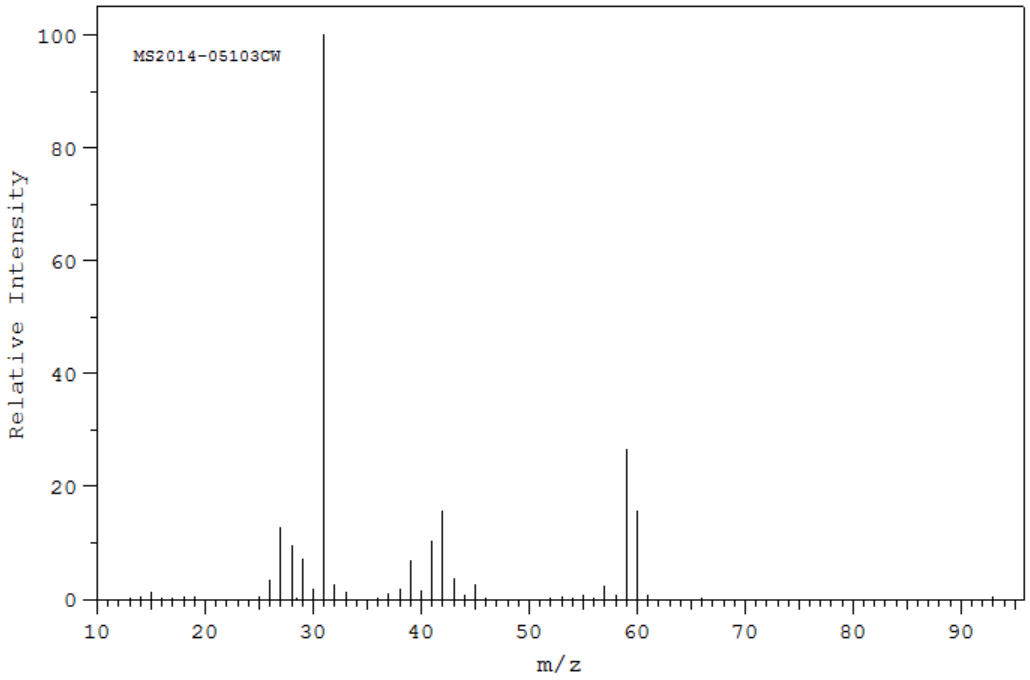
Calculate the equilibrium constant at 600 K. 4 marks

c. What changes should a manufacturer make to both the temperature and pressure to increase the product yield of the equation on the previous page? Explain your answer. 4 marks

d. In the original process no catalyst was used. Describe the effect of adding a catalyst to the rate of reaction and product yield for the Haber process. 2 marks

Question 3 (9 marks)

A substance with a known empirical formula of C_3H_8O underwent chemical analysis using mass spectrometry. Below is the mass spectrum of this analysis.



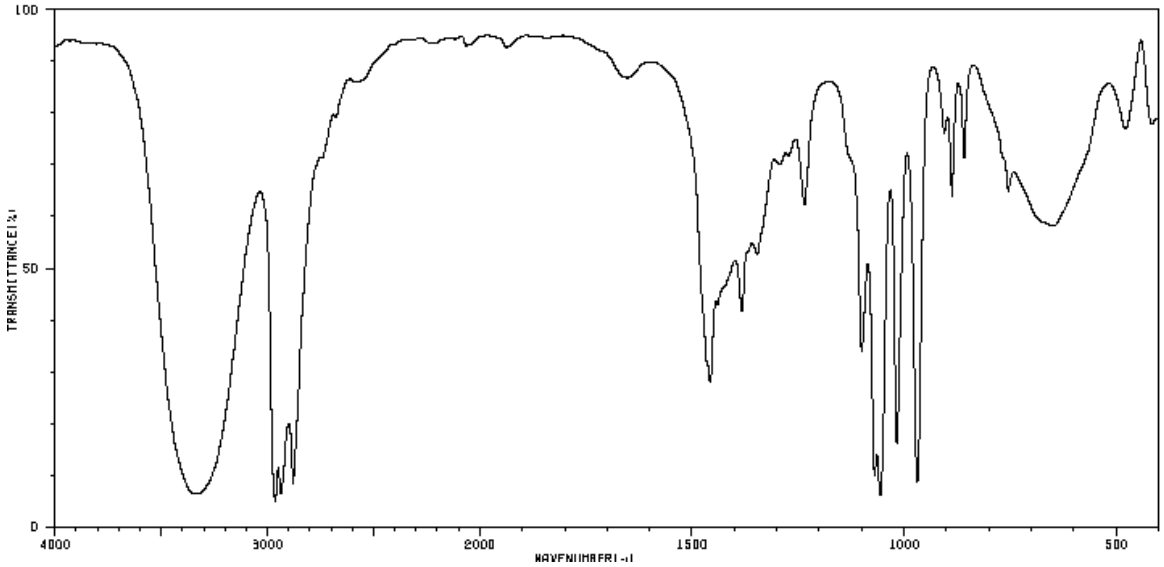
Data: SDBS Web, <http://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

a. Identify the molecular formula of this compound. Justify your answer using the spectrum above. 2 marks

b. Explain why there is a small peak with an m/z value of 61. 1 mark

Further analysis was undertaken to try and determine the structural formula and hence the name of this compound.

An I-R Spectrum was produced as shown below.



Data: SDBS Web, <http://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

c. Identify the functional group responsible for the absorption band in the range 3300-3400cm^{-1}. 1 mark

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d. Using the information provided in both the mass spectrum and infrared spectrum, draw **two** possible structures for this compound. 2 marks

To determine the actual compound, both carbon-NMR and hydrogen-NMR were undertaken.
The results are shown in the table below.

Type of analysis	Number of environments
13-C NMR	2
1-H NMR	3

e. State the name of the compound. Justify your answer by referencing the results of the table above. 3 marks

Question 4 (10 marks)

The Vitamin C content of fruit juice can be determined via a redox titration with iodine. Starch is used as an indicator as it will turn blue in the presence of I^-(aq).

Below is the chemical equation for the redox titration.

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

a. Explain why the above equation represents a redox equation by using the oxidation numbers of iodine. 2 marks

b. Hence, write the reduction half equation. (States not required). 1 mark

In a particular experiment, a few drops of starch were added to a 250mL sample of fruit juice. The student then added 0.0150M iodine solution until the end point was reached. It took 43.40mL of iodine solution for this to occur.

c. Calculate the number of moles of iodine that were added to the fruit juice. 2 marks

d. Hence, find the number of moles of Vitamin C that are present in the fruit juice. 1 mark

e. Calculate the mass of Vitamin C present. 2 marks

f. Hence, determine the %(m/v) of Vitamin C in the fruit juice. 2 marks

Question 5 (10 marks)

A solution of nickel (II) nitrate underwent electrolysis at standard laboratory conditions. Inert carbon electrodes were used. A solid deposit of nickel was formed on one of the electrodes.

a. State the polarity of the electrode where the deposit of metal formed. 1 mark

b. Write the half equation for the reaction occurring at the cathode. 1 mark

c. Write the half equation for the reaction occurring at the anode. 1 mark

The solution was electrolysed for 10.0 minutes. A current of 2.5A was used.

d. Calculate the amount of electric charge that flowed through the circuit. 1 mark

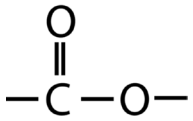
e. Hence, calculate the number of moles of electrons. 1 mark

f. What mass of nickel was therefore deposited on an electrode? 2 marks

g. The carbon anode was replaced with iron metal. What effect, if any, would this have on the products of electrolysis for this circuit? 3 marks

Question 6 (10 marks)

Esters are a class of organic molecules that contain the ester functional group as shown below:



To produce an ester, a carboxylic acid and a primary alcohol can be reacted in the presence of concentrated sulphuric acid.

a. Write the complete balanced equation for the reaction between propan-1-ol and ethanoic acid that will produce an ester. 2 marks

b. Hence, state the name of the ester produced. 1 mark

The two reactants above can be produced via a range of organic pathways. Ethanoic acid can be produced from ethanol by using suitable reagents.

c. Identify possible reagents that could be used to convert ethanol to ethanoic acid. 1 mark

d. Hence, write down the oxidation half equation showing this conversion. 1 mark

Propan-1-ol can be produced via a two-step process that starts with an alkane.

e. State the name of this alkane. 1 mark

f. Write the **two** chemical equations that show how the above alkane is converted into propan-1-ol. 2 marks

Step 1:

Step 2:

A separate organic pathway involves the production of butan-1-amine from 1-chlorobutane as shown below:

$$CH_3CH_2CH_2CH_2Cl + NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + HCl$$

g. Calculate the percentage atom economy to produce butan-1-amine using this reaction pathway. 2 marks

Question 7 (9 marks)

Students in a VCE Chemistry class were asked to determine the molar heat of combustion of ethanol by carrying out an experiment, where 0.450g of ethanol was ignited to produce a combustion reaction. The energy released from this reaction was then used to heat 200g of water. The temperature of the water increased from 23.0°C to 27.0°C.

a. Write a balanced chemical equation for the complete combustion of ethanol. 2 marks

b. Calculate the energy absorbed by the 200g of water in kilojoules. 2 marks

c. Due to the experimental design, a significant proportion of the energy was lost to the environment. If the molar heat of enthalpy for ethanol is 1370 kJ mol^{-1}, calculate the percentage of energy that did not go towards heating the water. 3 marks

Ethanol can be classed as a biofuel if it is produced renewably using sugar cane.

d. Write a balanced chemical equation for the fermentation of sugar. 2 marks

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Question 8 (8 marks)

Enzymes are proteins that have the function of being a biological catalyst. A section of the structure of a particular biological catalyst is represented below:

-Gly-Ala-Ser-

a. Draw the structure of this chain of amino acids. 3 marks

One model to describe the action of enzymes is the lock and key model.

b. Explain how an enzyme will catalyse a reaction using the above model. 3 marks

The enzyme pepsin operates in the acidic environment of the stomach.

c. Describe how the effectiveness of this enzyme would be affected if the environment became basic. 2 marks

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Question 9 (7 marks)

A group of Year 12 students decided to investigate Faraday's 1st Law, with respect to the mass of metal deposited at the cathode during the discharge of an electrochemical cell.

They designed a galvanic cell using a Ni^{2+}/Ni half-cell and Zn^{2+}/Zn half-cell in aqueous solution.

The volume of solution used in each half cell was 100 mL and each electrode was the same size.

The half-cell containing the nickel electrode was the cathode.

Below is a table of their results for five trials.

Time	Increase in mass of cathode
1000s	0.304g
2000s	0.608g
3000s	0.850g
4000s	1.22g
5000s	1.52g

a. According to the results table, state the independent variable. 1 mark

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b. Identify a controlled variable. 1 mark

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c. The increase in mass of the electrode for the time value of 3000s is not the value that was expected. State whether it is higher or lower than expected and explain a possible experimental reason why this may have occurred. 2 marks

d. The group of students decided to repeat this experiment with the Ni^{2+}/Ni half-cell to be replaced by a Co^{2+}/Co half-cell. However, during the preparation of this half-cell, a significant amount of Cu^{2+} ions was mixed into the Co^{2+} solution. Briefly describe what effect this would have on the students' result. 3 marks

Question 10 (5 marks)

a. Green hydrogen is a term currently being used to describe hydrogen that can be produced without a net contribution to greenhouse gases. Briefly outline a method that could be used to produce hydrogen in this manner. 3 marks

b. Hydrogen has a high energy content by mass but not by volume. Describe **one** method for the effective storage of hydrogen. 2 marks

END OF SECTION B

END OF EXAMINATION