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Year 12 *Trial Exam Paper*

2017

CHEMISTRY

Written examination

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

STUDENT NAME:

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	11	11	90
			Total 120

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white-out liquid/tape into the examination.

Materials provided

- The question and answer book of 35 pages
- An answer sheet for multiple-choice questions
- A data book

Instructions

- Remove the data book from this book during reading time.
- Write your **name** in the box provided.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- You must answer the questions in English.

At the end of the examination

- Place the multiple-choice answer sheet inside the front cover of this question and answer book.
- You may keep the data book

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

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

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

Question 1

Which fuel is the most sustainable?

A. natural gas obtained from fracking of coal

B. ethanol obtained from ethane in natural gas

C. bioethanol produced from sugar cane

D. biodiesel produced from whale blubber

Use the following information to answer Questions 2–4.

Butane is a significant component of LPG. The equation for the complete combustion of butane is

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

Question 2

The energy, in kJ, released from the combustion of 1.00 g of butane will be

A. 49.7

B. 58.0

C. 2880

D. 49 700

Question 3

The mass, in g, of O_2 gas required for the complete combustion of 1.16 g of butane will be

A. 2.08

B. 4.16

C. 8.32

D. 16.0

Question 4

The volume, in L, of CO_2 gas produced from the complete combustion of 1.16 g of butane at 850 °C and 500 kPa will be

A. 0.0037

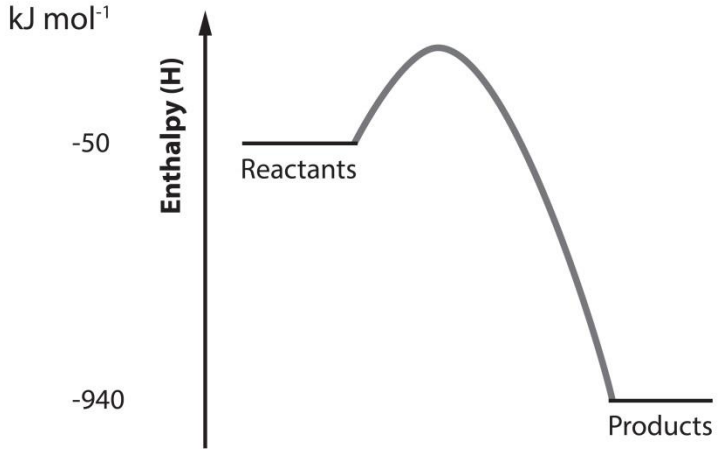
B. 0.149

C. 0.373

D. 1.49

Question 5

Consider the energy profile diagram below to answer this question. The enthalpies of the reactants and the products are shown on the vertical axis.



Which fuel has this energy profile diagram when it undergoes complete combustion?

A. hydrogen

B. methane

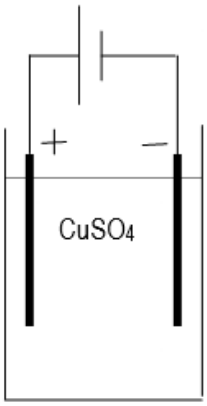
C. methanol

D. ethanol

Use the following information to answer Questions 6 and 7.

Electrolysis is conducted on a dilute solution of copper(II) sulfate, $CuSO_4$.

Copper electrodes are used. They are weighed before the circuit is switched on and after it is switched off.



Question 6

The reaction occurring at the anode is

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

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

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

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

Question 7

While the circuit is closed and electrolysis is occurring, the

A. concentration of Cu^{2+} ions in solution will increase due to the anode reaction.

B. concentration of SO_4^{2-} ions in solution will drop as Cu^{2+} ions deposit on the cathode.

C. concentration of the $CuSO_4$ solution will be unchanged.

D. concentration of Cu^{2+} ions in solution will decrease due to the cathode reaction.

Question 8

Methane can be used as a reactant in a fuel cell. If the cell is operating in acidic conditions, the reaction occurring at the anode will be

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

B. $CH_4(g) + 2O^{2-}(aq) \rightarrow CO_2(g) + 2H_2O(g) + 4e^-$

C. $CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$

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

Question 9

The equation for the redox reaction between manganese dioxide and hydrochloric acid is

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

The reduction half-equation occurring is

A. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

B. $4H^+(aq) + 4e^- \rightarrow 2H_2(g)$

C. $MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + 2Cl_2(g)$

D. $MnO_2(s) + 4H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$

Question 10

A description of a new cell is given below.

'This cell features a continuous supply of fuel and air. It is very expensive but offers a high efficiency and potentially sustainable fuel.'

The cell reactants are most likely to be

A. PbO_2 and Pb.

B. aluminium and oxygen.

C. methane and oxygen.

D. butane and oxygen.

Use the following information to answer Questions 11 and 12.

The equation for the decomposition of hydrogen peroxide is

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

This is a relatively slow reaction that can be catalysed by the addition of manganese dioxide or by the addition of pieces of liver from animals. There is an enzyme in liver that catalyses the reaction.

Question 11

A 1.0 M solution of hydrogen peroxide is prepared for testing with the two catalysts. Which alternative will lead to one of the catalysts being very **ineffective**?

A. boiling a sample of crushed liver then adding it to 100 mL of hydrogen peroxide

B. grinding the MnO_2 to a fine powder before adding it to 100 mL of hydrogen peroxide

C. heating 100 mL of hydrogen peroxide to 90 °C before adding the MnO_2

D. blending a liver sample before adding it to 100 mL of hydrogen peroxide

Question 12

Two experiments with hydrogen peroxide and MnO_2 are conducted.

Experiment 1	Experiment 2
100 mL of H_2O_2 with 1 spatula of MnO_2	100 mL of H_2O_2 with 2 spatulas of MnO_2

Both reactions are monitored until no further reaction occurs.

Select the correct statement comparing the two experiments.

A. Experiment 2 will produce twice the volume of oxygen gas.

B. The volume of oxygen gas will depend upon which chemical is in excess.

C. Both reactions produce the same volume of oxygen gas but at different rates.

D. The rate of reaction will be the same in both flasks.

Question 13

An expression for an equilibrium constant is shown below.

$$K = \frac{[H_2]^{½}[I_2]^{½}}{[HI]}$$

This expression is for the equation

A. $2HI(g) \rightleftarrows H_2(g) + I_2(g)$

B. $½H_2(g) + ½I_2(g) \rightleftarrows HI(g)$

C. $H_2(g) + I_2(g) \rightleftarrows 2HI(g)$

D. $HI(g) \rightleftarrows ½H_2(g) + ½I_2(g)$

Question 14

The reaction between nitrogen and hydrogen gases to produce ammonia is

$$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

Which of the following changes to an equilibrium mixture of these gases will lead to a greater yield of ammonia?

A. an increase in temperature

B. an increase in volume

C. addition of a catalyst

D. an increase in pressure

Question 15

Infrared spectroscopy is used to detect the presence of propanoic acid in a sample of propanal and a sample of propan-1-ol. The best absorption to use as evidence of the presence of propanoic acid is

A. an absorption band around 1700 cm^{-1}

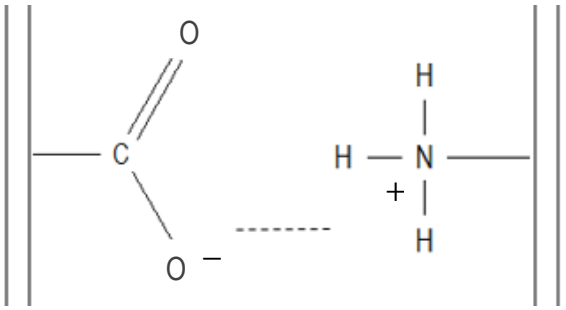
B. a sharp absorption band around 3000 cm^{-1}

C. a broad peak around 3300 cm^{-1}

D. a broad peak around 3000 cm^{-1}

Question 16

The diagram below is of a small snippet from a protein.



The bond in the diagram with a dashed line is an example of

A. hydrogen bonding between different parts of a protein molecule.

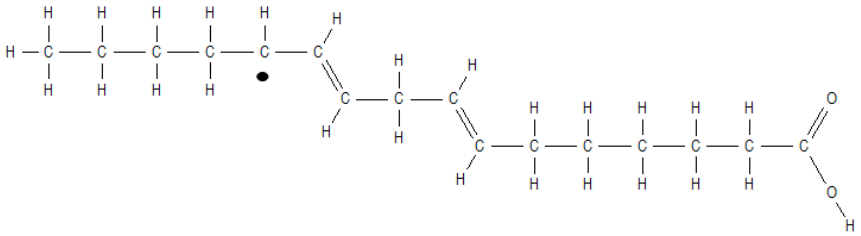
B. the hydrogen bonding that causes a protein to have a tertiary structure.

C. an ionic bond that can form between side chains on a protein molecule.

D. an ionic bond that forms part of the primary structure of a protein.

Question 17

Consider the molecule shown below.



This molecule is a

A. triglyceride.

B. free radical of a saturated fatty acid molecule.

C. free radical of an unsaturated fatty acid.

D. free radical of a triglyceride.

Question 18

A soft drink company sells two similar orange soft drinks. A simplified version of the label on each is shown in the table below.

Soft drink A	**100 mL**	**Soft drink B**	**100 mL**
Carbonated water		Carbonated water	
Caramel colouring		Caramel colouring	
Aspartame	1 g	Sucrose	10 g
Orange flavour		Orange flavour	

When compared with soft drink A, soft drink B has

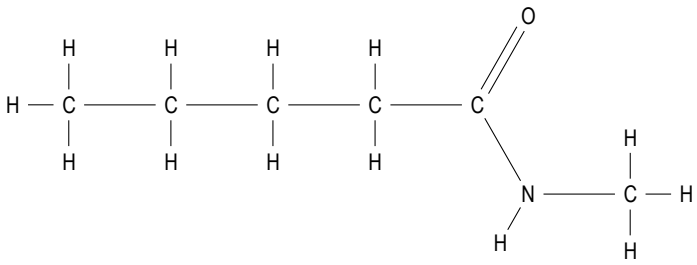
A. a significantly higher energy content and a significantly higher sweetness level.

B. a significantly higher energy content but a significantly lower sweetness level.

C. a significantly higher energy content but a similar sweetness level.

D. a similar energy content and a higher sweetness level.

Question 19



The molecule shown could be formed from the reaction between

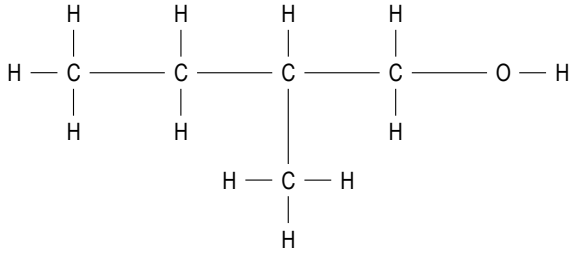
A. methanoic acid and pentanamine.

B. methanamine and pentanoic acid.

C. ethanamine and pentanoic acid.

D. ethanamine and pentan-1-ol.

Question 20



The systematic name for the molecule shown is

A. 3-methylbutan-1-ol.

B. 2-hydroxybutane.

C. 3-methylbutan-4-ol.

D. 2-methylbutan-1-ol.

Question 21

Hydrolysis of a particular macronutrient produces many carboxyl groups and hydroxyl (alcohol) groups. The macronutrient is most likely to be a

A. triglyceride.

B. protein.

C. carbohydrate.

D. vitamin.

Question 22

Which of the following statements **correctly** compares the solubility in water of amylose and amylopectin?

A. The solubility of amylopectin is higher because the cross-links allow better water access.

B. The solubility of amylose is higher because the molecules have fewer cross-links.

C. The solubility of amylose is higher because the molecules can more easily form hydrogen bonds with water molecules.

D. The solubility is similar because they are both forms of starch.

Question 23

Which one of the following molecules can form geometric isomers?

A. but-2-ene

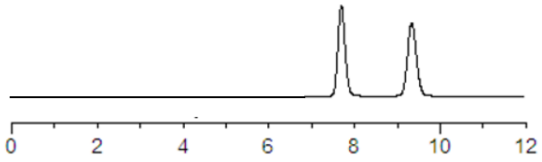
B. but-1-ene

C. butane

D. 2-chlorobutane

Question 24

A mixture of propan-1-ol and butan-1-ol is injected into an HPLC column that is using a polar solvent. The print-out below is obtained.



Peak (min)	Area
7.6	4200
9.4	3600

A second sample is passed through the same column and produces only one peak with a retention time of 9.4 minutes and an area of 1200 units.

The second sample contains

A. propan-1-ol and butan-1-ol at lower concentrations than the original solution.

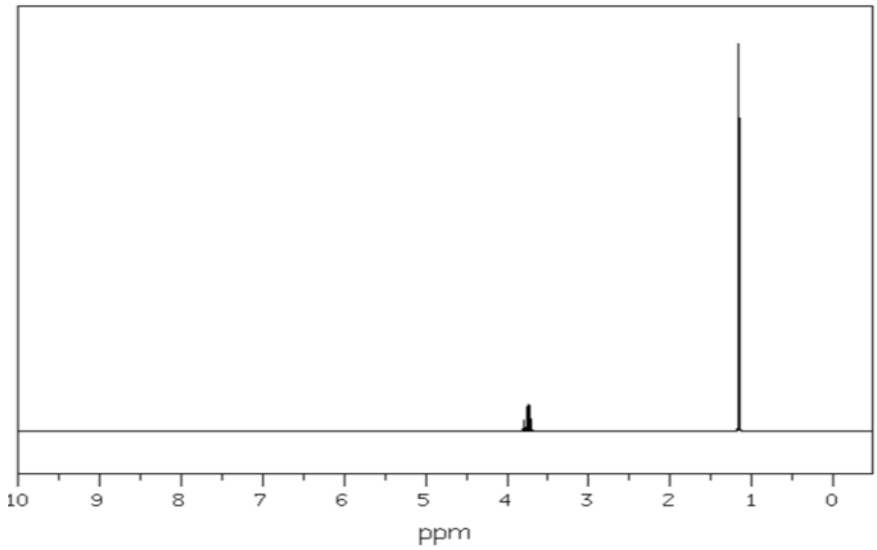
B. propan-1-ol only, with a concentration that is one-third of the original solution.

C. butan-1-ol only, with a concentration that is one-third of the original solution.

D. butan-1-ol only, with a concentration that is three times that of the original solution.

Question 25

The high resolution proton-NMR spectrum below is of 2-chloropropane.



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

The nature of the splitting on the peak with a shift of 3.8 is not very distinct. Given the structure of 2-chlorpropane, this peak should be a

A. singlet (1 peak only).

B. doublet (split into 2).

C. sextet (split into 6).

D. septet (split into 7).

Question 26

A student wishes to investigate the rate of reaction between calcium carbonate and hydrochloric acid. She prepares five HCl solutions of concentrations ranging from 0.1 M to 0.5 M. She adds 50 mL of each solution to a different beaker and places the five beakers on a hot plate set to 50 °C. Once the contents of the beaker have reached 50 °C, she adds 1.0 g of calcium carbonate to each beaker and records the time required for the reaction to cease.

Select the alternative that **correctly** identifies the variables in this experiment.

	Control variable	**Independent variable**	**Dependent variable**
A.	temperature	time for reaction	HCl concentration
B.	temperature	HCl concentration	time for reaction
C.	HCl concentration	mass of $CaCO_3$	time for reaction
D.	time for reaction	HCl concentration	mass of $CaCO_3$

Question 27

A class is provided with a solution of ethanoic acid and asked to determine the concentration of the acid using a titration. The results obtained by the class are shown below:

	Group 1	**Group 2**	**Group 3**	**Group 4**
Concentration obtained	0.123 M	0.122 M	0.122 M	0.124 M

The concentration of the ethanoic acid is tested in a commercial laboratory and found to be 0.186 M. The results of the class can be described as

A. neither precise nor accurate.

B. precise but not accurate.

C. accurate but not precise.

D. accurate and precise.

Use the following information to answer Questions 28 and 29.

A 10.0 mL sample of vinegar is diluted to 250 mL in a volumetric flask. A 20.0 mL aliquot is then titrated against 0.15 M KOH to determine the ethanoic acid concentration. The mean titre of KOH is found to be 12.0 mL.

Question 28

The concentration, in M, of ethanoic acid in the undiluted vinegar is

A. 0.090

B. 0.180

C. 0.810

D. 2.25

Question 29

Select the **correct** statement about this titration.

A. The titration cannot discern if ethanoic acid is the only acid present in the vinegar.

B. The burette should be rinsed with ethanoic acid before titration.

C. Methyl orange would be an appropriate indicator to use for this titration.

D. The calculations must take into account that ethanoic acid is a weak acid.

Question 30

The calibration factor of a bomb calorimeter is determined to be 586 J $°C^{-1}$. A 1.80 g sample of cashew is burnt in excess air in this calorimeter. The heat of combustion of cashew is quoted as 5.4 kJ g^{-1}. The expected rise in temperature, in °C, in the calorimeter will be

A. 8.3

B. 16.6

C. 22.6

D. 33.2

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$, NaCl(s).

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

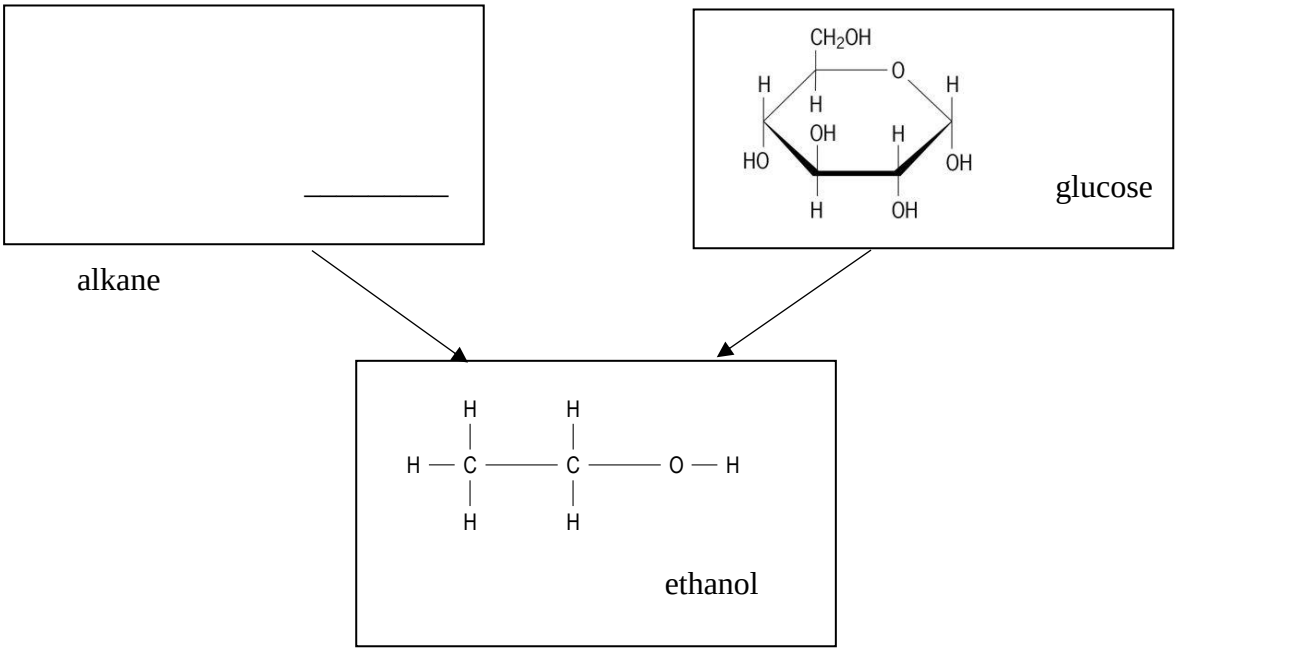
Question 1 (12 marks)

The use of ethanol as a fuel is becoming more and more widespread as countries look at smart ways of obtaining ethanol from sources that were once considered waste. Production of ethanol for fuel in the United States, for example, is now over 50 billion litres per year.

a. Ethanol can be produced from an alkane in petroleum.

i. Use the box provided to draw and name the most suitable alkane to use.

1 mark



ii. Draw a pathway, including reagents required, for the production of ethanol from this alkane.

2 marks

iii. Is the ethanol produced this way considered to be bioethanol?

Explain your answer.

1 mark

b. Ethanol can be produced from carbohydrates, such as glucose.

i. Write a balanced equation for the production of ethanol from glucose.

1 mark

ii. Is the ethanol produced this way considered to be bioethanol?

Explain your answer.

1 mark

c. **i.** Write a balanced equation for the complete combustion of ethanol in air.

1 mark

_____

ii. Calculate the amount of energy released by the complete combustion of 10.0 kg of ethanol.

2 marks

_____

_____

_____

d. **i.** Write a balanced equation for the incomplete combustion of ethanol to form carbon monoxide and water.

1 mark

_____

ii. Calculate the volume of CO that will be formed from the incomplete combustion of 10.0 kg of ethanol if the temperature is 400 °C and the pressure is 400 kPa.

2 marks

_____

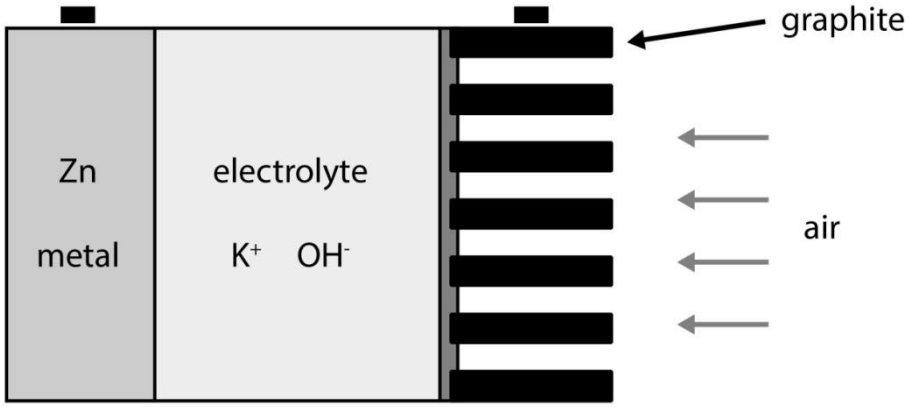
_____

_____

Question 2 (7 marks)

The zinc–air fuel cell is powered by the oxidation of zinc in air. The battery has a high energy density and is relatively cheap to produce. It is referred to as 'mechanically rechargeable' because the zinc electrode can be replaced when it is fully oxidised and the discharge of the cell starts over again.

An outline of the cell is shown below. The electrode on the left is made from zinc and the electrode on the right is porous graphite. Air is able to flow through the graphite.



The relevant half-equations for this cell at the temperature and pH at which it will operate are

$\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightleftarrows 2OH^-(aq)$ 0.34 V

$ZnO(s) + H_2O(l) + 2e^- \rightleftarrows Zn(s) + 2OH^-(aq)$ –1.25 V

a. Write a balanced half-equation for the reaction occurring at the

2 marks

i. anode _____

ii. cathode _____

b. **i.** Write an overall equation for this cell.

1 mark

_____

ii. What is the theoretical voltage of this cell?

1 mark

_____

c. **i.** This cell is relatively inexpensive. Give **two** reasons why the cell is cheap.

2 marks

_____

_____

_____

_____

ii. Explain why this cell is considered a type of fuel cell.

1 mark

_____

_____

Question 3 (10 marks)

A liquid found in a bottle has a molecular formula of C_3H_6O. There are several possible structures that match this formula. The information provided in this question will allow you to deduce the structure that matches the liquid in the bottle.

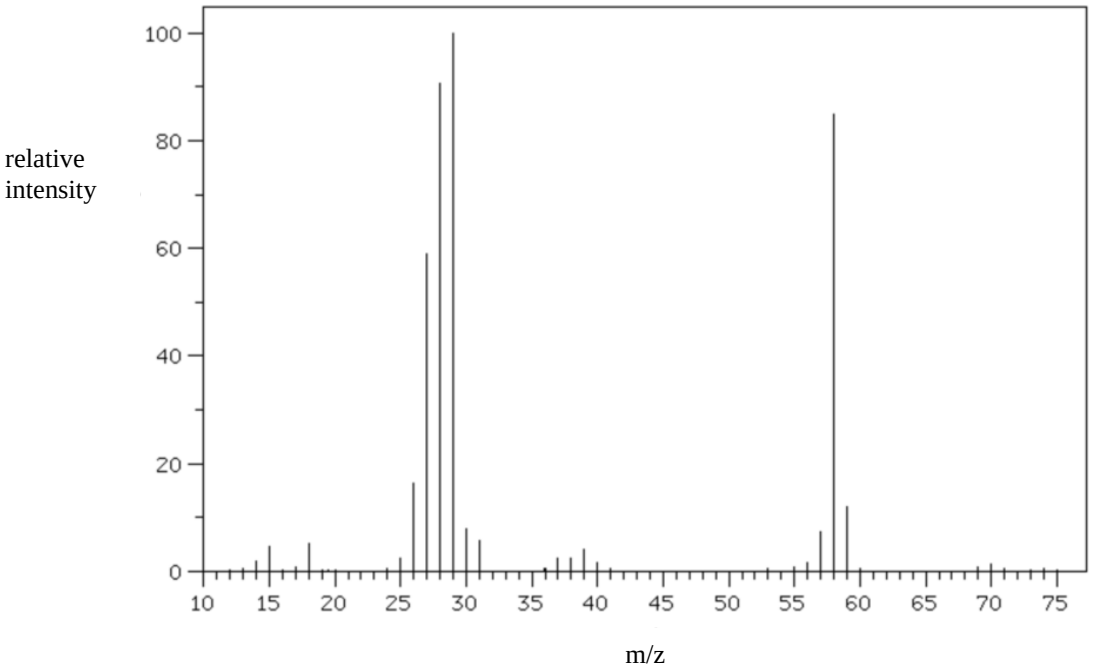
a. Draw the structures of three molecules that have a molecular formula of C_3H_6O.

Use the line provided to give the systematic name of the molecules you have drawn.

3 marks

1.	**2.**	**3.**
1. _____	**2.** _____	**3.** _____

The mass spectrum of the molecule is shown below.



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

b. **i.** What is the m/z ratio of the base peak for this molecule?

1 mark

_____

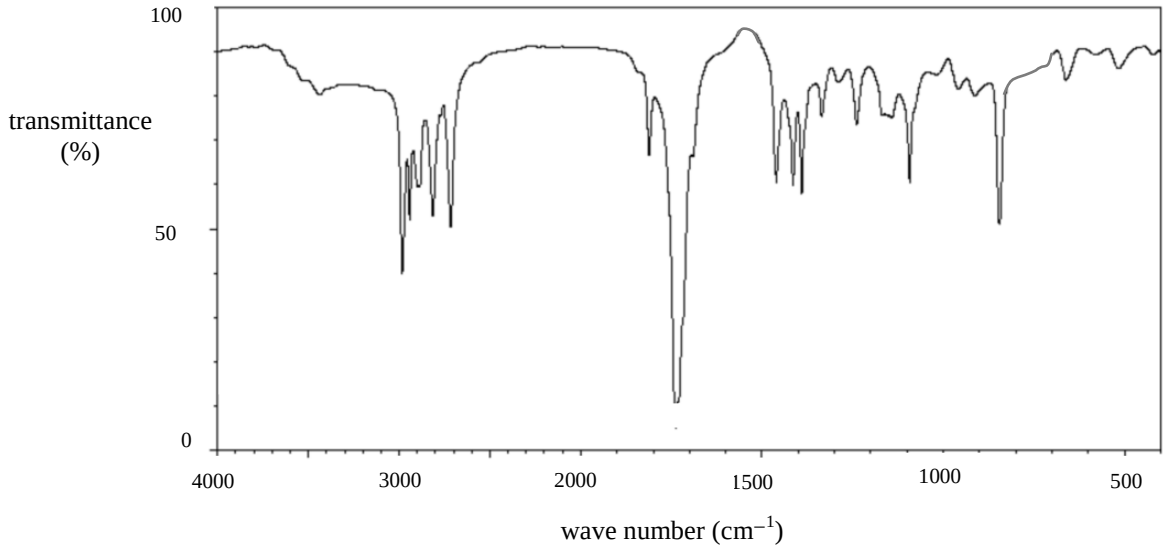
ii. Suggest two possible fragments that could cause this peak.

2 marks

_____

_____

The infrared spectrum of the molecule is shown below.



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

c. From the infrared spectrum given,

i. is this molecule likely to be an alcohol? Justify your answer.

1 mark

_____

_____

ii. does this molecule contain a C=O bond? Justify your answer.

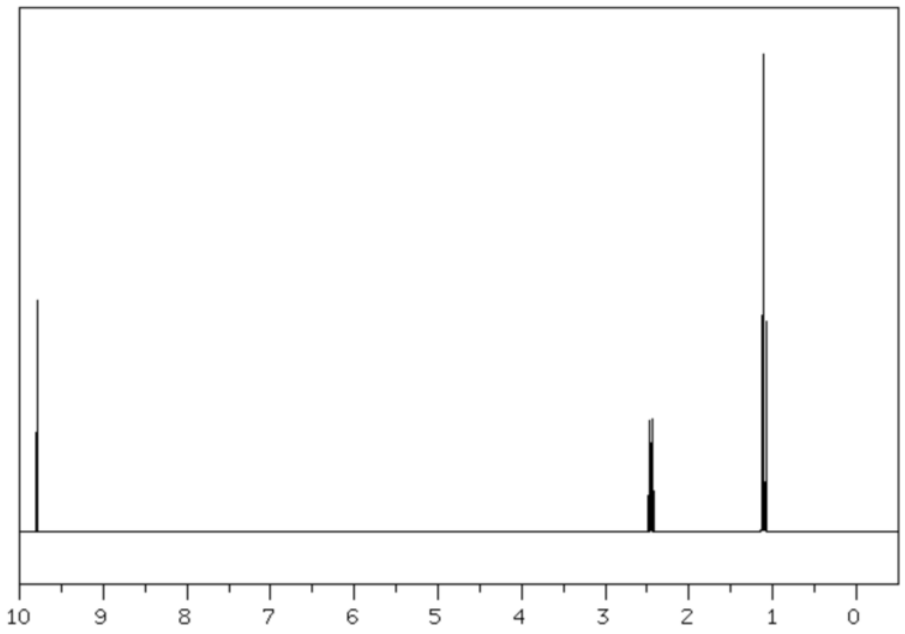
1 mark

_____

_____

The proton-NMR of the molecule is shown below. The peaks on this spectrum are

- shift 9.8 triplet
- shift 2.4 quintet
- shift 1.1 triplet



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

d. Use the proton-NMR to decide the identity of the liquid. Justify your choice.

2 marks

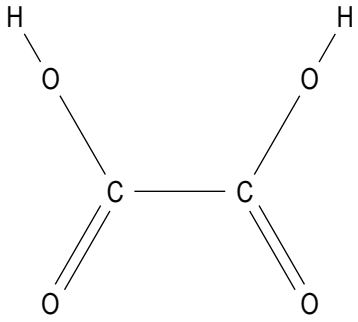
_____

_____

_____

Question 4 (6 marks)

Oxalic acid is sold as a white powder. It is used to bleach surfaces and as a stain remover. Its chemical structure is shown below.



A student conducts a titration to determine the percentage by mass of oxalic acid in a commercial sample of oxalic acid. He prepares a solution of oxalic acid by weighing a sample and adding it to a 250.0 mL volumetric flask. The volumetric flask is made up to the mark with deionised water and titrated against 0.120 M NaOH solution. The student then uses phenolphthalein indicator to detect the endpoint.

The student's measurements are recorded below.

Mass of commercial oxalic acid	2.46 g
Mean titre of oxalic acid	14.8 mL
NaOH aliquots	20.00 mL

a. Write a balanced equation for the reaction between oxalic acid and NaOH.

1 mark

_____

b. **i.** Determine the number of moles of NaOH in the aliquots.

1 mark

_____

ii. Determine the number of moles of oxalic acid in the titre.

1 mark

_____

iii. Determine the mass of oxalic acid in the volumetric flask.

2 marks

_____

_____

_____

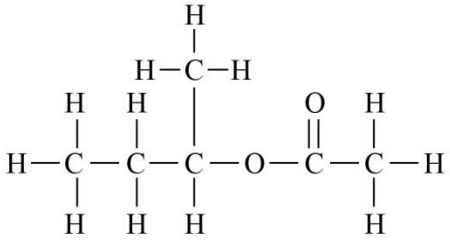
iv. Calculate the % (m/m) of oxalic acid in the commercial product.

1 mark

_____

Question 5 (9 marks)

The molecule shown below is an ester.

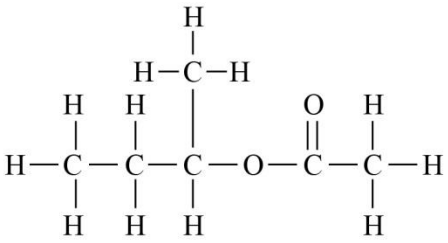


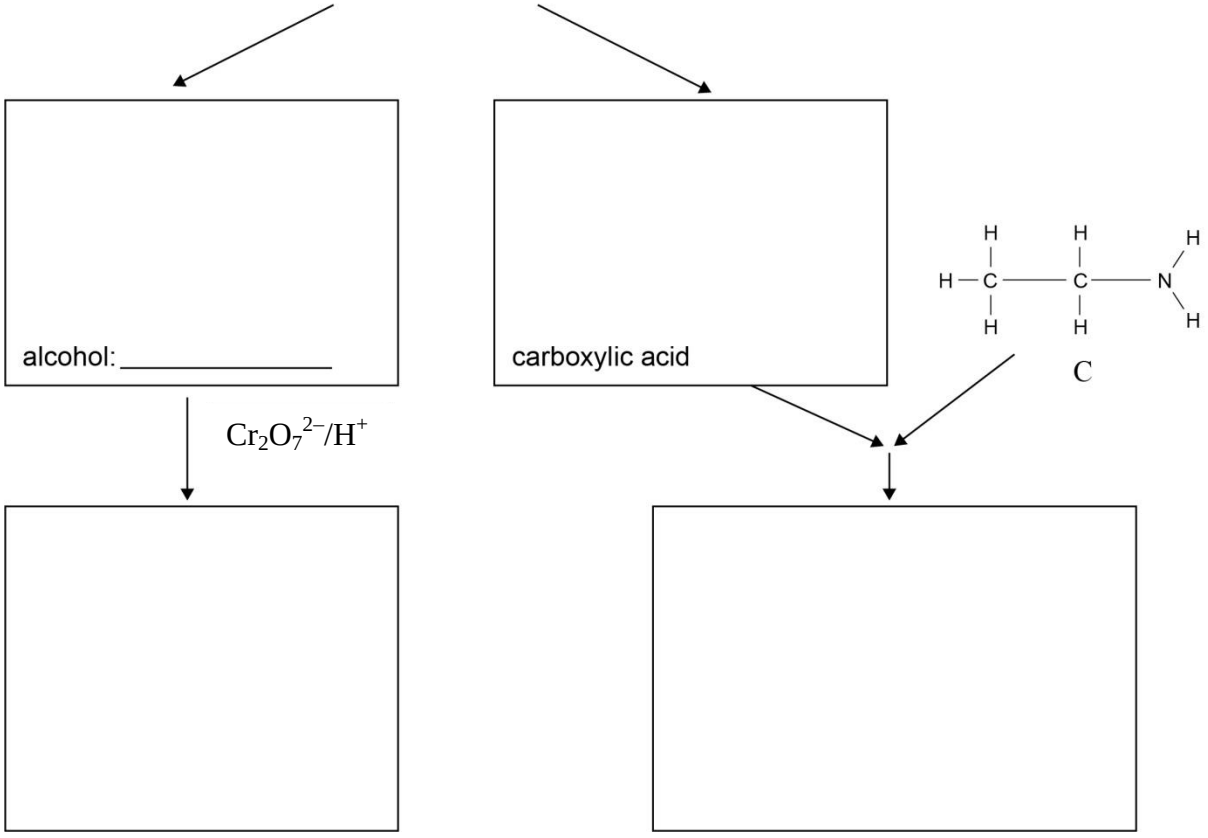
2 marks

a. **i.** What is the molecular formula of this ester? _____

ii. What is the empirical formula? _____

The molecule is hydrolysed using NaOH solution to form an alcohol and an ionic salt. The products are separated and HCl is added to the salt to convert it to a carboxylic acid.





b. **i.** Use the box provided on the opposite page to draw the structural formula of the alcohol molecule formed.

1 mark

ii. This molecule contains a chiral centre. Mark this centre with an asterisk.

1 mark

iii. Use the line provided in the box to name the alcohol.

1 mark

iv. The alcohol is reacted with acidified $Cr_2O_7^{2-}$ solution. Use the box provided to draw the structural formula of the molecule that will form.

1 mark

c. **i.** Use the box provided to draw the structural formula of the carboxylic acid formed when the ester is hydrolysed.

1 mark

ii. The carboxylic acid is reacted with the molecule shown as molecule C. Use the box provided to draw the structural formulas of the products formed.

2 marks

Question 6 (8 marks)

Carbon monoxide and hydrogen can be formed from the reaction of methane with steam according to the equation

$$CH_4(g) + H_2O(g) \rightleftarrows CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

a. 2.0 mole of methane and 1.8 mole of steam are added to an empty 1.0 L reactor. When equilibrium is reached, the amount of carbon monoxide formed is 0.24 mol.

Calculate the value of the equilibrium constant for this reaction.

3 marks

b. The volume of an equilibrium mixture of the abovementioned gases is halved at time t_1. The mixture returns to equilibrium at time t_2. The temperature is held constant.

At time t_2, how does the

i. value of K compare to the value of K just before t_1?

1 mark

ii. amount of CO compare to the amount of CO just before t_1?

1 mark

iii. concentration of CO compare to the concentration just before t_1?

1 mark

iv. rate of the forward reaction compare to the rate just before t_1?

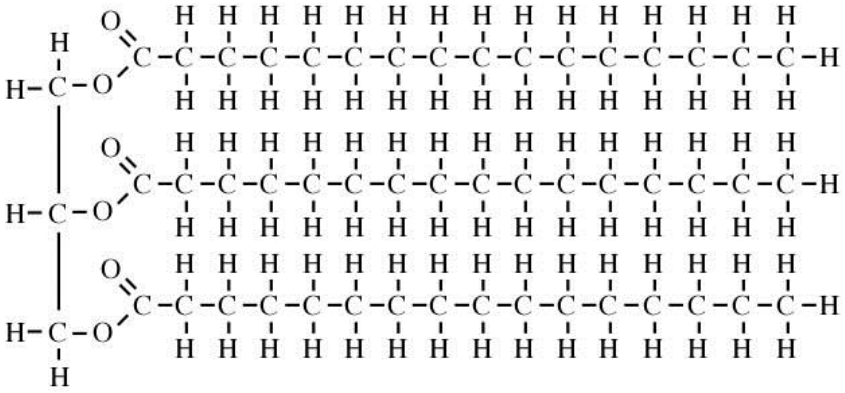
1 mark

c. The value of the equilibrium constant for the reaction above is K. Write a balanced equation for the reaction that will have an equilibrium constant of $\frac{1}{K}$ at the same temperature.

1 mark

Question 7 (7 marks)

The molecule shown below is an example of a triglyceride.



a. **i.** Triglycerides are hydrolysed in the body as part of the digestion process.

Draw structural diagrams of the **two** products resulting from hydrolysis of this triglyceride.

2 marks

ii. In which part of the digestive system is hydrolysis of a triglyceride most likely to occur? Explain your answer.

2 marks

b. One of the products of hydrolysis of this triglyceride could be reacted with methanol to form a molecule of biodiesel.

i. Write the semi-structural formula of the biodiesel molecule formed.

1 mark

ii. Write a balanced equation for the complete combustion of the biodiesel molecule.

2 marks

SECTION B – continued

Question 8 (9 marks)

a. Hydrolysis of macronutrients is an important step in the digestion of most macronutrients.

Complete the table below to summarise the bonds broken and the products formed during hydrolysis.

6 marks

Macronutrient	**Draw the bond broken during hydrolysis**	**Name of product(s) of hydrolysis**
Protein		
Carbohydrate		
Triglyceride		

b. Two examples of D group vitamins are drawn in the data book.

i. Will vitamin D be soluble in water? Explain your answer.

1 mark

_____

_____

ii. Do humans need a regular intake of vitamin D? Explain your answer.

1 mark

_____

_____

c. Fruits are generally low-GI foods despite them having a high monosaccharide content. Explain the possible reason why.

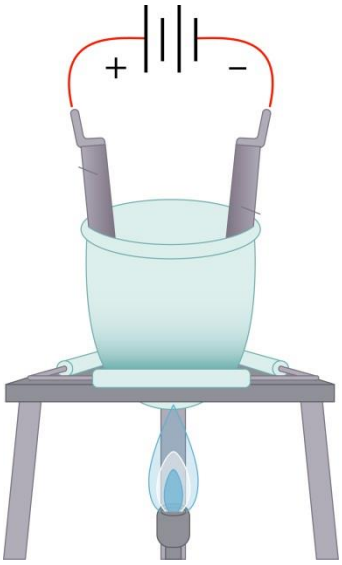
1 mark

_____

_____

Question 9 (10 marks)

A sample of sodium chloride is added to a crucible and heated strongly. When the solid melts, two carbon electrodes are placed in the liquid and connected to a power supply. The power supply is switched on.



a. Describe the movement of the particles in the liquid.

2 marks

_____

_____

b. Write half-equations for the reactions occurring at the

2 marks

i. anode _____

ii. cathode _____

c. Write a balanced equation for the overall reaction that is occurring.

1 mark

_____

d. Give **two** reasons why this experiment should not be conducted in a school laboratory.

2 marks

_____

_____

_____

e. If the current is 5.62 amperes, determine the time required for 0.460 moles of gas to be produced in the cell.

3 marks

_____

_____

_____

_____

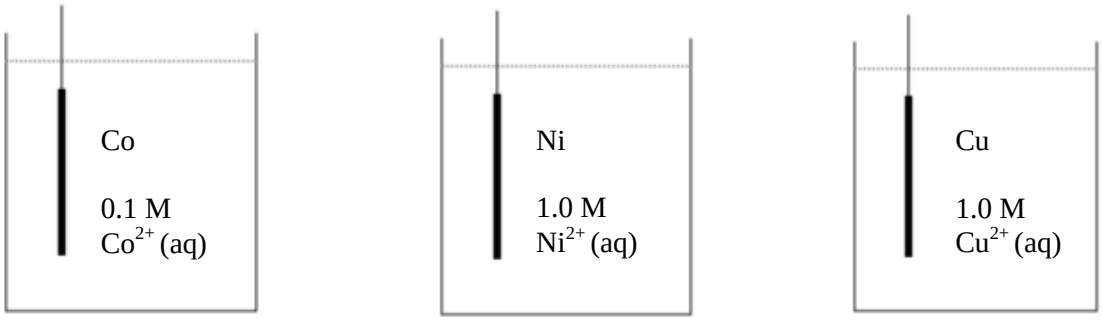
_____

Question 10 (6 marks)

Chemistry students frequently refer to the electrochemical series when answering questions relating to redox reactions.

Two chemistry students conduct experiments with half-cells to attempt to replicate the voltages of three of the common half-equations shown on this series.

The three half-cells used by the students are shown below. Over a series of days, the students tested each combination possible in a galvanic cell and recorded the polarity of the electrodes and the voltage obtained. The students then used the voltages obtained to form their own mini-electrochemical series. For their series, the students made the nickel half-cell their standard and assigned it a value of 0.00 V.



Results

Cell combination	Voltage obtained	Positive electrode
cobalt/nickel	0.10 V	cobalt
cobalt/copper	0.41 V	copper
nickel/copper	0.51 V	copper

Student electrochemical series

	V
$Cu^{2+}(aq) + 2e^- \rightleftarrows Cu$	0.51
$Co^{2+}(aq) + 2e^- \rightleftarrows Co$	0.10
$Ni^{2+}(aq) + 2e^- \rightleftarrows Ni$	0.00

Conclusion

It is not possible in a school laboratory to obtain the same sequence as a data book electrochemical series.

The students' description of their experimental procedure contains some errors, which may include omissions.

a. Briefly describe **two** errors (or omissions) in the students' procedure and explain how the procedure could have been modified to improve the data obtained.

4 marks

Error 1 _____

_____

_____

Error 2 _____

_____

_____

b. The students arbitrarily assign the nickel half-cell a voltage of 0.00 volts. Use the electrochemical series provided in your data book to determine the voltages that the other two half-cells should have if nickel has a value of 0.00 V.

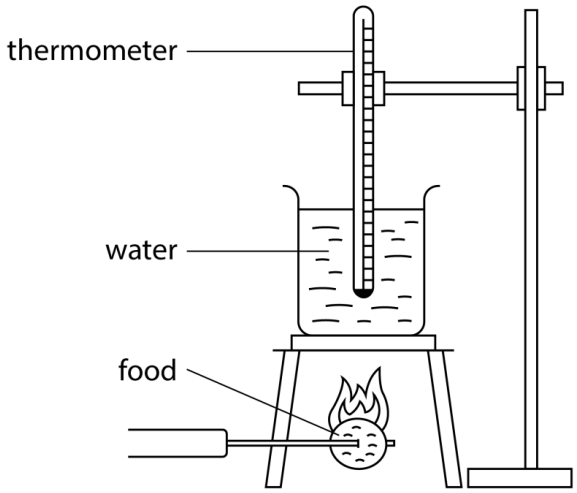
2 marks

$Cu^{2+}(aq) + 2e^- \rightleftarrows Cu$ voltage _____

$Co^{2+}(aq) + 2e^- \rightleftarrows Co$ voltage _____

Question 11 (6 marks)

The energy content of a biscuit can be determined by burning a sample under a beaker of water. The apparatus used is shown in the diagram below.



The results obtained for a particular experiment are shown below.

Mass of biscuit before heating:	3.782 g
Mass of biscuit after combustion:	1.122 g
Volume of water:	900.0 mL
Initial temperature of water:	18.8 °C
Final temperature of water:	24.4 °C

a. **i.** Calculate the energy released by the biscuit.

2 marks

_____

_____

_____

ii. Calculate the heat of combustion of the biscuit in kJ g^{-1}.

1 mark

_____

_____

b. The heat of combustion value obtained is significantly lower than the accepted value on the packet label.

Suggest three modifications to the experiment design that should lead to a more accurate result for the heat of combustion.

3 marks

_____

_____

_____

_____

_____

_____

END OF QUESTION AND ANSWER BOOK