Victorian Certificate of Education
CHEMISTRY 2026 Unit 1 and 2
End of Year Examination

Reading time: 10 minutes
Writing time: 120 minutes

Student's Name: _____

Teacher: _____

Structure of booklet

Section	Question to be answered	Total marks
Multiple choice	20	25
Short answer	9	74
	Total	99

Directions to students

Materials

- Students are permitted to bring into the examination room: pencils, highlighters, erasers, sharpeners, rulers, and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room:
white out liquid/tape, phones or electronic devices, including smart watches.
- Students are provided with the following: Question and answer book of 20 pages and VCAA Data booklet.

The task

- Please ensure that you write your name and teacher's name on this booklet. This paper consists of Part A (25 multiple choice questions) to be answered on the answer sheet on page 9 and Part B (9 short answer questions)
- There are a total of 99 marks available.
- Be sure to include states with all chemical equations.
- All numerical answers need to be quoted to the correct number of significant figures.
- All working out must be shown in the space provided for marks to be awarded

Section A

Question 1:

The electronegativity values of various elements are shown in the table below.

Element	H	N	F	C
Electronegativity value	2.20	3.04	3.98	2.55

Which one of the following bonds is the most **polar**?

a) C–H

b) H–F

c) H–N

d) F–F

Question 2:

Sodium and carbonate ions bond to form sodium carbonate. Choose the correct combination of chemical formula and solubility (in water) for sodium carbonate.

	Chemical Formula	**Solubility in Water**
a)	Na_2CO_3	soluble
b)	Na_2CO_3	insoluble
c)	$Na(CO_3)_2$	soluble
d)	$Na(CO_3)_2$	insoluble

Question 3:

A sample of methane, CH_4, contains 4.82×10^{24} hydrogen atoms. The **mass** of the sample, in g, would be closest to

a) 26

b) 32

c) 128

d) 8

Questions 4 and 5 refer to the following list of compounds.

I	CH_2CHCl
II	C_8H_{18}
III	CH_3F
IV	CH_3OH
V	NH_3

Question 4:

The substances that contain molecules that are attracted to each other by **hydrogen bonds** are:

a) I and II

b) I, III and IV

c) III, IV and V

d) IV and V

Question 5:

Methanol, CH_3OH, will readily dissolve in water to form aqueous solutions. What **types of bonding** will be present in an aqueous solution of methanol?

a) Hydrogen bonding between the methanol and water molecules.

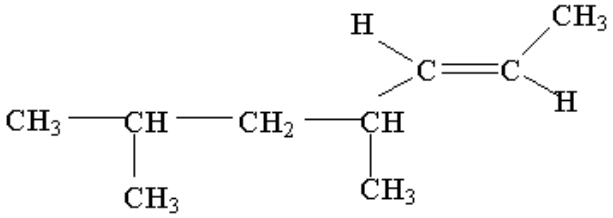
b) Covalent bonding within the methanol and water molecules and hydrogen bonding between the molecules.

c) Covalent bonding within the methanol and water molecules and dispersion forces between the molecules.

d) Covalent bonding within and between the methanol and water molecules.

Question 6:

What is the systematic name for the compound whose structural formula is shown below?



A. 2,4 - methylhept-5-ene

B. 2,4 - dimethylnon-2-ene

C. 4,6 - dimethylhept-2-ene

D. 4, 6 - methylnon-2-ene

Question 7:

The empirical formula of an unknown substance is CH_2O. If the molar mass of the substance is 180 g mol^{-1}, the **molecular formula** is likely to be

a) $C_5H_{10}O_5$

b) $C_5H_8O_7$

c) $C_6H_{12}O_6$

d) $C_5H_{11}COOH$

Question 8:

If solution X has a pH of 3 and solution Y has a pH of 6, it can be concluded that

a) $[H^+]$ in solution X is 1000 times that of $[H^+]$ in solution Y

b) $[H^+]$ in solution X is half that of $[H^+]$ in solution Y

c) $[OH^-]$ in solution Y is twice that of $[OH^-]$ in solution X

d) Solution Y must contain a stronger acid that solution X

Question 9:

Pentan-1-ol is converted into a carboxylic acid by a chemical reaction.

What is the molecular formula of the carboxylic acid formed in this reaction?

a) $C_5H_{10}O_2$

b) $C_5H_{12}O_2$

c) $C_5H_{10}O$

d) $C_6H_{12}O_2$

Question 10:

Consider the following statements about water.

I. Water has a relatively high latent heat of vaporisation.
II. For its molecular size, water has a high specific heat capacity.
III. Solid ice has a greater density than liquid water at low temperatures.

Which of these statements are **correct**?

a) I and II only

b) I and III only

c) II and III only

d) I, II and III

Question 11:
A 400 g sample of water at 25.0 °C is heated absorbing 50 kJ of energy. The maximum temperature, in °C, that can be reached by the water sample is:

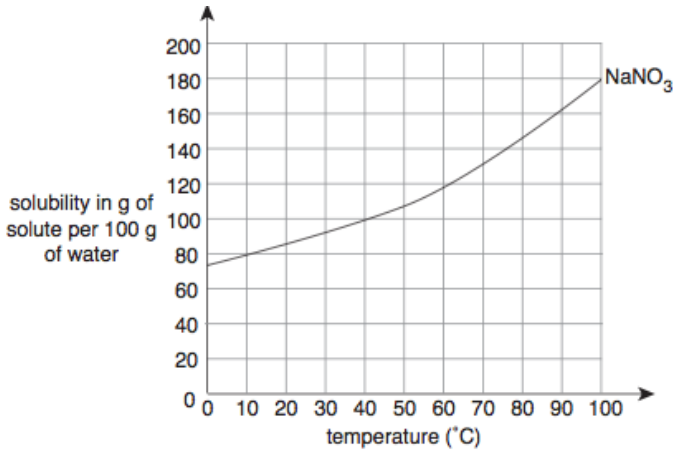
a) 12.0

b) 29.9

c) 37.0

d) 54.9

Question 12:
The graph below shows the solubility curve for sodium nitrate, $NaNO_3$.



If 70 mL of a saturated sodium nitrate solution was cooled from 90 °C to 40 °C, the mass of sodium nitrate, in gram, expected to **crystallise** from solution would be **closest** to:

a) 40

b) 160

c) 60

d) 100

Question 13:
The concentration of **K^+ ions** in 200 mL of 0.100 M K_2CO_3 solution, in g L^{-1}, is

a) 0.392

b) 0.782

c) 3.92

d) 7.82

Question 14:
20 mL of water is added to 20 mL of 0.50 M sodium sulfate, Na_2SO_4, solution. The concentration of sodium sulfate in the resultant solution, in M, is

a) 0.13
b) 0.25
c) 0.50
d) 1.0

Question 15:

Which one of the following combinations of solutions is **least** likely to form a precipitate?

a) Na_2SO_4 and $NiCl_2$
b) $Pb(NO_3)_2$ and $CuCl_2$
c) K_2CO_3 and $ZnCl_2$
d) LiOH and $FeCl_2$

Question 16:
Which of the following is the conjugate **acid** of OH^-?

a) H_2O
b) H_3O^+
c) O^{2-}
d) H_2O_2

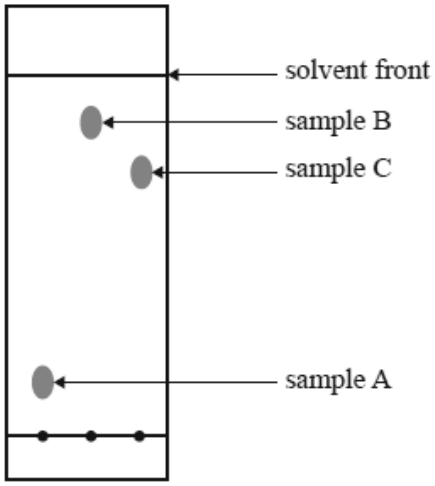
Question 17:
What volume of 0.300 M hydrochloric acid must be taken to obtain 0.150 mol of HCl?

a) 5.0L
b) 50 mL
c) 0.5L
d) 2.0L

Question 18:
The mass of NaOH required to make 2 L of a 0.25 M NaOH solution would be:

a) 4.0 g
b) 8.0 g
c) 20.0 g
d) 40.0 g

Question 19:
The thin layer chromatography plate shown below has a polar stationary phase. It was developed using hexane as the solvent.



Which sample has the **most polar** molecules?

a) sample A
b) sample B
c) sample C
d) There is not enough information to determine which sample has the most polar molecules

Question 20:
In which of the following reactions is sulfuric acid, H_2SO_4, **not** acting as a Lowry-Brønsted acid?

a) $H_2SO_4\ (aq) + Ba(OH)_2\ (aq) \rightarrow BaSO_4\ (aq) + 2H_2O\ (l)$
b) $H_2SO_4\ (aq) + Mg\ (s) \rightarrow MgSO_4\ (aq) + H_2\ (g)$
c) $H_2SO_4\ (aq) + H_2O\ (aq) \rightarrow H_3O^+\ (aq) + HSO_4^-\ (aq)$
d) $H_2SO_4\ (aq) + 2NaHCO_3\ (s) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l) + 2CO_2\ (g)$

Question 21:

Sodium can react with sulfur according to the equation:

$$2Na(s) + S(s) \rightarrow Na_2S(s)$$

In this reaction the **sulfur** is

a) oxidised, because it gains two electrons.
b) oxidised, because it loses two electrons.
c) reduced, because it loses two electrons.
d) reduced, because it gains two electrons.

Question 22:
Which combination **will** result in a metal displacement reaction?

a) $Al_{(s)}$ and $Zn_{(s)}$

b) $Fe^{3+}_{(aq)}$ and $Ag^{+}_{(aq)}$

c) $Pb^{2+}_{(aq)}$ and $Na_{(s)}$

d) $Zn^{2+}_{(aq)}$ and $Sn_{(s)}$

Question 23:
Which of these chemical species is the **strongest reducing agent**?

a) Ag

b) Ag^{+}

c) Na

d) Na^{+}

Question 24:
Three different students conduct a titration to determine the concentration of an acid solution. Their results are

Student 1: 0.86 M *Student 2*: 0.88 M *Student 3*: 0.85 M

The concentration of the solution is tested by a certified laboratory and found to be 0.98 M.

The students' results can be described as

a) neither precise nor accurate.

b) precise but not accurate.

c) accurate but not precise.

d) precise and accurate.

Question 25:
The 20.0 mL pipette used by a class for a titration is later tested and found to deliver 20.3 mL.

This is an example of a

a) mistake when the students use the pipette.

b) random error as the pipette would have a different impact each time it is used.

c) systematic error as it caused the same problem each time it was used.

d) poor procedure as students have not learnt to use this piece of equipment properly.

Multiple choice answer sheet.

Circle one correct response for each question.
Do not remove from the examination paper.

Name _____

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

Section B

Question 1: (5 marks)

The metal lead is extracted from lead (II) sulfide ore by heating in air and then reacting the lead (II) oxide which is produced with carbon monoxide. The following equations show the chemical reactions involved:

$$2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g)$$

$$PbO(s) + CO(g) \rightarrow Pb(l) + CO_2(g)$$

a) If 1000 kg of lead (II) sulfide is reacted with excess oxygen, calculate the amount, in mol, of lead sulfide reacting. (1 mark)

b) Calculate the mass of lead (II) oxide, **in kg,** that would be produced in the first step of the pathway. (2 marks)

c) Given all of the lead (II) oxide reacts with excess carbon monoxide, calculate the mass, **in g**, of lead that could be produced. (2 marks)

Question 2: (10 marks)
Ammonia gas (NH_3) is used industrially in a multitude of ways; including, but not limited to, wastewater treatment, cold storage, fertiliser and the manufacture of pharmaceuticals, leather, rubber and paper. The most common process is called the Haber-Bosch process where nitrogen from the air is mixed with hydrogen gas to form ammonia.

a) Write a balanced chemical equation, including states, for the production of ammonia gas from nitrogen gas and hydrogen gas. (2 marks)

Unfortunately, due to the manufacturing conditions needed and the use of hydrogen gas from fossil fuels, the Haber-Bosch process uses a lot of energy and contributes about 1.3% of the global CO_2 emissions. Researchers are working on alternative ways to manufacture ammonia gas.
One technique under investigation is to mix nitrogen, from the air, and water, in the presence of a new catalyst, to form ammonia and oxygen gas.

$$2N_{2\,(g)} + 6H_2O_{\,(g)} \rightarrow 4NH_{3\,(g)} + 3O_{2\,(g)}$$

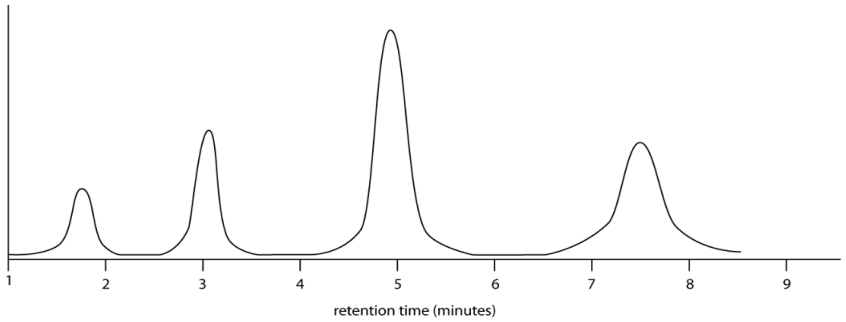
b) If the process uses 3.00kg of water and 2.00kg of nitrogen in the manufacturing process, determine the limiting reagent. *Show all working.* (3 marks)

c) If 24.5mol of oxygen is produced, calculate the amount, in mol, of ammonia that would also be produced. (2 marks)

d) Calculate the volume, in L, of NH_3 gas being produced if the process is run at 125.0°C and 2.00 atm? *Give your answer to the correct number of significant figures.* (3 marks)

Question 3: (7 marks)

While working in a quality control laboratory, a chemist was given the task of verifying that a specific brand of nail polish remover was correct in its claim of being 'acetone free'. In order to test the sample, the chemist ran a sample of the nail polish remover through a HPLC chromatograph and produced the following chromatogram:



a) How many components were detected in the nail polish remover? Explain your answer. (2 marks)

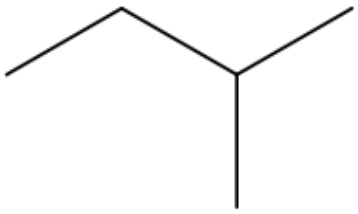
b) Identify the retention time for the component that is most strongly attracted to the HPLC stationary phase. Explain your reasoning. (2 marks)

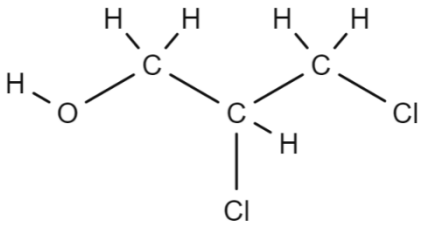
c) The chemist also has a sample of pure acetone. Explain how the chemist can confirm whether the claim of being 'acetone free' was true for the nail polish remover. (2 marks)

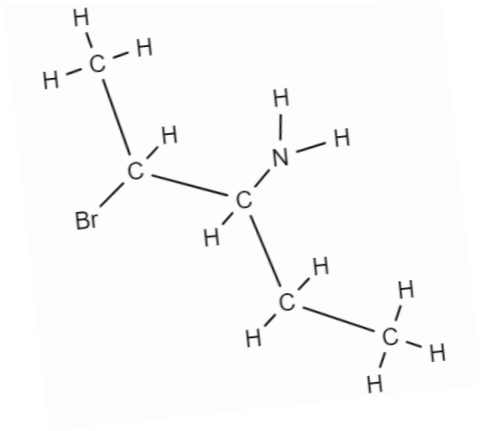
d) Other than the number of peaks and the identity of each peak, what **other** piece of information can be obtained from a HPLC? (1 mark)

Question 4: (15 marks)

1. Name the following molecules. (3 marks)

i. 

ii. 

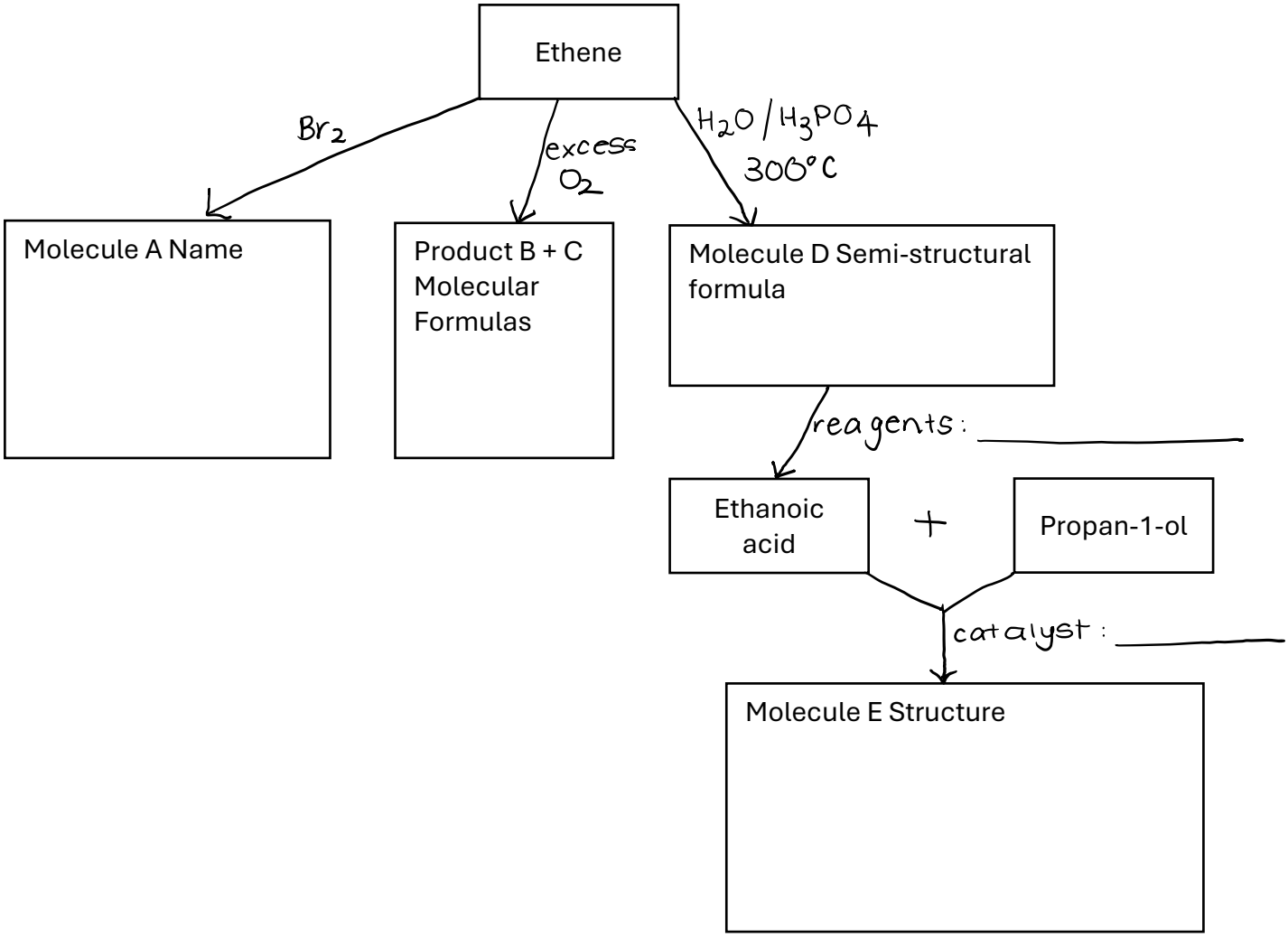
iii. 

2. Ethene is the first molecule in its homologous series.

   i. **Name** the molecule within the same homologous series that contains 5 carbons. (1 mark)

   ii. **Draw** and **name** a branched isomer of the compound named in part b. i. (2 marks)

3. Ethene may also participate in many different reactions, some of these are shown on the pathway below.



i. **Name** molecule A in the box above. (1 mark)

ii. State the **molecular** formulas of products B + C in the box above. (2 marks)

iii. Write the **semi-structural** formula of molecule D in the box above. (1 mark)

iv. State the reagents required to turn molecule D into ethanoic acid. (1 mark)

v. Draw the **structural** formula of molecule E in the box above. (1 mark)

vi. State the catalyst required (including **state**) to form molecule E. (1 mark)

vii. A 0.1M solution of ethanoic acid was tested with a pH probe, state whether the probe would have measured a pH above, below or equal to 1. Explain your reasoning. (2 marks)

_____

_____

_____

Question 5:(6 marks)

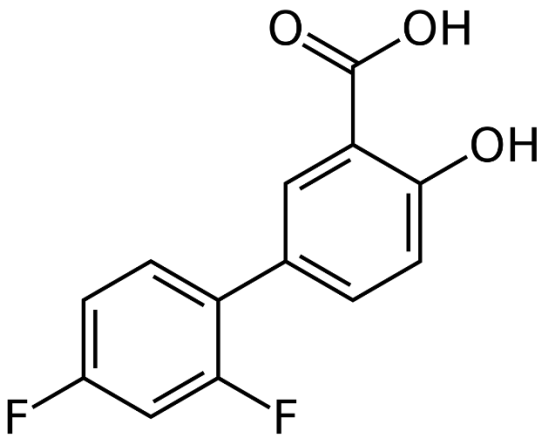
Medicines are an important application of organic chemistry compounds. Depending on the functional groups present within the molecules, the properties of the medicines and their function within the body will change.

One commonly used, over the counter medicine is antacids which contain bases that react to neutralise stomach acids.

a) One antacid contains calcium carbonate. Write the balanced chemical equation, including states, for the reaction between calcium carbonate and hydrochloric acid (stomach acid). (2 marks)

Diflunisal is another commonly used medicine. This drug is used in the treatment of pain, swelling and tenderness caused by osteoarthritis.

b) Circle and name 2 different functional groups present on the structure of Diflunisal below. (2 marks)



c) Would Diflunisal be soluble or insoluble in water? Explain your reasoning.

(2 marks)

_____

_____

_____

_____

Question 6:(9 marks)

Another pain relief medication is aspirin, the aspirin molecule contains a **carboxyl (-COOH)** functional group and has a molar mass of **180.0g/mol**. A group of medicinal scientists set out to determine the concentration of aspirin in a tablet using a titration with 0.0152M sodium hydroxide (NaOH). The reaction occurs according to the chemical equation: $HC_9H_7O_{4\,(aq)} + NaOH_{\,(aq)} \rightarrow NaC_9H_7O_{4\,(aq)} + H_2O_{\,(l)}$

To conduct the titration, 1 tablet of aspirin was dissolved in a 100.0mL volumetric flask. 20.00mL aliquots of this solution were then titrated against the NaOH standard. The average titre was found to be 23.70mL.

d) Suggest a suitable indicator for this titration and state the colour change that would occur. (2 marks)

_____

_____

e) Calculate the amount, in mol, of aspirin reacting in the titration. (2 marks)

f) Calculate the amount, in mol, of aspirin in the tablet. (1 mark)

g) Calculate the mass of aspirin in the tablet. (1 mark)

h) Calculate the concentration of aspirin in %(m/m) given that 1 tablet weights 400mg. (1 mark)

i) Explain how the calculated concentration would change if the burette was incorrectly washed with water. (2 marks)

_____

_____

_____

_____

Question 7: (10 marks)

a) For the two incomplete half equations below, balance them and identify whether they are oxidation or reduction reactions. (4 marks)

i. $H_2O_{2(aq)} \rightarrow O_{2(g)}$

ii. $VO_2^{+}{}_{(aq)} \rightarrow VO^{2+}{}_{(aq)}$

b) Identify the two oxidants from the half equations in part a. (2 marks)

c) Write the overall reaction for the two half equations in part a. (2 marks)

d) State the oxidation of both V and O in VO_2^{+} (2 marks)

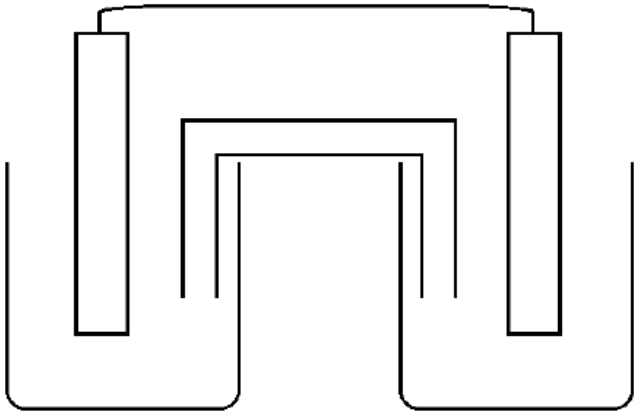
V: _____

O: _____

Question 8: (9 marks)
A Year 11 chemistry student is given the following resources and asked by their teacher to construct a Galvanic cell that would provide the largest possible voltage:

- 2 electrodes (1 zinc and 1 graphite)
- Solutions of KNO_3, $Zn(NO_3)_2$, $AgNO_3$
- 2 x 200mL beakers
- Wires with alligator clips
- Filter paper

a) On the diagram below, begin representing the student's galvanic cell by labelling the electrodes, solutions and salt bridge with their species. (4 marks)



b) Label the electrodes with their polarities. (1 mark)

c) On your diagram indicate, with a labelled arrow, the direction the electrons are moving on the external wire. (1 mark)

d) On your diagram indicate, with a labelled arrow, the direction of the positive ions in the salt bridge. (1 mark)

e) State the voltage produced by the cell. (1 mark)

f) Write the half equation that occurs at the cathode. (1 mark)

_____

Question 9: (8 marks)

A student investigated the effect of solution concentration on the corrosion rate of zinc metal. The student's report is provided below.

Report

Background

Zinc metal will corrode when placed in a copper (II) sulfate solution according to the following displacement reaction.

$$Zn\ (s) + CuSO_4\ (aq) \rightarrow Cu\ (s) + ZnSO_4\ (aq)$$

Aim

To investigate the effect of increasing copper (II) sulfate concentration on the average rate of zinc metal corrosion over 30 minutes.

Method

The mass change of a piece of zinc metal was measured after 30 minutes of being placed in a solution of copper (II) sulfate. The procedure was repeated using various concentrations of copper (II) sulfate solution ranging from (0.25 M – 1.0 M).

Results

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Concentration of $CuSO_4$ solution (M)	0	0.25	0.50	0.75	1.0
Change in mass of zinc metal (g)	0.000	0.130	0.248	0.383	0.499

Figure 1. Table of results

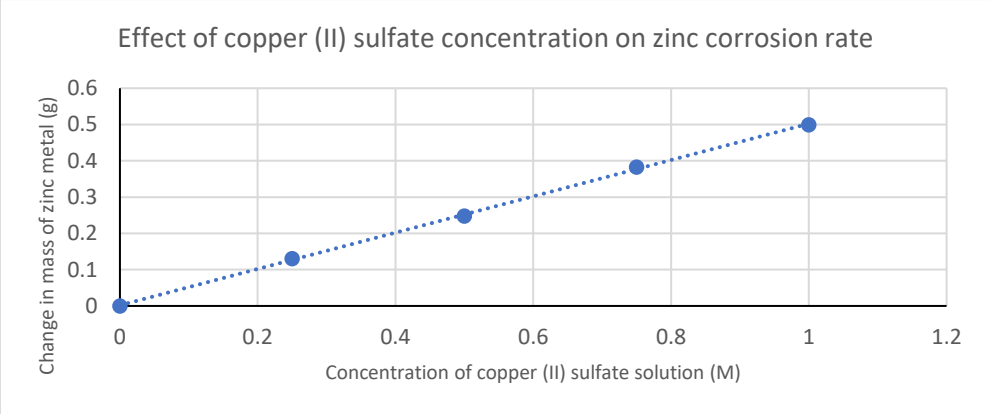


Figure 2. Graph of results

Conclusion

The gradual increase in copper (II) sulfate solution from 0.25 M to 1.0 M resulted in an increase in the mass of zinc metal lost. This demonstrates that the rate of zinc corrosion depends on the concentration of the copper (II) sulfate solution it is placed in.

a) State the **independent** variable in this experiment. (1 mark)

b) Identify a **controlled** variable in this experiment and **explain** why it is important for this variable to be controlled. (2 marks)

c) The student's conclusion is **not** valid because the experimental design is flawed. Critically review the student's experimental design. In your response, you should:
- Explain two improvements that you would make to the experimental design.
- Link these improvements to either the accuracy, precision, repeatability or reproducibility of the data (4 marks)

d) The material safety data sheet (MSDS) for 1.0 M copper (II) sulfate solution includes the following hazard statement: 'Causes skin irritation and serious eye irritation.' Apart from a laboratory coat, what personal protective equipment should be used by the student when handling 1.0 M copper (II) sulfate solution? (1 mark)

END OF EXAM