



ALL SAINTS'
COLLEGE

Semester 1 Examination 2016

Question/Answer Booklet

CHEMISTRY ATAR UNITS 3 & 4

Name: _____

Teacher: _____

Student Number:

In figures

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In words

Time allowed for this paper

Reading time before commencing work: ten minutes

Working time for paper: three hours

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: ten minutes

Working time for the paper: three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Book

To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

| Section | Number of questions available | Number of questions to be answered | Suggested working time (minutes) | Marks available | Percentage of exam |
|--------------------------------|-------------------------------|------------------------------------|----------------------------------|-----------------|--------------------|
| Section One: Multiple-choice | 25 | 25 | 50 | /50 | /25 |
| Section Two: Short answer | 9 | 9 | 60 | /70 | /35 |
| Section Three: Extended answer | 6 | 6 | 70 | /80 | /40 |
| | | | | | /100 |

Instructions to candidates

1. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each questions shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
 - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
 - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.
5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

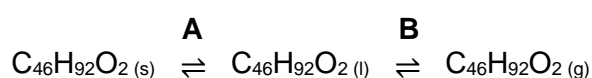
Section One: Multiple-choice

25% (50 marks)

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

1. When a candle burns, there are many different chemical processes occurring. Firstly the solid candle wax ($C_{46}H_{92}O_2$) is melted by the heat of the flame. This liquid wax is then drawn up the wick, where the heat of the flame vaporises it. The wax vapour then burns in air to produce the heat and light seen. The equation below represents the physical changes taking place in the candle wax **before** combustion occurs.



Classify the processes labelled A and B as endothermic or exothermic.

- | | A | B |
|-----|-------------|-------------|
| (a) | endothermic | endothermic |
| (b) | endothermic | exothermic |
| (c) | exothermic | exothermic |
| (d) | exothermic | endothermic |
2. Consider the information in the table below regarding three different monoprotic acids.

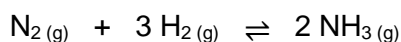
| Acid | K_a |
|-------------------|-----------------------|
| Formic acid | 1.82×10^{-4} |
| Hydrofluoric acid | 6.76×10^{-4} |
| Propionic acid | 1.35×10^{-5} |

If separate 0.5 mol L^{-1} solutions of these three acids were tested with a pH meter, at the same temperature, which would have the highest pH?

- (a) Formic acid.
(b) Hydrofluoric acid.
(c) Propionic acid.
(d) More information is required.
3. Which of the following statements regarding a 'salt bridge' is **not** correct?
- (a) A salt bridge allows ions to move between half-cells.
(b) A salt bridge prevents build up of charge in half-cells.
(c) A salt bridge is an optional component of a galvanic cell.
(d) A salt bridge takes no part in the chemical reaction occurring in either half-cell.

Questions 4 and 5 refer to the information below.

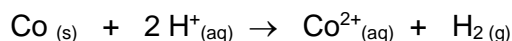
The Haber process is the final step in the production of ammonia. It involves the reaction of nitrogen and hydrogen gases in the presence of an iron/iron oxide catalyst. This process is carried out at 350-550 °C and 15-35 MPa. The reaction can be represented by the equation below.



4. Which statement is **not** correct regarding the action of a catalyst?
- A catalyst increases the rate of reaction.
 - A catalyst increases the average kinetic energy of the reactant particles.
 - A catalyst allows a greater proportion of particles to react.
 - A catalyst provides an alternate reaction pathway.
5. The iron/iron oxide catalyst is added to this system **before** it establishes equilibrium. What is the resulting effect?
- Both forward and reverse reactions would be favoured equally.
 - The forward reaction rate would be increased more than the reverse reaction rate.
 - The system would establish equilibrium faster.
 - The yield of NH_3 would be increased.
6. A student had five different 0.2 mol L⁻¹ solutions on her lab bench. They were;
- nitric acid, $\text{HNO}_3(\text{aq})$
 - zinc chloride, $\text{ZnCl}_2(\text{aq})$
 - lithium hydrogencarbonate, $\text{LiHCO}_3(\text{aq})$
 - potassium hydroxide, $\text{KOH}(\text{aq})$
 - ammonium chloride, $\text{NH}_4\text{Cl}(\text{aq})$

Rank these solutions in order of **increasing** pH (i.e. lowest to highest).

- $\text{HNO}_3 < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{KOH}$
 - $\text{KOH} < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{HNO}_3$
 - $\text{HNO}_3 < \text{LiHCO}_3 < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{KOH}$
 - $\text{KOH} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{NH}_4\text{Cl} < \text{HNO}_3$
7. Consider the following reaction between cobalt metal and hydrochloric acid.

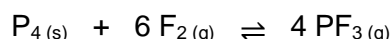


Which of the following statements is **correct**?

- Electrons are transferred from $\text{Co}(\text{s})$ to $\text{H}^+(\text{aq})$.
- Electrons are transferred from $\text{H}^+(\text{aq})$ to $\text{Co}(\text{s})$.
- Both $\text{Co}(\text{s})$ and $\text{H}^+(\text{aq})$ will each gain and lose some electrons.
- Electrons are not transferred, as this is not a redox reaction.

Questions 8, 9 and 10 refer to the following information.

Consider the following equilibrium system, which is formed when solid white phosphorus reacts with fluorine gas to form phosphorus trifluoride vapour.



8. What is the correct equilibrium constant (K) expression for the following reaction?

(a) $K = \frac{[\text{P}_4][\text{F}_2]^6}{[\text{PF}_3]^4}$

(b) $K = \frac{4[\text{PF}_3]}{6[\text{F}_2]}$

(c) $K = \frac{[\text{PF}_3]^4}{[\text{F}_2]^6}$

(d) $K = \frac{[\text{PF}_3]^4}{[\text{P}_4][\text{F}_2]^6}$

9. If the total volume of the system was increased, which of the following effects would **not** occur while equilibrium is being re-established?

- (a) The forward reaction rate would decrease.
- (b) The reverse reaction rate would be higher than the forward reaction rate.
- (c) The reverse reaction rate would increase.
- (d) The forward reaction rate would have the greater change in rate.

10. Once the system has re-established equilibrium (after the increase in total volume), which of the following statements would **not** be correct?

- (a) The mass of $\text{P}_{4(s)}$ would not have changed.
- (b) The concentration of $\text{F}_{2(g)}$ would have decreased.
- (c) The number of moles of $\text{PF}_{3(g)}$ present would have decreased.
- (d) The number of moles of $\text{F}_{2(g)}$ present would have increased.

11. The endothermic auto-ionisation of water can be represented by the equation below.



If the temperature of pure water was raised to 50°C , which of the following statements are **correct**?

- (i) The concentration of $\text{H}_3\text{O}^+_{(aq)}$ would be greater than $1.0 \times 10^{-7} \text{ mol L}^{-1}$.
- (ii) The concentration of $\text{OH}^-_{(aq)}$ would be lower than $1.0 \times 10^{-7} \text{ mol L}^{-1}$.
- (iii) The value of K_w would increase.
- (iv) The pH of the water would increase.
- (v) The acidity of the water would increase.

- (a) (i) and (ii) only
- (b) (iii) and (iv) only
- (c) (i), (iii) and (v) only
- (d) (i) and (iii) only

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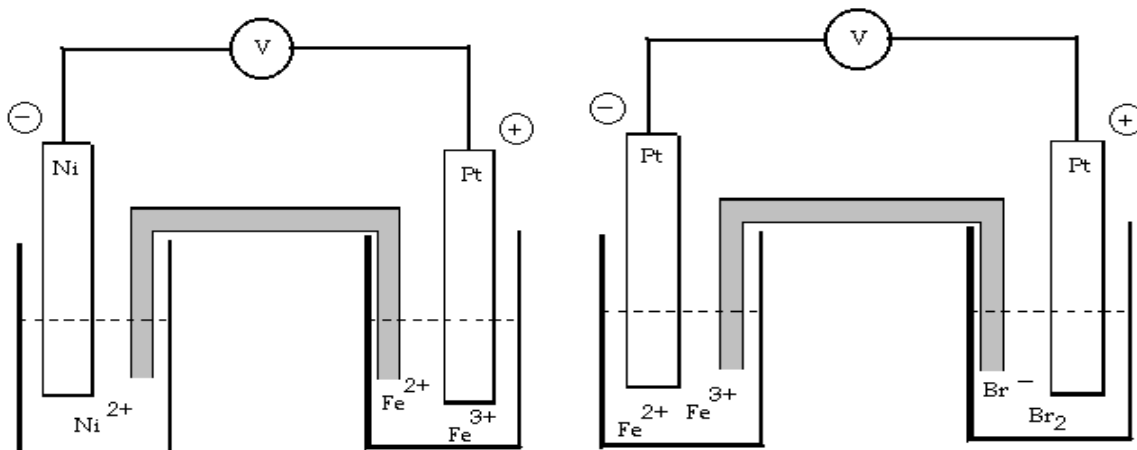
12. The pH of an aqueous solution is found to be 12.00. Which of the following solutions is consistent with this observation?

- (a) $1.00 \times 10^{-12} \text{ mol L}^{-1}$ sodium hydroxide.
- (b) $5.00 \times 10^{-3} \text{ mol L}^{-1}$ barium hydroxide.
- (c) $1.00 \times 10^{-12} \text{ mol L}^{-1}$ nitric acid.
- (d) $1.00 \times 10^{-1} \text{ mol L}^{-1}$ potassium hydroxide.

13. Calculate the pH of a solution formed by mixing 10.0 mL of 0.125 mol L^{-1} nitric acid, $\text{HNO}_3(\text{aq})$, with 90.0 mL of water.

- (a) 2.90
- (b) 1.86
- (c) 0.90
- (d) 1.90

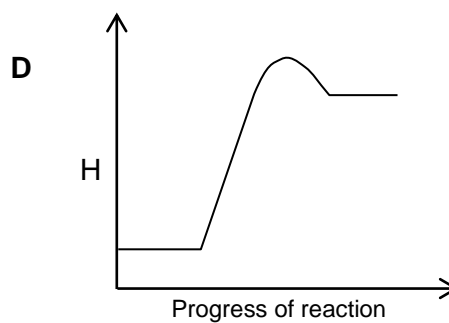
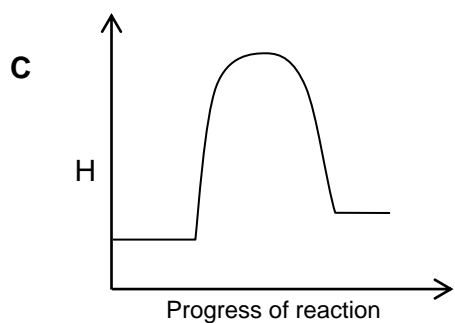
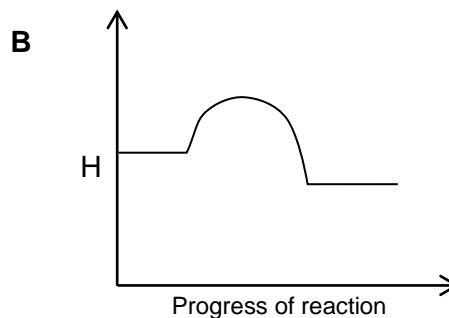
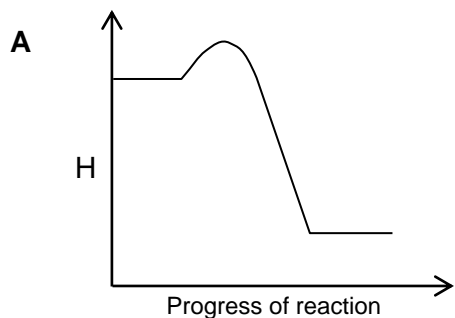
14. Consider the following electrochemical cells:



The polarities of the electrodes indicate that the strongest reducing agent present is:

- (a) $\text{Ni}_{(\text{s})}$
- (b) $\text{Ni}^{2+}_{(\text{aq})}$
- (c) $\text{Br}_{2(\text{aq})}$
- (d) $\text{Br}^{-}_{(\text{aq})}$

15. Examine the following energy profile diagrams which represent four different chemical processes. You may assume the scale on the y-axis is the same for each diagram.

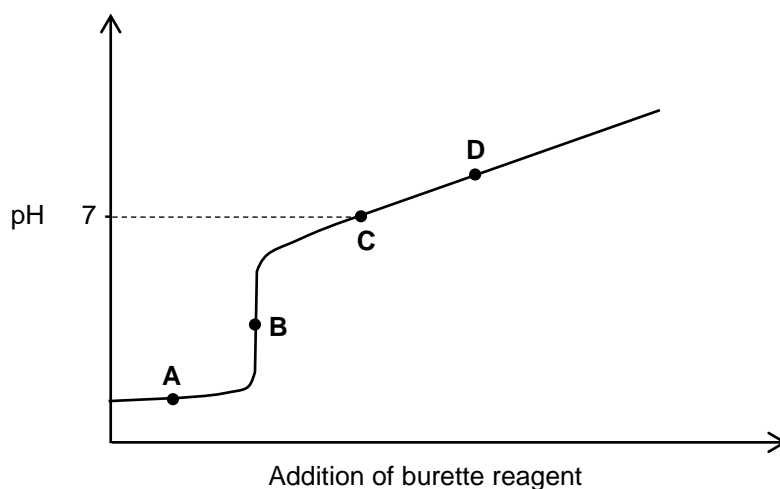


Considering the forward and reverse activation energies of these reactions, which is **most likely** to be a reversible reaction (i.e. the reaction that is most likely to proceed in both the forward and reverse directions)?

- (a) A
- (b) B
- (c) C
- (d) D

Questions 16 and 17 refer to the information below.

An acid-base titration was conducted by a chemistry professor, with the pH being monitored throughout the experiment. From the data collected, the following titration curve was produced.



16. Which of the following arrangements could have produced this titration curve?

| | Burette reagent | Conical flask reagent |
|-----|------------------------|-------------------------------|
| (a) | HNO_3 (aq) | KOH (aq) |
| (b) | NH_3 (aq) | HCl (aq) |
| (c) | NaOH (aq) | CH_3COOH (aq) |
| (d) | HCl (aq) | Na_2CO_3 (aq) |

17. Which letter represents the equivalence point of the titration?

- (a) A
- (b) B
- (c) C
- (d) D

Questions 18 and 19 refer to the following information.

Consider the following equilibrium which is formed between iron(III) ions and citrate ions, when 50 mL of iron(III) nitrate, $\text{Fe}(\text{NO}_3)_3(\text{aq})$, is mixed with 50 mL of sodium citrate, $\text{Na}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$.

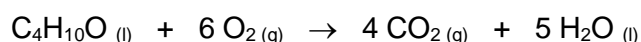


18. If this system was allowed to establish equilibrium at 25°C , which of the following would be the **best prediction** of the appearance of the system?
- (a) The solution would appear yellow.
 (b) The solution would appear brown-yellow.
 (c) The solution would appear very pale brown.
 (d) The colour of the solution cannot be predicted.
19. If a few drops of citric acid ($\text{C}_6\text{H}_8\text{O}_7$) were added to this equilibrium system, which of the following gives the expected result?

| | Favoured direction | New concentration of $\text{Fe}^{3+}_{(\text{aq})}$ |
|-----|---------------------------|---|
| (a) | forward | increased |
| (b) | forward | decreased |
| (c) | reverse | increased |
| (d) | reverse | decreased |

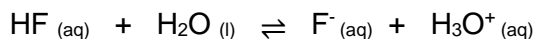
Questions 20 and 21 refer to the following information.

The equation for the complete combustion of butanol is shown below.



20. How does the oxidation number of the element carbon (C) change during this reaction?
- (a) +2 to +4
 (b) -2 to +2
 (c) -2 to +4
 (d) +2 to 0
21. Which of the following statements regarding combustion is **not** correct?
- (a) Combustion requires oxygen.
 (b) Combustion is exothermic.
 (c) Oxygen (O_2) is the oxidant/oxidising agent.
 (d) Combustion is spontaneous.

22. Consider the buffer solution shown below.



Which of the following would be **true** after the addition of a small amount of $\text{H}_3\text{O}^{+}_{(\text{aq})}$ to the buffer solution?

- (a) The forward reaction rate would decrease.
- (b) The amount of HF present in the system would increase.
- (c) The pH of the system would increase.
- (d) The forward reaction would be favoured.

23. In standardising a sodium hydroxide solution by titrating 20.00 mL aliquots against a standard hydrochloric acid solution, a student experienced difficulty in obtaining consistent values for the volume of acid added.

Which of the following sequential steps could be responsible for this lack of precision?

- (a) The burette was cleaned and rinsed thoroughly with the standard acid solution before being filled.
- (b) Several 250 mL conical flasks were washed, and rinsed thoroughly with the sodium hydroxide solution.
- (c) A clean pipette was rinsed with the sodium hydroxide solution and a 20.0 mL aliquot was carefully pipetted into each conical flask.
- (d) To each flask in turn, standard hydrochloric acid solution was added with care from the burette until the end point was observed, and the volume added was recorded.

24. In which of the following does the oxidation number of an element decrease by 3?

- (a) $\text{NO} \rightarrow \text{NO}_3^{-}$
- (b) $\text{MnO}_2 \rightarrow \text{MnO}_4^{-}$
- (c) $\text{PH}_4^{+} \rightarrow \text{P}$
- (d) $\text{CrO}_4^{2-} \rightarrow \text{Cr}^{3+}$

25. Pieces of four different metals J, L, M and N were separately placed into four solutions containing J^{2+} , L^{2+} , M^{2+} and N^{2+} ions respectively and the observations listed below:

- I Metal L remained unchanged in all four solutions.
- II Displacement reactions were observed when metal M was placed in solutions of L^{2+} and J^{2+} , but not in N^{2+} .

Which of the following electrochemical cells would produce the largest cell potential?

- (a) $\text{L} / \text{L}^{2+} // \text{N}^{2+} / \text{N}$
- (b) $\text{M} / \text{M}^{2+} // \text{J}^{2+} / \text{J}$
- (c) $\text{J} / \text{J}^{2+} // \text{L}^{2+} / \text{L}$
- (d) $\text{L} / \text{L}^{2+} // \text{M}^{2+} / \text{M}$

End of Section One

See next page

Section Two: Short answer**35% (70 marks)**

This section has **9** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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Suggested working time: 60 minutes.

Question 26**(6 marks)**

Arsenic acid (H_3AsO_4) can be produced by reacting solid arsenic trioxide (As_2O_3) with nitric acid. This produces arsenic acid, as well as the gaseous by-product dinitrogen trioxide.

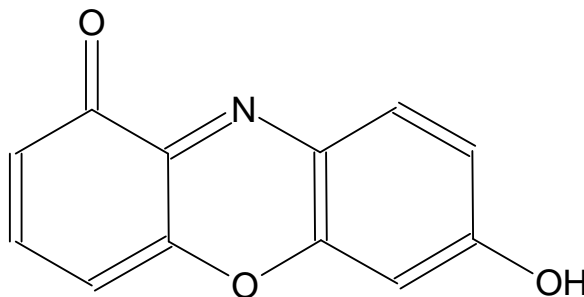
Write the oxidation and reduction half-equations and the overall redox equation for this reaction, assuming acidic conditions.

| | |
|-------------------------|--|
| Oxidation half-equation | |
| Reduction half-equation | |
| Overall redox equation | |

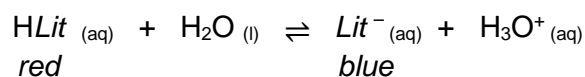
Question 27

(4 marks)

Litmus is a very common acid-base indicator which is extracted from lichens. It turns red in solutions that have a pH below 7 and blue when the pH is above 7. The substance responsible for the colour of litmus indicator is called 7-hydroxyphenoxazone. The structure of this molecule is shown below in its 'red form'.



A simplified way to express this molecule is $HLit$. This simplified notation is used in the equation below to demonstrate the reaction that litmus undergoes to change colour.



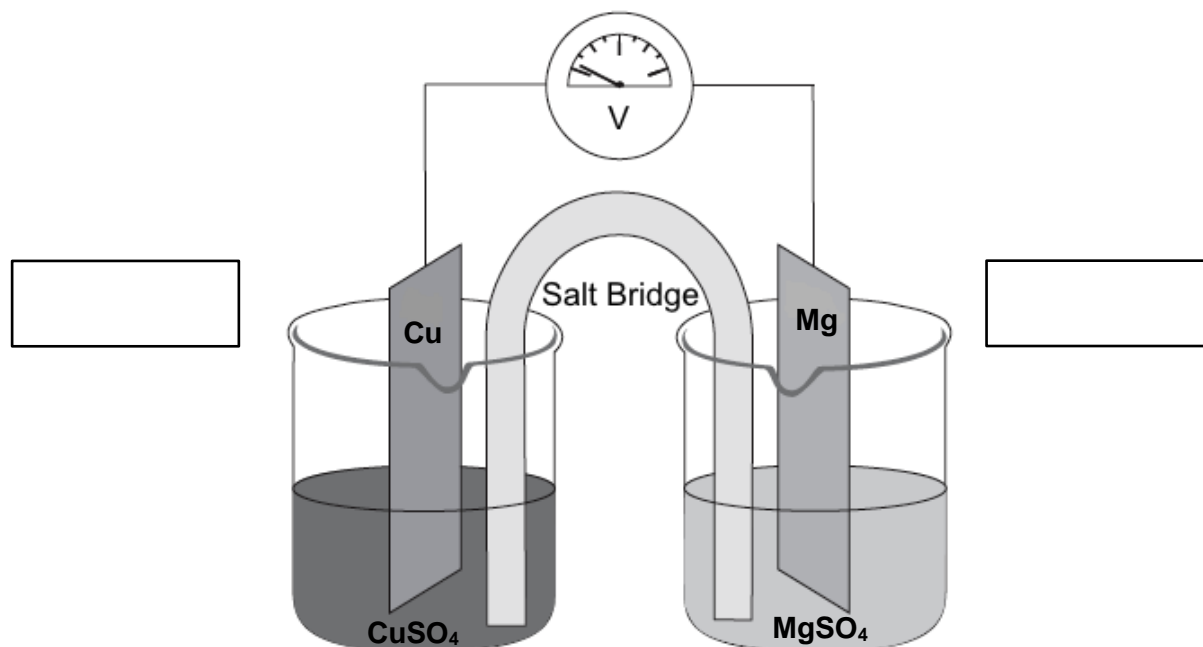
- (a) Explain how litmus indicator works. With reference to acid-base equilibria, explain the colour changes observed in acidic and basic solution. (3 marks)

- (b) Draw the 'blue form' of 7-hydroxyphenoxazone. (1 mark)

Question 28

(10 marks)

A student wishing to investigate the oxidising strength of various metals set up an electrochemical cell made up of a copper rod immersed in a solution of copper(II) sulfate and a magnesium rod immersed in a solution of magnesium nitrate. The apparatus used is shown in the diagram below.



- (a) Label the anode and cathode in the boxes provided. (1 mark)
- (b) By adding an arrow to the diagram, show the direction of electron flow in the external circuit. (1 mark)
- (c) On the diagram show the movement of ions across the salt bridge (1 mark)
- (d) Give the half equation for the reaction occurring at the positive electrode. (1 mark)
-
- (e) Identify the reducing agent (reductant) in the cell. (1 mark)
-

- (f) The initial voltage measured in the cell was higher than the 2.70 V that the student had expected to measure. Give **one** possible reason for this observation. (1 mark)

- (g) Describe an observation that would be expected to be made in the copper half-cell whilst the experiment was taking place. (1 mark)

- (h) The student weighed both electrodes before and after the experiment, and found that one had increased in mass by 0.253 g. Calculate the mass lost from the other electrode. (3 marks)

Question 29

(9 marks)

Consider the following closed equilibrium system, which has been allowed to establish equilibrium at a temperature of 600 °C. The value of K for this reaction at 600 °C is 7.94×10^{-7} .



- (a) Write an equilibrium constant (K) expression for this reaction. (1 mark)

Some additional $\text{O}_{2(g)}$ is injected into this equilibrium system at 600 °C. The system was then allowed to re-establish equilibrium.

- (b) How has the mass of $\text{Cu}_{(s)}$ present changed in this new equilibrium? (circle) (1 mark)

increased

decreased

no change

- (c) At this new equilibrium, state the concentration of $\text{O}_{2(g)}$, in mol L^{-1} . Explain your answer. (2 marks)

- (d) A small amount of $\text{Cu}_2\text{O}_{(s)}$ was then added to this equilibrium system. Explain how this would affect the equilibrium position. (2 marks)

- (e) At 800 °C, the value of K for this reaction is 3.16×10^{-5} . What does this tell you about the enthalpy change (ΔH) for this reaction? Explain your answer. (3 marks)

Question 30**(11 marks)**

Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) is an organic acid, found in high levels in foods such as almonds, banana, rhubarb and spinach. It is a weak, diprotic acid which has many uses in the laboratory, such as in volumetric analysis where it can be used as a primary standard.

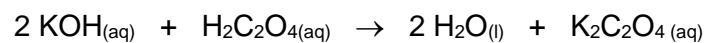
- (a) Explain what is meant when oxalic acid is referred to as a 'weak, diprotic acid'. Use relevant chemical equations to support your answer. (4 marks)

Some oxalic acid dihydrate crystals were used to produce a primary standard for use in a titration. 4.434 g of $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}_{(s)}$ was dissolved in water and made up to 250.0 mL in a volumetric flask.

- (b) Calculate the concentration of the oxalic acid primary standard. (2 marks)

- (c) What properties of oxalic acid make it a good primary standard for acid-base and redox titrations ? (2 marks)

The oxalic acid solution was then used to standardise some aqueous potassium hydroxide. A 20.00 mL sample of $\text{KOH}_{(\text{aq})}$ required 17.85 mL of oxalic acid to reach equivalence. The relevant chemical equation for the titration is shown below.



- (d) Calculate the concentration of $\text{KOH}_{(\text{aq})}$. (3 marks)

Question 31**(6 marks)**

Two beakers contained separate samples of zinc bromide solution, $\text{ZnBr}_{2(\text{aq})}$. To one beaker a piece of tin metal, $\text{Sn}_{(\text{s})}$, was added. To the second beaker a piece of magnesium metal, $\text{Mg}_{(\text{s})}$, was added. In one beaker, a reaction took place, while in the other beaker no reaction was observed.

- (a) Which of these metals (i.e. magnesium or tin) is the strongest reducing agent? Explain your answer. (2 marks)

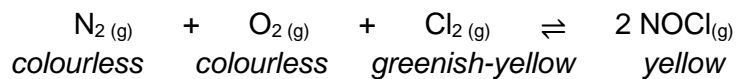
- (b) Write a balanced chemical equation for the reaction that does occur, and explain why no reaction is observed in the other beaker. (2 marks)

Some chlorine water, $\text{Cl}_{2(\text{aq})}$, was added to a separate third sample of zinc bromide solution.

- (c) Explain what would occur when these solutions were mixed. Include in your answer the expected observations. (2 marks)

Question 32**(8 marks)**

In the following equilibrium system, nitrogen, oxygen and chlorine gases combine to produce nitrosyl chloride vapour. This equilibrium system can form at temperatures of around 400 °C.



Into an initially empty, sealed flask at 400 °C, an equal number of moles of $\text{N}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{Cl}_2(\text{g})$ are injected.

- (a) Explain what would happen to the forward and reverse reaction rates as the system moved to establish equilibrium. (3 marks)

- (b) Explain what would happen to the concentration of all gases as the system moved to establish equilibrium. (3 marks)

- (c) Explain what you would observe as the system moved to establish equilibrium. (2 marks)

Question 33

(8 marks)

Phosphate buffered saline (PBS) is a solution which is commonly used in biological research. It was specifically designed so that the ion concentrations of the buffer solution match those found in the human body. The table below gives a standard 'recipe' for making PBS. The four salts are dissolved in water to produce the concentrations indicated.

| Salt | Final concentration when dissolved in distilled water | |
|----------------------------------|---|-------------------------------|
| | Conc. (g L ⁻¹) | Conc. (mmol L ⁻¹) |
| NaCl | 8.0 | 137 |
| KCl | 0.2 | 2.7 |
| Na ₂ HPO ₄ | 1.42 | 10 |
| KH ₂ PO ₄ | 0.24 | 1.8 |

- (a) Which components would produce the buffering effect observed in PBS? Explain your answer. (2 marks)

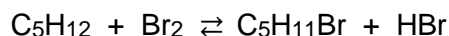
- (b) Write an equation showing the buffering system that would form. (1 mark)

- (c) Explain how this buffer is able to resist a change in pH when a small amount of NaOH(aq) is added. (2 marks)

- (d) Define 'buffering capacity' and describe how you could increase the buffering capacity of PBS. (3 marks)

Question 34**(8 marks)**

Consider the reaction in which bromine is reacted with pentane in the presence of UV light to produce 1-bromopentane. The equation for this reaction is shown below.



The reaction is allowed to reach equilibrium in a closed container.

The melting points and boiling points of each of the species in the process is given in the table below.

| Species | Melting point ($^{\circ}\text{C}$) | Boiling point ($^{\circ}\text{C}$) |
|------------------------------------|--------------------------------------|--------------------------------------|
| C_5H_{12} | -129 | 36 |
| Br_2 | -7.2 | 58.5 |
| $\text{C}_5\text{H}_{11}\text{Br}$ | -95 | 130 |
| HBr | -87 | -67 |

Write the phase, i.e., solid (s) liquid (l) or gas (g) of each species in this system at the temperatures shown in the table and **predict the effect of the imposed change** on this equilibrium at each of the temperatures in the table below.

| Temp ($^{\circ}\text{C}$) | Phase (s), (l) or (g) | | | | Imposed change | Shift in equilibrium (left, right or no change) |
|-----------------------------|---------------------------|---------------|------------------------------------|--------------|--|---|
| | C_5H_{12} | Br_2 | $\text{C}_5\text{H}_{11}\text{Br}$ | HBr | | |
| 200 | | | | | Total pressure decreased | |
| 100 | | | | | Total volume decreased | |
| 50 | | | | | Br_2 is added at constant temperature | |
| 0 | | | | | HBr is added at constant temperature | |

(8 marks)**End of Section Two**

See next page

Section Three: Extended answer**40% (80 marks)**

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

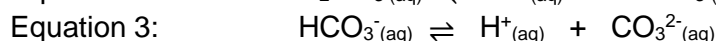
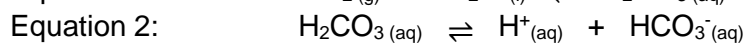
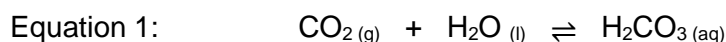
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 35**(8 marks)**

For the last few decades, the climate change debate has been taking place between the scientists, governments, companies and citizens of our planet. Rising carbon dioxide levels are thought to have contributed significantly to this climate change, including the phenomenon known as 'ocean acidification'. Some of the chemistry behind carbon dioxide and its link to ocean acidification is represented in the equations below.

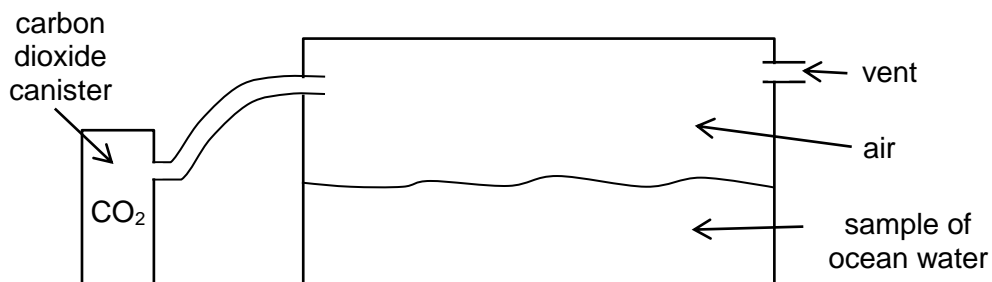


One of the many negative consequences of ocean acidification is thought to be the disruption of the chemistry of ocean water, leading to things such as a decreased rate of calcification amongst many marine organisms. For example, one of the main compounds from which coral build their structure is calcium carbonate. Ocean acidification decreases the amount of calcium carbonate available to these organisms and thereby severely impacts their survival. This has already been observed in the Great Barrier Reef and many countries are already committed to reducing their nation's carbon dioxide emissions in an effort to combat the climate change we are witnessing.

- (a) With reference to equations 1 – 3, explain how an increase in atmospheric carbon dioxide, $\text{CO}_2(\text{g})$, levels can cause a change in the pH of our oceans. (3 marks)

See next page

A chemistry teacher was attempting to demonstrate the process of ocean acidification to her class using the apparatus shown in the diagram below. A sample of ocean water was placed in a glass fish tank and a canister of carbon dioxide was attached by a tube. When the canister was opened, additional carbon dioxide gas was introduced into the air in the fish tank. A small vent ensured the overall air pressure in the fish tank remained constant.



- (b) Explain, in terms of the collision theory and with reference to Equation 1, the effect on both the forward and reverse reaction rates, when the partial pressure of $\text{CO}_{2(g)}$ present in the tank was increased. (3 marks)

- (c) Does the teacher's demonstration represent an open or closed equilibrium system? Explain. (2 marks)

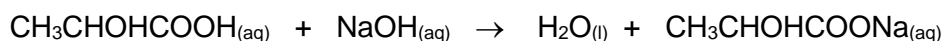
Question 36

(15 marks)

In the process of cheese making a bacterial culture is added to milk, which causes the milk to separate into the curds (solid cheese) and whey (remaining liquid). During this process the bacteria convert the lactose present in milk, into lactic acid, $\text{CH}_3\text{CHOHCOOH}$. Lactic acid is a weak, monoprotic, organic acid. Cheese makers use the concentration of lactic acid in the whey to determine when the reaction has proceeded to the extent that the cheese (curds) are ready for consumption or storage.

The concentration of lactic acid present in the whey can be determined at any time during the cheese making process via a simple titration. This usually involves taking a 10 mL sample of whey and titrating it against some standard sodium hydroxide solution, $\text{NaOH}(\text{aq})$, using phenolphthalein as an indicator.

A cheese maker added 4.00 L of milk to a small sample of bacterial culture. He knew that once the concentration of lactic acid reached $1.25 \times 10^{-2} \text{ mol L}^{-1}$ the cheese would be ready. He took a 10.00 mL sample of the whey, added several drops of phenolphthalein, and titrated the sample against a 0.111 mol L^{-1} NaOH solution. 1.15 mL of NaOH was required for equivalence. The reaction that took place in the titration is shown below.



- (a) Determine the concentration of lactic acid in the whey, and comment on whether or not the cheese maker should allow the reaction to proceed for longer before isolating the curds. (4 marks)

- (b) Explain why phenolphthalein indicator is used. Use a chemical equation to support your answer. (3 marks)

See next page

- (c) Determine the percent by mass of lactic acid present in the whey at this point in time, if the 10.00 mL sample was taken from a total volume of 3.10 L of whey. The density of the whey is 1.040 kg L^{-1} . (5 marks)

Another cheese maker mistakenly used methyl orange indicator in an identical titration.

- (d) Would he have obtained a smaller or larger NaOH titre reading? Comment on whether this is a random or systematic error. Explain your answer. (3 marks)

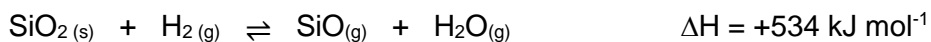
- (b) Assuming standard conditions, what results would you expect? Give your answer in the form of a table displaying the predicted EMF values. (4 marks)

- (c) Briefly describe the chemical principles behind an electrochemical cell and explain why different cells are able to produce different voltages. (4 marks)

Question 38

(17 marks)

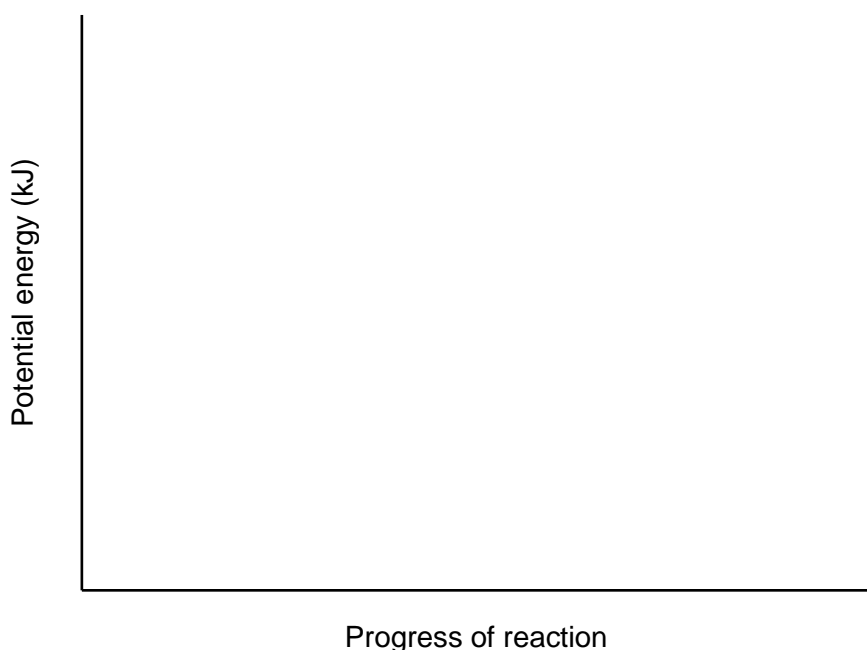
Silicon dioxide (SiO_2) is one of the most abundant substances in the Earth's crust. It is most commonly found in quartz and many types of sand and because of this, is often found in metal ores that are mined from the Earth's crust. One of the methods that can be used to remove silicon dioxide from an ore is illustrated in the equation below.



This chemical equation represents the equilibrium that forms between silicon dioxide and silicon monoxide. The activation energy for this reaction is 565 kJ mol^{-1} .

- (a) Identify the oxidising agent (oxidant) and reducing agent (reductant) in this reaction. Use oxidation numbers to support your answer. (2 marks)

- (b) Draw an energy profile diagram for this reaction. Label the activation energy and the enthalpy change. (4 marks)



- (c) Determine the value of; (2 marks)

$E_a(\text{rev})$ _____

$\Delta H(\text{rev})$ _____

Quite a low pressure, around atmospheric, is used for this process. However a high temperature of 1550 °C is maintained in the reaction chamber.

- (d) Explain, in terms of the collision theory, the effect of each of the following on reaction rate. (4 marks)

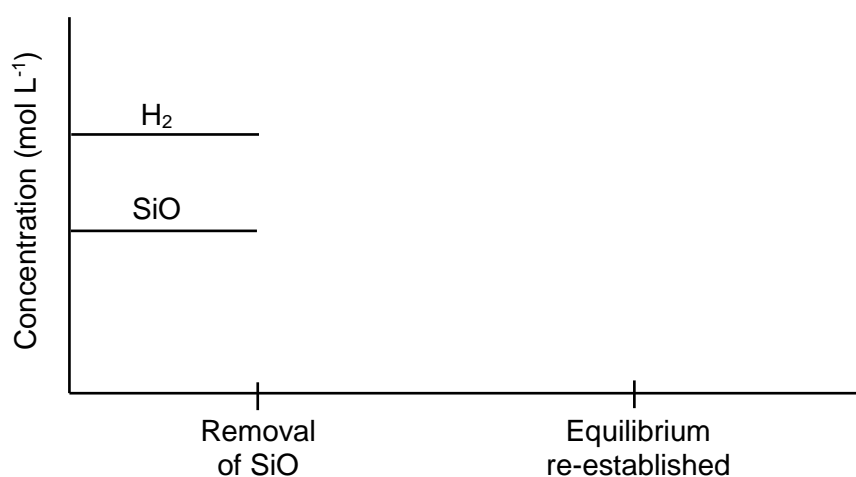
| | |
|-------------------------|--|
| Use of high temperature | |
| Use of low pressure | |

- (e) State the effect (increased, decreased or no change) of each of the following on yield. (2 marks)

| | |
|-------------------------|--|
| Use of high temperature | |
| Use of low pressure | |

Since the silicon monoxide is produced in gaseous form, SiO(g), it is easily removed from the system. This in turn helps to favour the forward reaction.

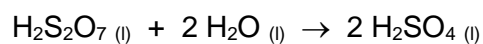
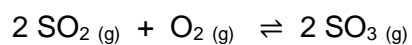
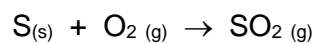
- (f) Continue the concentration graph below, by sketching the effect of removing a batch of SiO(g) from the reaction chamber. (3 marks)



See next page

Question 39**(9 marks)**

Sulfuric acid is produced in the Contact Process in the following sequence of reactions:

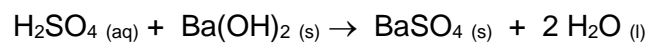


A company has an order for 4 tonnes of Sulfuric acid.

(a) Determine the molar relationship between Sulfur and Sulfuric acid. (1)

(b) Determine the mass of Sulfur needed, considering the process is 98.5 % efficient. (3)

Sulfuric acid can be used to neutralise barium sulfate, producing a precipitate of barium sulfate. A chemist dissolved 1.31 g of solid anhydrous $\text{Ba}(\text{OH})_2$ crystals into 795 mL of water and added 600 mL of a sulfuric acid solution with a concentration of $0.0125 \text{ mol L}^{-1}$.



- (c) Determine whether this solution was acidic, basic or neutral (i.e. whether one of the reactants is limiting). (2)

- (d) Calculate the resulting pH of the solution (3)

Question 40

(18 marks)

Barium is a highly toxic substance to higher animals and can accumulate in animal and plant tissue. High barium levels can affect the ability of plants to photosynthesize, and in higher animals can cause heart disease, respiratory failure, kidney damage, and muscle weakness. Student chemists were interested in determining the concentration of barium (II) ions in a large water pond outside of a glass making factory.

The basic technique involved adding sodium sulfate (Na_2SO_4) to a 400.0 mL water sample to precipitate out the barium as barium (II) sulfate. The acceptable level of barium in drinking water is 2.0 mg/L. Levels above 50 mg/L are considered to be immediately dangerous to life and health.

- (a) Write a balanced chemical equation for the precipitation reaction. (1 mark)

- (b) The barium sulfate precipitate was collected and placed in a special oven for drying at 110°C. Over time the sample was weighed and re-weighed. (1 g = 1000 mg)

| Weighing | Mass(mg) |
|----------|----------|
| 1 | 23.0 |
| 2 | 21.5 |
| 3 | 19.0 |
| 4 | 19.0 |

- Why was the sample weighed four times? (1 mark)

- (c) Calculate the mass of **barium** (in mg) in the dry precipitate. (2 marks)

- (d) Determine the concentration of barium ions (in mg/L), in the polluted water sample. (Assume the density of the water is 1000 mg/L) (2 marks)

- (e) How does the concentration of barium ions in the water sample compare with the accepted level in drinking water? (1 mark)

- (f) The students assumed that no other ions in the water formed precipitates with the sodium sulfate solution.
Name **ONE** other ion that would also form a precipitate with sulfate ions? (1 mark)

After this preliminary result, the students decided to extend their investigation over a number of weeks to see how barium levels changed over time, and so tested more water samples. Their results are tabulated below:

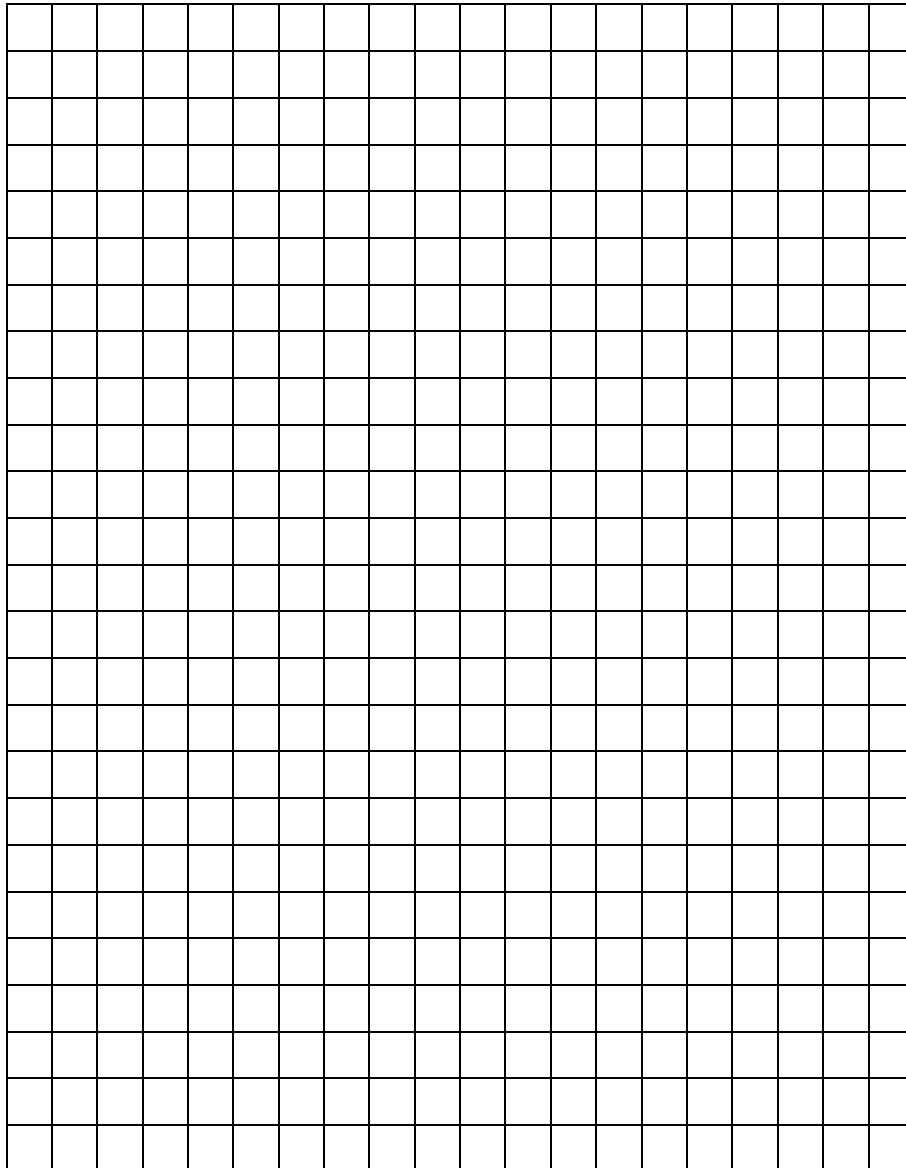
| Day | Concentration of Ba ²⁺ (mg/L) |
|-----|--|
| 0 | Refer to answer in (d) |
| 3 | 30 |
| 6 | 36 |
| 9 | 45 |
| 12 | 60 |
| 15 | 55 |
| 18 | 58 |

- (g) For this extended investigation what was the: (2 marks)

| | |
|----------------------|--|
| independent variable | |
| dependent variable | |

- (h) State two (2) variables that would need to be controlled? (2 marks)

- (i) Plot the information on the graph paper below. Include a heading and all labels. (5 marks)



- (j) What conclusions can be made from this investigation? (1 mark)

END OF EXAM

See next page

