Neap:

Trial Examination 2018

VCE Chemistry Unit 2

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	5	5	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 17 pages
Data booklet
Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

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

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.
You may keep the data booklet.

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

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

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

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

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

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

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

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

Question 1

Which one of the following is a conjugate **redox** pair?

A. H_2O and OH^-

B. Na^+ and NaCl

C. HNO_3 and NO_3^-

D. Ca and Ca^{2+}

Question 2

40 mL of 0.10 M sodium hydroxide is added to 60 mL of 0.10 M hydrochloric acid.

The concentration of hydronium ion (in M) in the final solution is closest to

A. 1.0×10^{-7}

B. 2.0×10^{-3}

C. 2.0×10^{-2}

D. 3.3×10^{-3}

Question 3

Acid rain is produced when acidic gases in the atmosphere dissolve in the rainwater as it falls to form a solution with a pH as low as 5.5. Consider the following:

I marble statues and buildings mostly made from calcium carbonate

II structures made from iron

III aquatic life in rivers which collect rainwater

Which of the above are likely to be damaged when exposed to acid rain?

A. I and II only

B. II and III only

C. I and III only

D. I, II and III

Use the following information to answer Questions 4–6.

The percentage ionisation of three different acids of concentration 0.10 M is shown in the table below.

Acid	citric	ethanoic	nitric
% ionisation	8	1.3	100

Question 4

The pH of 0.10 M citric acid is closest to

A. 1.0
B. 1.9
C. 2.1
D. 8.0

Question 5

The three acid solutions are colourless liquids and have the same appearance. To distinguish between the three acid solutions, the following methods were suggested:

I measure the electrical conductivity of each liquid

II use different indicators and observe the colour changes

III determine the volume of a strong base needed to neutralise a set volume of each acid solution

Which of these methods could be used to distinguish between the three acid solutions?

A. I and II only
B. II and III only
C. I and III only
D. I, II and III

Question 6

Which one of the following shows correct descriptions for the acids and the solutions in the table above?

	0.1 M ethanoic acid	**0.1 M nitric acid**
A.	dilute	concentrated
B.	weak	weak
C.	dilute	strong
D.	weak	concentrated

Question 7

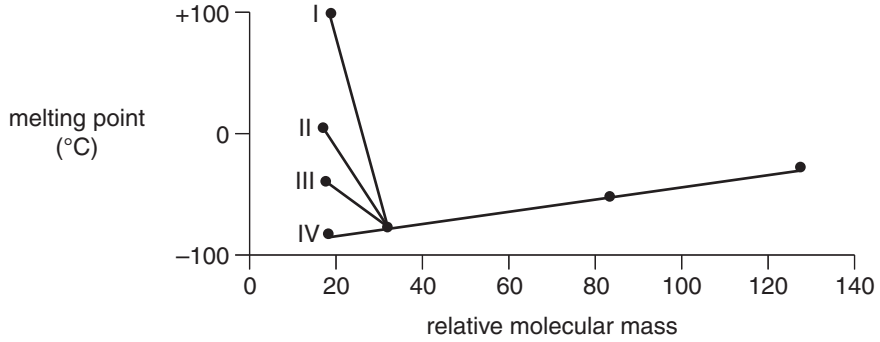
75.0 mL of 0.546 M sodium chloride solution was taken and diluted with water to produce a solution of concentration 0.164 M.

What volume of water, in mL, was added in the dilution?

A. 22.5
B. 97.5
C. 175
D. 250

Use the following information to answer Questions 8 and 9.

The graph below shows the melting points of the group 16 hydrides plotted against the relative molecular mass of the hydrides.



Question 8

Which line shows the correct melting point value for the hydride with the lowest relative molecular mass?

A. I
B. II
C. III
D. IV

Question 9

Which type of intermolecular bonding accounts for the increase in melting points for the hydrides with molecular masses between 30 and 130?

A. dispersion forces
B. covalent bonding
C. dipole-dipole interactions
D. hydrogen bonding

Question 10

The latent heat of vaporisation of water is approximately five times the value for methane.

Which one of the following is the best explanation for this difference?

A. The covalent bonds in water are stronger than those present in methane.
B. At room temperature, water is a liquid whereas methane is a gas.
C. Water molecules have a higher relative molecular mass than methane molecules.
D. The bonds between the molecules are weaker for methane than for water.

Use the following information to answer Questions 11 and 12.

The pH values of three different solutions at the same concentration at 25°C are shown in the table below.

Solution	Na_2SO_4	$NaHSO_4$	H_2SO_4
pH at 25°C	7.0	3.0	1.0

Question 11

Which one of the following statements about the solutions is correct?

A. The concentration of all of the solutions is 0.10 mol L^{-1}.

B. The acidity of Na_2SO_4 solution is more than double that of $NaHSO_4$ solution.

C. Adding water to a sample of H_2SO_4 solution will decrease its pH.

D. In the Na_2SO_4 solution, $[H_3O^+] = [OH^-] = 10^{-7.0}$ M.

Question 12

Which of the solutions will react with both a strong acid and a strong base?

A. Na_2SO_4 only

B. $NaHSO_4$ only

C. H_2SO_4 only

D. Na_2SO_4 and $NaHSO_4$

Question 13

Sodium carbonate (Na_2CO_3) is used as a primary standard in volumetric analysis.

What mass of sodium carbonate is needed to produce 250.0 mL of 0.612 M standard solution?

A. 1.44 g

B. 3.85 g

C. 16.2 g

D. 43.3 g

Question 14

Oxidation is said to have occurred when

A. a non-metal ion reacts to form a gaseous molecule of the non-metal.

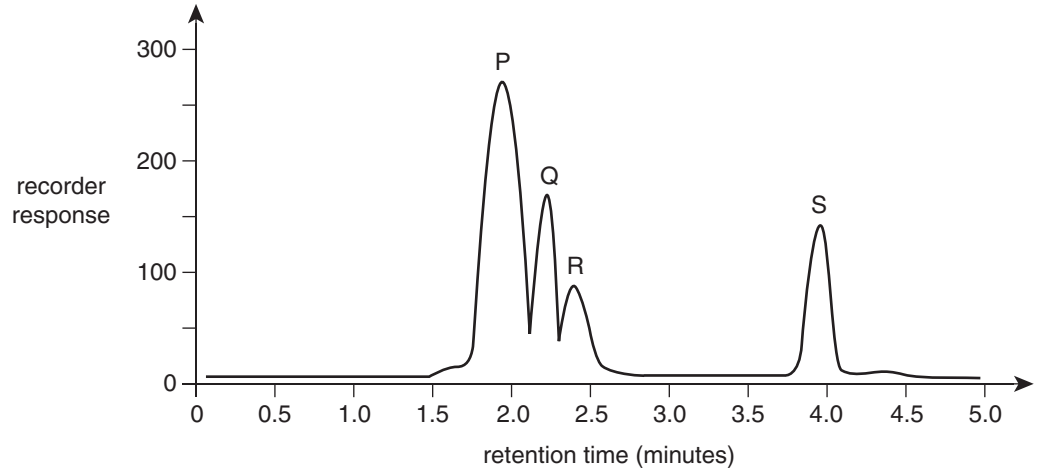
B. a metallic ion precipitates from a solution as an insoluble salt.

C. a metal ion becomes a metal atom.

D. oxygen changes from the liquid state to the gaseous state.

Use the following information to answer Questions 15 and 16.

The water in the dams on two different farms was analysed by high-performance liquid chromatography (HPLC) using the same instrument under identical conditions. The result of farm 1's analysis is shown below with the peaks labelled P, Q, R and S.



Question 15

Which one of the following statements is **incorrect**?

A. Each of the four peaks shows the presence of a different compound in the water.

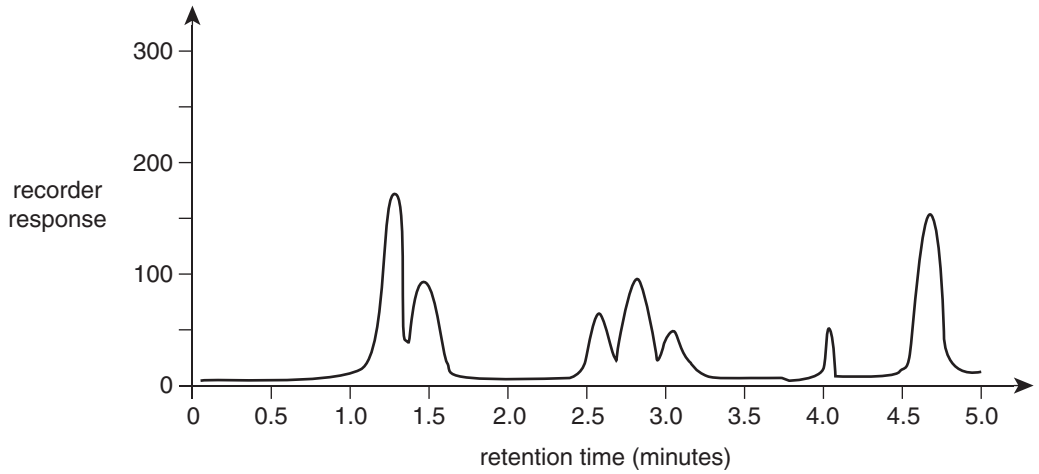
B. Lowering the temperature of the column would decrease each retention time.

C. Component P is least strongly attracted to the HPLC column.

D. Component R has the lowest concentration of any of the components.

Question 16

Component S in the dam water analysis of farm 1 has been shown to be a particular pesticide of concentration 20 ppm. The following HPLC analysis is for dam water on farm 2.



Which of the following is the most likely concentration of the pesticide in the water from farm 2?

A. 0 ppm

B. 3 ppm

C. 10 ppm

D. 20 ppm

Question 17

Freshwater makes up approximately 2.5% of the total water on Earth.

Approximately how much of this global freshwater is found in glaciers and ice caps?

A. less than 20%
B. 20%
C. 50%
D. more than 50%

Question 18

Which one of the following shows an **incorrect** concentration of the solution formed when 1.0 g of chlorine gas (Cl_2) is dissolved completely in 250 000 L of water?

A. 4.0×10^{-5} % m/v
B. 4.0×10^{-6} g L^{-1}
C. 5.6×10^{-8} M
D. 4.0×10^{-3} ppm

Question 19

A strip of lead (Pb) is placed in a solution containing both copper ions and zinc ions.

Which one of the following would **not** be expected to occur?

A. A deposit appears on the surface of the lead.
B. The concentration of the zinc ion in the solution decreases.
C. The blue colour of the solution caused by the copper ion slowly fades.
D. The lead strip slowly dissolves.

Question 20

Which one of the following relating to the solubility of methane gas (CH_4) molecules in water is correct?

	Methane gas solubility in water	**Change in solubility with increasing temperature**
A.	very low	decrease
B.	very low	increase
C.	very high	decrease
D.	very high	increase

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black 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 booklet are **not** drawn to scale.

Question 1 (13 marks)

Aluminium is one of the most widely used metals globally.

a. Aluminium reacts readily in air to produce a layer of aluminium oxide which does not allow oxygen gas or water to penetrate.

Write a balanced chemical equation for this reaction. 2 marks

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b. An experiment was conducted to determine the relative reactivity of aluminium with three other metals: X, Y and Z. Freshly polished samples of each of the metals were placed separately in solutions of the metal ions and any displacement reaction (deposition of a metal) was noted. The results of the experiment are shown in the table below.

	Al	**Metal X**	**Metal Y**	**Metal Z**
$\mathbf{Al^{3+}}$		no reaction	displacement	no reaction
$\mathbf{X^{2+}}$	displacement		displacement	no reaction
$\mathbf{Y^{2+}}$	no reaction	no reaction		no reaction
$\mathbf{Z^{2+}}$	displacement	displacement	displacement	

Commencing with the most reactive metal, use X, Y, Z and Al to show the order of reactivity of the four metals. 2 marks

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c. As with all reactive metals, aluminium will react with an acid.

i. Write a balanced **ionic** equation for the reaction of aluminium with sulfuric acid (H_2SO_4). 2 marks

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ii. Write the half-equation for the oxidation process which occurs in the reaction between aluminium and the acid. 1 mark

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iii. Identical pieces of pure aluminium were reacted separately with 1.0 M HCl (a strong acid) and 1.0 M HCOOH (a weak acid).

Outline how the observations in the experiments would be different. 1 mark

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d. Aluminium is produced from the mineral alumina, which is refined from a substance known as bauxite. Sodium hydroxide (NaOH) is used in the extraction process.

i. Sodium hydroxide solutions contain the strong base, hydroxide ion.

Why is the hydroxide ion classified as a strong base? 1 mark

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ii. Samples of waste water from the alumina refinery were found to contain sodium hydroxide. Volumetric analysis was used to determine the concentration of sodium hydroxide in the waste water. The following results were recorded:

volume of waste water sample analysed	20.00 mL
concentration of hydrochloric acid used in titrations	0.135 M
average titre of HCl required to reach the **endpoint**	14.65 mL

Calculate the concentration of sodium hydroxide (in mol L^{-1}) in the waste water. 3 marks

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iii. What is meant by the 'endpoint' of the titration? 1 mark

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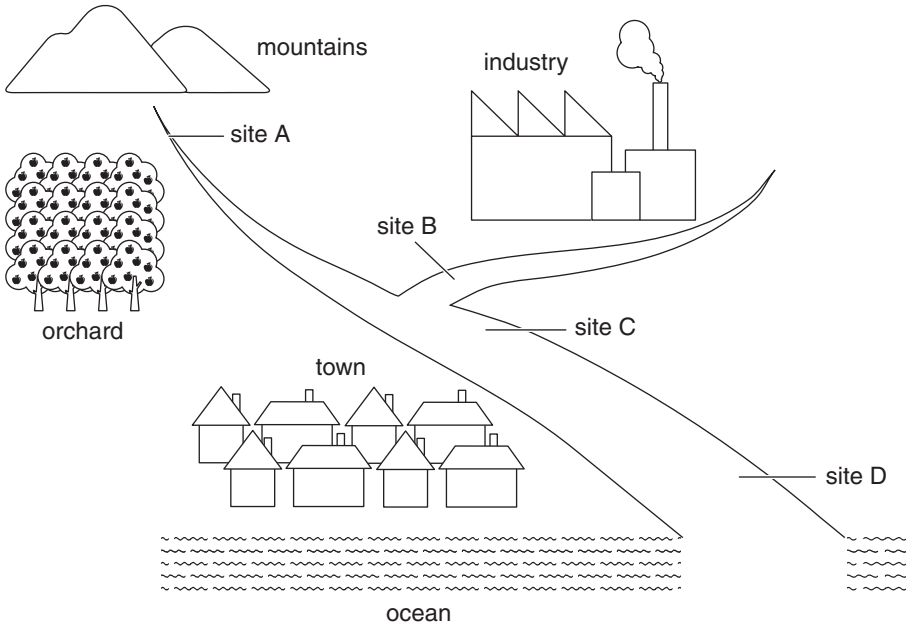
Question 2 (13 marks)

The map below shows a region in which water from industry, an orchard and a town finds its way into the river system. Water samples were collected at sites A, B, C and D and transported to a laboratory for a range of water quality tests.



a. **i.** Chemical contaminants are likely to be present in the river system.

Define the term 'chemical contaminant'. 1 mark

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ii. State **two** important steps in the water-sampling protocol which must be taken to allow accurate analytical results to be obtained. 2 marks

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b. The dissolved oxygen content of the water at site B was much lower than any of the other sites.

Explain how the industry in the map could be responsible for this. 2 marks

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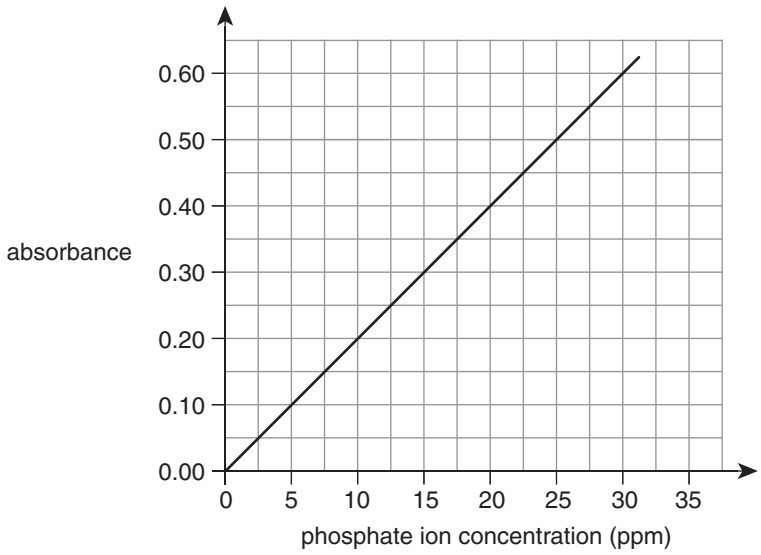
c. UV-visible spectroscopy was used to analyse water samples for phosphate ion content. Each water sample was treated with a special reagent to form a phosphate ion complex which is coloured blue. Standard solutions of known concentration of phosphate ion were similarly treated with the reagent and used to produce the calibration graph shown below.



i. The absorbance of the water sample from site C is 0.35.

What is the phosphate ion concentration of the sample in parts per million? 1 mark

_____

ii. The phosphate ion concentrations at sites A and B are both close to zero.

Suggest **one** reason why the concentration at site C is so high. 1 mark

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iii. The absorbance of the water sample from site D is 0.70.

Explain what action could be taken to determine the phosphate ion concentration in this water sample accurately. 2 marks

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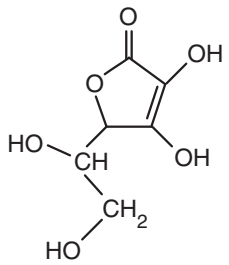
d. Site D will include waste materials from the town. The molecular structures of two of the compounds in this waste material are shown below.



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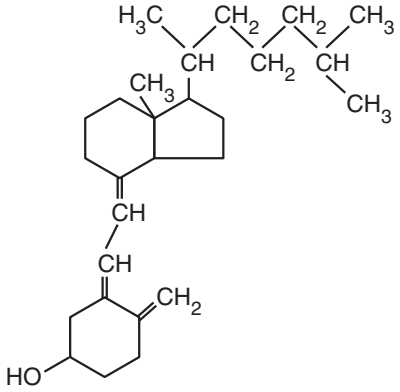

II

Which compound/s is/are likely to be water-soluble? Give an explanation for each choice in terms of structure and bonding. 2 marks

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e. To determine the concentration of iron in the water samples, any iron present as Fe^{2+} ions was reacted with a particular reagent to form the orange–yellow complex iron(II)-1,10-phenanthroline. UV-visible spectroscopy was again used for analysis.

Explain why it is necessary to use a different wavelength of light in this UV-visible analysis compared to that used in the phosphate ion analysis. 1 mark

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f. Name another analytical instrument (other than a colorimeter/UV-visible spectrophotometer) which could be used for analysis of iron concentration in the water samples. 1 mark

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Question 3 (16 marks)

Two related compounds, potassium chloride (KCl) and potassium chlorate ($KClO_3$), have precisely the same solubility of 57 grams per 100 g of water at 98°C. At lower temperatures, KCl is much more soluble in water than $KClO_3$.

a. **i.** Calculate the molarity of KCl at 98°C at its maximum solubility, assuming the density of water is 1.0 g mL^{-1}. 2 marks

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ii. When KCl dissolves in water, dissociation occurs. When HCl is added to water, ionisation occurs.

Explain the difference between ionisation and dissociation. 2 marks

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iii. KCl is soluble in water because water molecules are able to keep both potassium ions and chloride ions in solution.

With the aid of a labelled diagram to show the interactions and bond type between the chloride ions and water molecules, explain how water molecules keep the chloride ions in solution. 3 marks

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b. Solutions of KCl conduct electricity because ions are free to move.

Outline the steps needed in a laboratory to determine the concentration of a solution of KCl using electrical conductivity. 3 marks

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c. An experiment was conducted to find the solubility of $KClO_3$ over a range of temperatures. The following method was used:

1. Heat 10.0 mL of pure water from 20°C to 85°C in a large test tube.
2. Add 4.00 g of solid $KClO_3$ and agitate to dissolve.
3. Allow to cool and note the temperature at which crystals of $KClO_3$ first appear.
4. Add a further 2.0 mL of pure water to the test tube and heat to 85°C to dissolve crystals.
5. Repeat steps 3 and 4 until five tests have been completed as shown in the table of results below.

	Test A	**Test B**	**Test C**	**Test D**	**Test E**
Contents of test tube	4.00 g of $KClO_3$ + 10.0 mL of water	a further 2.0 mL of water	a further 2.0 mL of water	a further 2.0 mL of water	a further 2.0 mL of water
Temperature at which crystals first appeared	82°C	74°C	68°C	63°C	59°C

i. Calculate the amount of energy (in J) used to heat the 10.0 mL of water in step 1.
Assume that the density of the water is 1.0 g mL^{-1}. 1 mark

_____

_____

ii. What type of solution is present when crystals first appear in step 3? 1 mark

_____

iii. Calculate the solubility of $KClO_3$ at 59°C in grams per 100 g of water. 2 marks

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_____

d. The solubility of NaCl in grams of solute per 100 g of water at various temperatures is shown in the table below.

Temperature (°C)	0	10	20	30	40	50
Solubility of NaCl (g of solute per 100 g of water)	35.7	35.8	36.0	36.3	36.6	37.0

Explain why the method to determine solubility used in **part c.** would not be suitable in determining the solubility of NaCl. 2 marks

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Question 4 (8 marks)

A 2.00 g sample of a particular fertiliser was analysed to determine the sulfate (SO_4^{2-}) content using the following steps:

1. The sample was added to water in a beaker and stirred thoroughly.
2. The contents of the beaker was filtered and some pure water was washed through the filter paper into the filtered liquid.
3. 50.0 mL of 0.750 M barium chloride solution was added to the filtered liquid.
4. The barium sulfate precipitate formed was isolated and found to weigh 3.54 g.

a. The equation for the precipitation reaction in step 3 is as follows:

$$MgSO_4(aq) + BaCl_2(aq) \rightarrow MgCl_2(aq) + BaSO_4(s)$$

i. Write the ionic equation for the precipitation reaction. 1 mark

_____

ii. Write the formula of a spectator ion in the reaction. 1 mark

_____

b. **i.** Why was filtration carried out in step 2? 1 mark

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ii. Calculate the number of mole of barium sulfate formed in step 4. 1 mark

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iii. Calculate the mass of SO_4^{2-} in the barium sulfate precipitate. 1 mark

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iv. Find the percentage by mass of SO_4^{2-} in the fertiliser sample. 1 mark

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c. State **one** assumption which was used in the investigation. 1 mark

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d. Suggest **one** way in which the reliability of the result of the analysis could be improved. 1 mark

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Question 5 (5 marks)

In addition to its ability to dissolve many substances, water can act as an acid, a base, an oxidising agent and a reducing agent.

a. Consider the reaction shown in the following equation:

$$2Cl_2(g) + 2H_2O(l) \rightarrow 4HCl(aq) + O_2(g)$$

How is water acting in this reaction? Indicate your response by circling one or more of the terms listed below. 1 mark

acid *base* *oxidising agent* *reducing agent*

b. Water may appear in the equation for a redox reaction but may not be either the oxidising or reducing agent.

Consider the reaction shown in the following equation:

$$C_2H_6O(aq) + MnO_4^-(aq) + H^+(aq) \rightarrow C_2H_4O_2(aq) + Mn^{2+}(aq) + H_2O(l)$$

i. Write a balanced half-equation for the oxidation process occurring in this reaction. 1 mark

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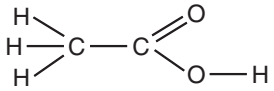
ii. The structural formula of the product $C_2H_4O_2$ is shown below. This product is an acid.



Circle **one** acidic proton on the diagram of the CH_3COOH molecule. 1 mark

iii. The concentration of a solution of C_2H_6O was investigated using volumetric analysis based on the reaction shown.

10.0 mL of C_2H_6O solution was diluted to a total volume of 100.0 mL in a volumetric flask. A 20.00 mL aliquot of this diluted C_2H_6O solution was pipetted into a small conical flask. The flask contents were titrated with a standardised acidified MnO_4^- solution until the endpoint was detected.

In the table below, fill in the liquid which should be used for the final rinse of each piece of glassware immediately prior to its use in this volumetric analysis. 2 marks

Glassware	Liquid used for final rinse prior to use
100.0 mL volumetric flask	
50.0 mL burette	

END OF QUESTION AND ANSWER BOOKLET