

Semester Two Examination, 2013

Question/Answer Booklet

CHEMISTRY

Stage 3

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

Material required/recommended for this paper

To be provided by the supervisor

This Question/Answer booklet

Multiple-choice Answer sheet

Chemistry Data sheet

To be provided by the candidate

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

Special items: 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	25	25
Section Two: Short answer	8	8	60	70	35
Section Three: Extended answer	5	5	70	80	40
Total					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2013*. Sitting this examination implies that you agree to abide by these rules.
2. Answer the questions according to the following instructions.

Section One: 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.

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

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to three significant figures and include appropriate units where applicable.
4. 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.
5. 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 question(s) that you are continuing to answer at the top of the page.
6. The Chemistry Data Sheet 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: 45 minutes.

1. An element, X, was found to have the following successive ionisation energies:

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation energy/kJ mol ⁻¹	736	1450	7740	10500	13600	18000	21700	25600

Which of the following represents the **most** likely formula for the sulfate of X?

- (a) XSO₄
 - (b) X₂SO₄
 - (c) X₂(SO₄)₃
 - (d) X(SO₄)₂
2. Which of the following bonds would be expected to have the **greatest** polarity?
- (a) N–F
 - (b) P–F
 - (c) S–F
 - (d) O–F
3. Carbon, silicon, germanium, tin, and lead are all placed together in the same group of the periodic table because:
- (a) They have the same number of valence electrons.
 - (b) Each has a structural form with delocalized electrons.
 - (c) Atoms of each element have the same number of electrons.
 - (d) There is a gradual increase in their atomic masses.
4. Arsenic has 23 isotopes, the lightest of which is ⁶⁵As. Which of the following correctly lists the number of subatomic particles in the arsenide (⁶⁵As³⁻) ion?
- (a) 65 protons, 33 neutrons and 68 electrons
 - (b) 33 protons, 32 neutrons and 30 electrons
 - (c) 65 protons, 32 neutrons and 65 electrons
 - (d) 33 protons, 32 neutrons and 36 electrons

See next page

5. Place the following substances in order of melting point, starting with the **lowest**:

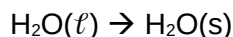
$\text{Na}_2\text{O}(\text{s})$, $\text{SO}_2(\text{s})$, $\text{O}_2(\text{s})$, $\text{CaO}(\text{s})$

- | | | | | |
|-----|-------------------------|-------------------------|---------------------------------|---------------------------------|
| (a) | $\text{SO}_2(\text{s})$ | $\text{O}_2(\text{s})$ | $\text{Na}_2\text{O}(\text{s})$ | $\text{CaO}(\text{s})$ |
| (b) | $\text{SO}_2(\text{s})$ | $\text{O}_2(\text{s})$ | $\text{CaO}(\text{s})$ | $\text{Na}_2\text{O}(\text{s})$ |
| (c) | $\text{O}_2(\text{s})$ | $\text{SO}_2(\text{s})$ | $\text{Na}_2\text{O}(\text{s})$ | $\text{CaO}(\text{s})$ |
| (d) | $\text{O}_2(\text{s})$ | $\text{SO}_2(\text{s})$ | $\text{CaO}(\text{s})$ | $\text{Na}_2\text{O}(\text{s})$ |
6. Which of the following statements about the carbonate, nitrate, and sulfite ions is/are **true**?
- (i) They are all negatively charged
 - (ii) They all have the same total number of electrons
 - (iii) They all have three atoms bonded to the central atom
 - (iv) They all have the same number of bonding pairs of electrons
- (a) (i) and (iii) only
(b) (ii) and (iv) only
(c) (i), (iii) and (iv) only
(d) (i), (ii), (iii) and (iv)
7. Which of the following molecules has a planar shape?
- (a) cyclopentene
(b) methanol
(c) methanal
(d) ammonia
8. Predict which of the following has the **greatest** solubility in water.
- (a) Propanoic acid
(b) Propan-1-ol
(c) Silver iodide
(d) Magnesium phosphate
9. Predict which one of the following aqueous solutions is the **best** conductor of electricity.
- (a) 1.00 mol L^{-1} ethanoic acid
(b) 1.00 mol L^{-1} ammonia
(c) 1.00 mol L^{-1} calcium chloride
(d) 1.00 mol L^{-1} nitric acid
10. The solubility of oxygen in seawater at 20°C is 14.4 mg L^{-1} . Which of the following is the maximum concentration of oxygen in seawater, given in mol L^{-1} ?
- (a) $4.5 \times 10^{-1} \text{ mol L}^{-1}$
(b) $9.0 \times 10^{-1} \text{ mol L}^{-1}$
(c) $4.5 \times 10^{-4} \text{ mol L}^{-1}$
(d) $9.0 \times 10^{-4} \text{ mol L}^{-1}$

11. Which of the following contains the **largest** number of atoms?

- (a) 6.022×10^{22} molecules of methane
- (b) 0.24 mol of argon gas
- (c) 12 L of nitrogen gas at 100 kPa and 200 K
- (d) 10 g of nitrogen monoxide

12. The sign of ΔH for the process:



- (a) is positive and the reaction is endothermic.
- (b) Is positive and the reaction is exothermic.
- (c) is negative and the reaction is endothermic.
- (d) is negative and the reaction is exothermic.

13. Which of the following statements about the effect of a catalyst is **false**?

- (a) A catalyst increases the proportion of particles possessing sufficient energy to react.
- (b) A catalyst boosts the energy of reactants, enabling to collide with enough energy to react.
- (c) A catalyst provides an alternative reaction pathway.
- (d) A catalyst is not consumed in a reaction.

14. Which of the following lists the 1 mol L⁻¹ solutions in of **increasing** pH?

- | | | | |
|--|--------------------------|--|--|
| (a) CH ₃ COOH(aq) | NH ₄ Cl(aq) | NaCl(aq) | CH ₃ CH ₂ NH ₂ (aq) |
| (b) CH ₃ COOH(aq) | NaCl(aq) | NH ₄ Cl(aq) | CH ₃ CH ₂ NH ₂ (aq) |
| (c) CH ₃ CH ₂ NH ₂ (aq) | NaCl(aq) | NH ₄ Cl(aq) | CH ₃ COOH(aq) |
| (d) NH ₄ Cl(aq) | CH ₃ COOH(aq) | CH ₃ CH ₂ NH ₂ (aq) | NaCl(aq) |

15. During an experiment to establish the concentration of an oxalic acid solution, a student carried out the following steps.

- Rinsed a burette with distilled water.
- Rinsed a conical flask with distilled water.
- Filled the burette with a standardised sodium hydroxide solution.
- Rinsed a pipette with the solution of oxalic acid.
- Dispensed 25 mL of oxalic acid into the conical flask using the pipette.

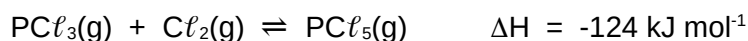
What effect would her procedure have had on the accuracy of her results?

- (a) An artificially large volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too low.
- (b) An artificially small volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too low.
- (c) An artificially large volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too high.
- (d) An artificially small volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too high.

16. What would be the **most** likely pH of a 0.10 mol L^{-1} solution of sulfuric acid?

- (a) Less than 0.5
- (b) Between 0.5 and 1
- (c) Exactly 1
- (d) Approximately 1.5

The next three questions (17, 18 and 19) refer to the following reaction between phosphorus trichloride and chlorine to form phosphorus pentachloride:



17. If phosphorus trichloride and chlorine were placed in a sealed insulated vessel together with a catalyst, which of the following would **not** cause an increase in the rate at which equilibrium would be attained?

- (a) Increasing the volume of the vessel
- (b) Increasing the temperature
- (c) The addition of chlorine to the reaction mixture
- (d) Increasing the state of sub-division of the catalyst

18. Which of the following statements is/are **true** when the system is at equilibrium?

- (i) Reactants are no longer turning into products.
- (ii) The concentration of chlorine in the vessel is constant.
- (iii) Adding a catalyst would not affect the proportions of the reaction mixture.

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

19. Which of the following changes would **not** be observed once equilibrium is re-established if a little phosphorus trichloride were added at constant temperature to an equilibrium mixture containing the three gases in the equation?

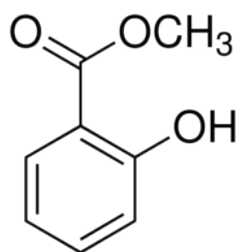
- (a) The reverse reaction would speed up.
- (b) The concentration of phosphorus trichloride would increase.
- (c) The mass of chlorine in the vessel would fall.
- (d) The value of the equilibrium constant, K , would fall.

20. Which of the following equations does **not** represent a redox reaction?

- (a) $\text{Mg}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$
- (b) $\text{Mg}(\text{OH})_2(\text{s}) + 2 \text{CH}_3\text{COOH}(\text{aq}) \rightarrow \text{Mg}(\text{CH}_3\text{COO})_2(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$
- (c) $\text{Sn}^{2+}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Sn}(\text{s}) + \text{Zn}^{2+}(\text{aq})$
- (d) $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$

21. A piece of cobalt is placed into a solution of copper(II) sulfate. Which of the following statements is **false**?
- (a) Copper is precipitated.
 - (b) There is no change in the number of charged particles in solution.
 - (c) Cobalt dissolves.
 - (d) Copper ions are oxidised.
22. Which of the following metals, when placed in a solution of nickel(II) sulfate, would cause the solution to fade from green to colourless?
- (a) Lead
 - (b) Zinc
 - (c) Chromium
 - (d) Iron

23. Consider the following molecule, commonly known as oil of wintergreen:

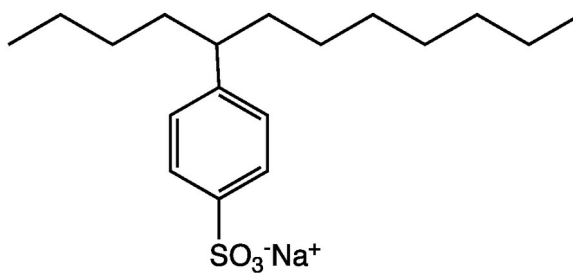


oil of wintergreen

Which of the following statements about oil of wintergreen is **false**?

- (a) It can be synthesised using methanol as one of the starting materials.
 - (b) It is an aldehyde.
 - (c) It is unsaturated.
 - (d) It is an ester.
24. Which of the following molecules can be classified as secondary alcohols?
- (i) 2-methylpropan-2-ol
 - (ii) 3-methylbutan-2-ol
 - (iii) CH₃CHO
 - (iv) CH₃COCH₃
- (a) (i) and (ii) only
 - (b) (ii) only
 - (c) (ii), (iii) and (iv) only
 - (d) (ii) and (iv) only

25. The following formula represents the structure of a compound commonly used as a detergent:



Which of the following statements about detergents is **false**?

- (a) They are often preferred to soaps because of their low tendency to form scums with hard water.
- (b) Part of the molecule is highly water-soluble.
- (c) They are the sodium salts of carboxylic acids.
- (d) The molecules contain large non-polar regions that can form strong intermolecular forces with fats.

End of section one

See next page

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Section Two: Short answer

35% (70 Marks)

This section has **eight (8)** questions. Answer **all** questions. Write your answers in the space provided.

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

Do not use abbreviations, such as 'nr' for 'no reaction', without first defining them.

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Suggested working time: 60 minutes.

Question 26

(7 marks)

For each of the following pairs of substances, provide details of a **chemical** test that would allow the two substances to be distinguished from one another. Equations are **not** required.

substances	chemical test	observations
Ni(s) and Mg(s)		Ni(s)
		Mg(s)
NaCH ₃ COO(s) and NaCl(s)		NaCH ₃ COO(s)
		NaCl(s)

See next page

Question 27

(8 marks)

- (a) 2-methylpropanal, whose formula is $(\text{CH}_3)_2\text{CHCHO}$, has two structural isomers. In the spaces provided below, draw the full structure and give the IUPAC names of these two isomers. (4 marks)

structure	IUPAC name

2-methylpropanal can be converted into substance Y by heating it with a mixture of sodium dichromate and dilute sulfuric acid.

- (b) State an observation that can be made as this reaction proceeds. (1 mark)

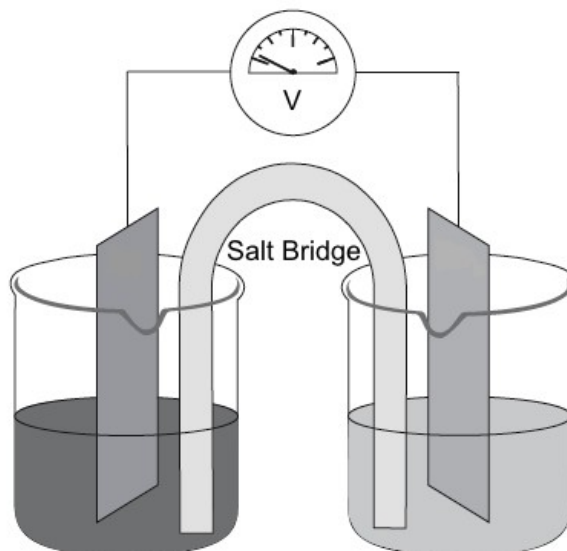
- (c) Name the functional group present in substance Y that is **not** present in 2-methylpropanal. (1 mark)

- (d) Write a balanced half-equation showing the conversion of 2-methylpropanal into substance Y (2 marks)

Question 28

(12 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, **with the copper half cell on the left.**



a) Add a label to the diagram to show the anode. (1 mark)

b) By adding an arrow to the diagram, show the direction of electron flow in the external circuit. (1 mark)

c) Give the half equation for the reaction occurring at the positive electrode. (1 mark)

d) Give the name or formula of a suitable substance that the salt bridge might contain. (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)

Rusting can be described as the formation of iron(III) hydroxide from iron in the presence of water and oxygen. Rusting can be prevented by attaching magnesium to the object that is to be protected.

- i) With reference to the list of redox potentials found on your data sheet, explain why magnesium is a suitable material for this purpose. (2 marks)

Question 29

(9 marks)

For each species listed in the table below, draw the Lewis structure, representing all valence shell electron pairs either as : or as — **and** state or sketch the shape of the species.

(for example, water $\text{H}:\ddot{\text{O}}:\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ or $\text{H}-\ddot{\text{O}}-\text{H}$ bent, polar)

Species	Lewis structure (showing all valence electrons)	Shape (sketch or name)
phosphorus trichloride PCl_3		
ethyne C_2H_2		
nitrate ion NO_3^-		

Question 30

(9 marks)

By referring to the structure and/or bonding present, account for the following:

- (a) Carbon's electronegativity (2.55) is higher than that of phosphorus (2.19). (3 marks)

- (b) Aluminium is a better conductor of electricity than magnesium. (2 marks)

- (c) Silicon dioxide (SiO_2) is a solid with an extremely high melting point, whilst carbon dioxide (CO_2) sublimes at -78°C . (4 marks)

Question 31

(7 marks)

- (a) But-1-ene and but-2-ene are isomers of one another. What is the name given to this type of isomerism? (1 mark)

- (b) In addition to the type of isomerism displayed by the molecules in part (a), but-2-ene itself exhibits another type of isomerism. State the name given to this type of isomerism, and identify the features of but-2-ene that make this type of isomerism possible. (3 marks)

- (c) In the space provided, draw a length of polymer chain that could be formed from 2-butene, showing **three** repeating units. (2 marks)

- (d) State the name given to the type of polymerisation described in part (c). (1 mark)

Question 32

(8 marks)

- (a) Nitrous acid (HNO_2) is a weak acid. Use relevant equations to explain how you would expect the pH of a 0.1 mol L^{-1} solution of nitrous acid to compare with that of a 0.1 mol L^{-1} solution of nitric acid. (3 marks)

A titration is carried out using 25.0 mL of approximately 0.9 mol L^{-1} ammonia solution placed in a conical flask. A few drops of indicator are added, and 0.900 mol L^{-1} nitric acid is added from a burette.

The table below shows some indicators, together with their pH ranges, and their colours.

indicator name	pH range	colour in acid	colour in base
methyl yellow	2.9 – 4.0	red	yellow
bromothymol blue	6.0 – 7.6	yellow	blue
nile blue	10.1 – 11.1	blue	red
nitramine	11.0 – 13.0	colourless	orange

- (b) From the indicators shown in the table, choose one that would be suitable for the titration, and state the colour change that would be expected to occur. (2 mark)

Indicator: _____

Colour change: _____

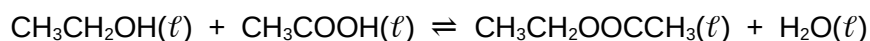
When approximately 12.5 mL of nitric acid have been added, the solution in the flask can be classified as a buffer solution.

- (c) With the aid of equations, explain how the solution is able to act as a buffer. (3 marks)

Question 33

(10 marks)

When ethanol and ethanoic acid are mixed together in concentrated sulfuric acid, the following reversible reaction occurs:



- (a) Identify the type of reaction taking place in the forward direction, and give the IUPAC name of the organic product. (2 marks)

Type of reaction: _____

Name of product: _____

- (b) Write an expression for the equilibrium constant, K , for the reaction in the space provided. (1 mark)

- (c) The reaction is usually carried out at high temperatures in order to increase the yield. State and explain what this tells us about the enthalpy of the products compared to the enthalpy of the reactants. (3 marks)

A titration can be used to determine the proportions of reactants and products present at equilibrium. Sodium hydroxide solution is added quantitatively to the reaction mixture, reacting first with the sulfuric acid and then with any remaining ethanoic acid. The amount of ethanoic acid present at equilibrium can be easily determined since the sulfuric acid is present in the same quantity as at the start of the experiment.

Although the addition of sodium hydroxide does disturb the equilibrium, the inaccuracy introduced is small if the reaction mixture is cooled immediately prior to titration.

- (d) State the effect of addition of sodium hydroxide on the value of the **equilibrium constant**, K , by circling the correct answer below. (1 mark)

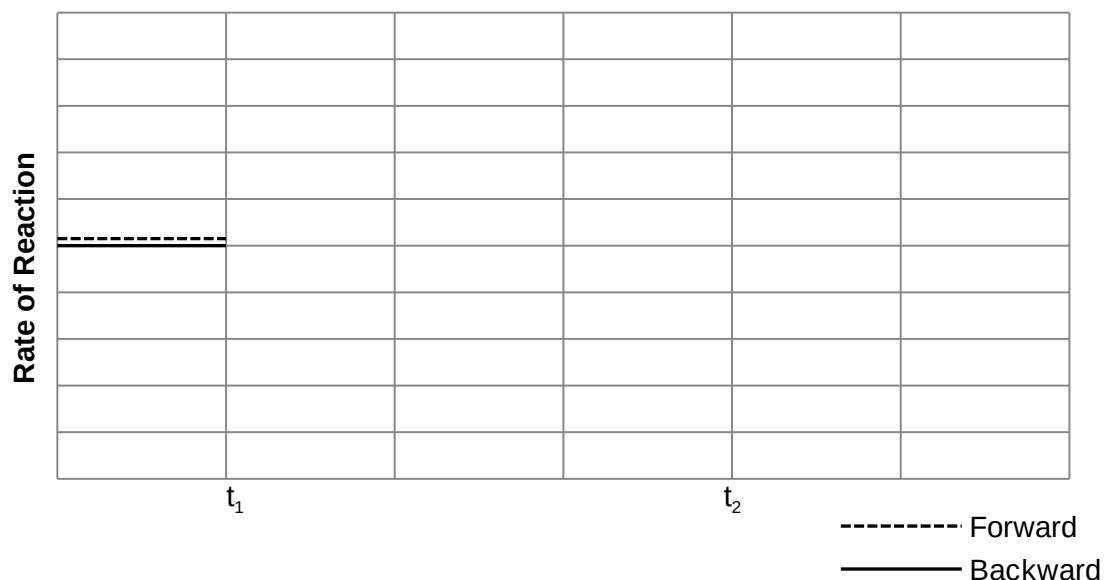
Effect on K (circle one)

INCREASE

DECREASE

NO CHANGE

- (e) On the axes shown below, sketch the effect of cooling the reaction mixture (t_1) on the rates of the forward and backward reactions until the system returns to a new equilibrium (t_2). (3 marks)



End of section two

See next page

Section Three: Extended answer

40% (80 marks)

This section contains **five (5)** questions. Answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed to three (3) 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.

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- 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 34

(13 marks)

Chlorine is found in acids of various strengths. Chlorine can exist in different oxidation states. Some acids are shown in the table below.

Name and formula of acid	Strong/Weak
hydrochloric acid HCl	strong
hypochlorous acid HOCl	weak
chlorous acid HClO_2	weak
chloric acid HClO_3	strong
perchloric acid HClO_4	strong

- (a) What mass of perchloric acid would need to be dissolved in 250 mL of distilled water to produce a solution with a pH of 3.59? (3 marks)

See next page

1.20 g of solid calcium hydroxide was added to a beaker containing 200 mL of a 0.160 mol L^{-1} aqueous solution of chloric acid, and the solution stirred until all the solid had dissolved.

(b) Write a balanced ionic equation to show the reaction taking place in the beaker. (2 marks)

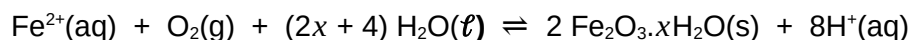
(c) Determine the limiting reagent by calculation. (4 marks)

(d) Calculate the pH of the resulting solution. (4 marks)

Question 35

(17 marks)

Solutions of iron(II) salts are often used in redox titrations, but can be problematic as the Fe^{2+} ions can be oxidised by oxygen in the environment, forming various hydrated forms of iron(III) oxide, according to the following equation:



Ammonium iron(II) sulfate, or Mohr's salt, is often preferred over iron(II) sulfate for redox titration purposes since the unwanted oxidation of Fe^{2+} is prevented by the ammonium ions present, which reduce the pH of the solution. Mohr's salt is commonly found in hydrated form, as any of a number of salts with the formula $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot x\text{H}_2\text{O}$.

- (a) Write an equation to show how the ammonium ions are able to lower the pH of the solution. (2 marks)

- (b) Use the equation given above to explain why the oxidation of Fe^{2+} is prevented in solutions of low pH. (2 marks)

10.0 g of hydrated ammonium iron(II) sulfate crystals were dissolved in distilled water and made up to 250 mL in a volumetric flask. 25.0 mL aliquots of this solution were titrated against 0.0240 mol L⁻¹ potassium permanganate solution until consistent results were obtained. The table below shows the results of the experiment.

	Rough	1	2	3	4
Final volume (mL)	23.00	21.25	21.25	22.65	23.35
Initial volume (mL)	0.00	0.05	0.00	0.10	2.10
Titre (mL)					

- (c) Complete the table and calculate the average titre volume. (1 mark)

Average titre: _____

(d) Write a balanced ionic equation for the reaction taking place.

(2 marks)

(e) Calculate the value of x in the formula $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot x\text{H}_2\text{O}$.

(10 marks)

[illegible]

Question 36

(22 marks)

A sample of powdered magnesium sulfate is known to have been contaminated with sodium chloride. The percentage purity of the magnesium sulfate can be determined by the following method:

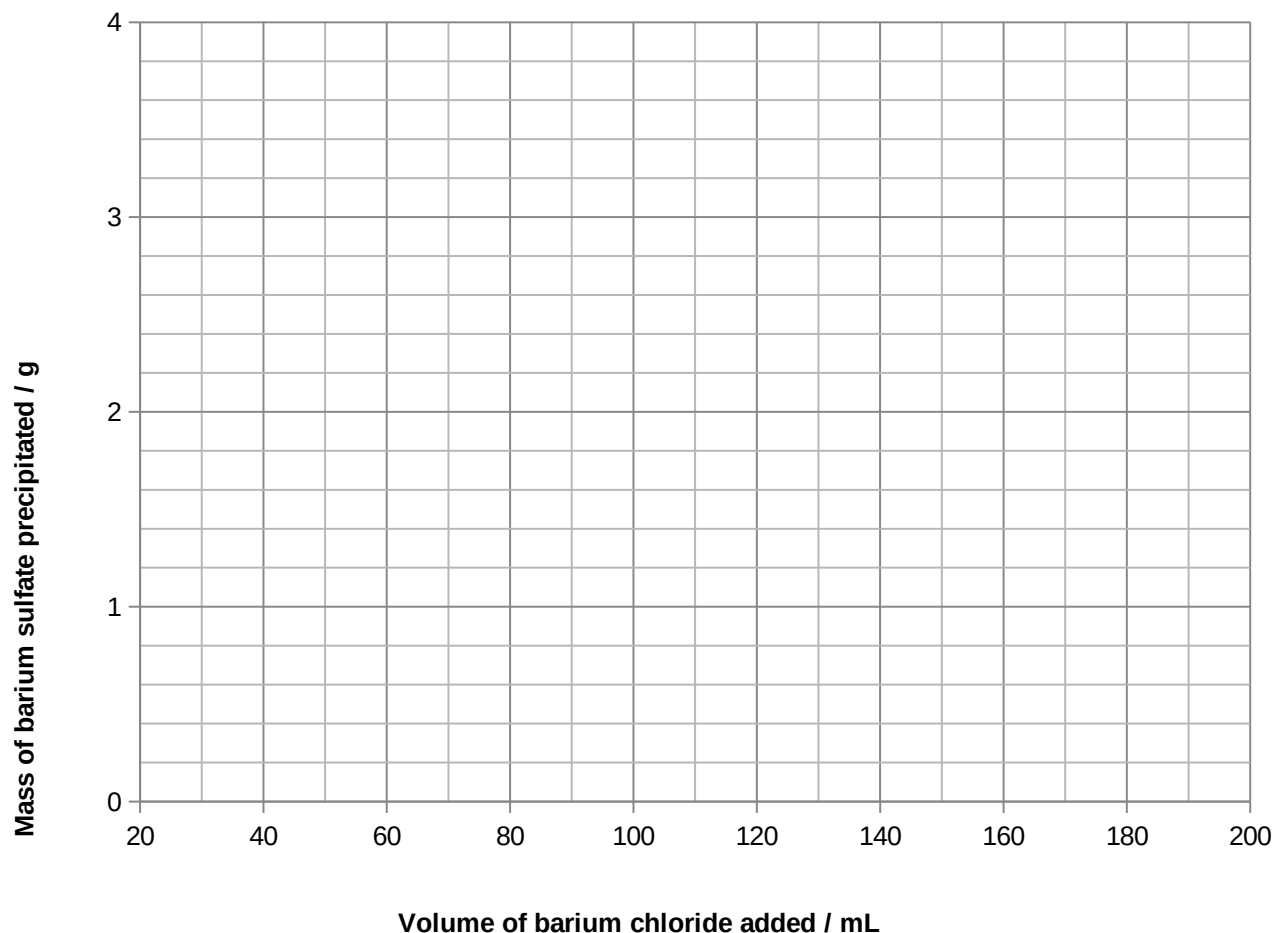
- 32.50 g of the impure magnesium sulfate is dissolved in water and the solution is made up to 500.0 mL in a volumetric flask.
- Six 20.0 mL aliquots of this solution are placed in separate conical flasks.
- Different volumes of $0.100 \text{ mol L}^{-1} \text{ BaCl}_2(\text{aq})$ are added to each flask, causing any sulfate ions present to precipitate out of the solution.
- The precipitate from each sample is filtered, rinsed with distilled water and then dried to constant mass.

The results of this analysis are shown in the table below.

Sample	1	2	3	4	5	6
Volume of $\text{BaCl}_2(\text{aq})$ added (mL)	30.0	60.0	90.0	120.0	150.0	180.0
Mass of $\text{BaSO}_4(\text{s})$ precipitated (g)	0.61	1.23	1.83	2.04	2.04	2.04

(a) Display the results in a suitable format using the axes provided.

(2 marks)



See next page

- (b) Write a balanced ionic equation for the reaction taking place. (1 mark)

- (c) Explain why the mass of precipitate remained constant for the last three samples, in spite of the fact that more barium chloride was being added. (1 mark)

- (d) Use the mass of precipitate to calculate the percentage purity of the magnesium sulfate. (5 marks)

- (e) Use the graph you have drawn in part (a) to estimate the minimum volume of barium chloride needed to precipitate all the sulfate ions from solution. (1 mark)

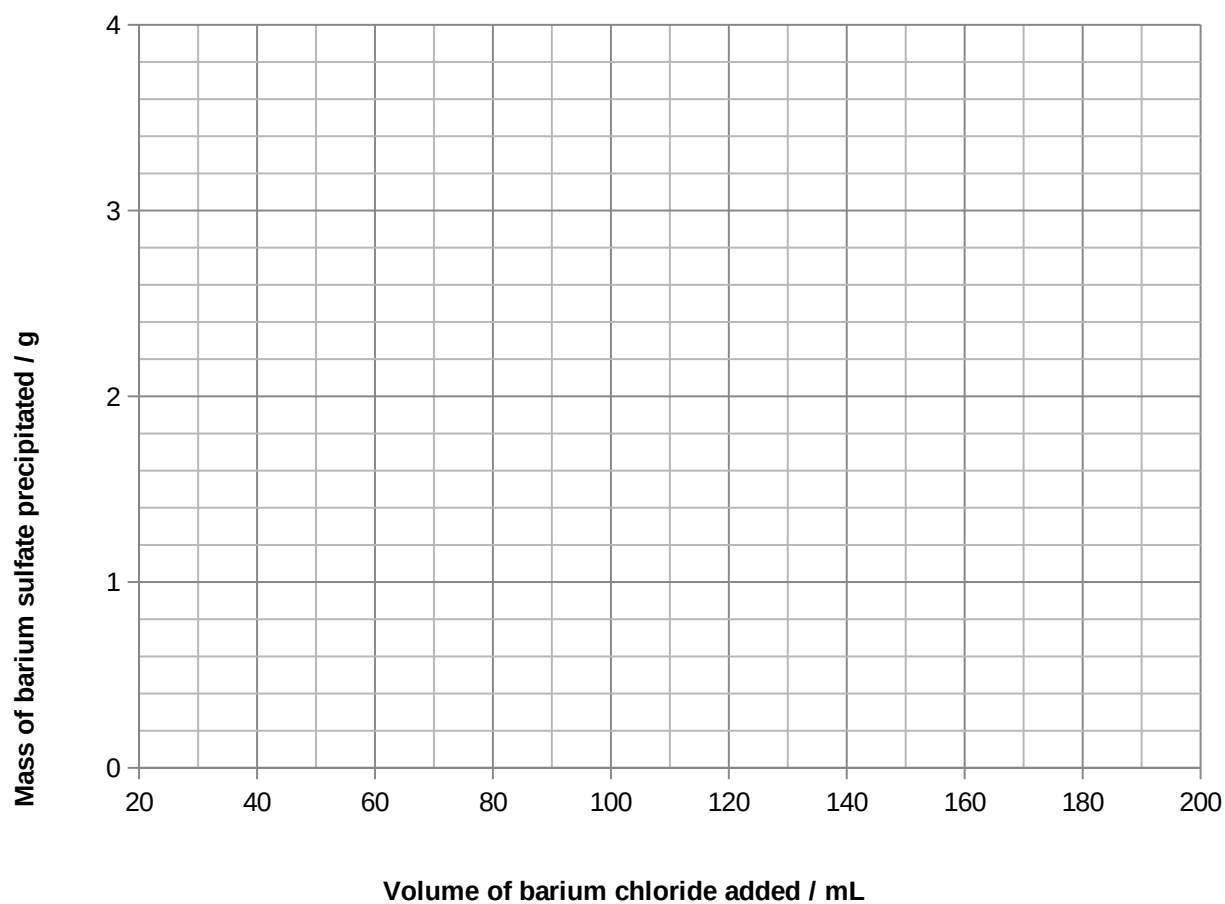
Question 36 (continued)

- (f) Calculate the final concentration (in mol L^{-1}) of chloride ions in the filtrate collected from **sample four**. You may assume that sodium chloride was the only impurity present in the impure magnesium sulfate. (7 marks)

- (g) Another student carried out a similar analysis, but neglected to rinse the precipitates before drying them. Explain what effect this would have on the student's calculated value of the percentage purity. (3 marks)

The analysis was repeated using six further 20 mL aliquots of the impure magnesium sulfate solution and the same volumes of barium chloride. However, the concentration of the barium chloride solution used was 0.200 mol L^{-1} .

- (h) Using the axes below, draw the graph of the expected results when plotting the mass of barium sulfate precipitated against volume of barium chloride added. (2 marks)



(11 marks)

The table below outlines some of the physical properties of four organic substances; pentane, 2,2-dimethylpropane, 2-pentene, and propanoic acid.

	boiling point (°C)	solubility in water	solubility in ethanol
pentane	36.1	low	high
2,2-dimethylpropane	9.5	low	high
pent-2-ene	37.0	low	high
propanoic acid	144.1	high	high

Marks are awarded for clarity of communication. Answers may be written as a series of dot points and diagrams may be used, but care should be taken to ensure that there is a logical sequence of ideas and that any abbreviations or diagrams are explained clearly.

[illegible]

[illegible]

(17 marks)

Sulfur is present in fossil fuels in the form of sulfur-containing organic compounds, such as dibenzothiophenes. Analysis of one such compound showed that it was made up only of the elements carbon, hydrogen and sulfur. Upon combustion in excess oxygen, a 22.60 g sample of the compound was found to produce 8.85 g of water vapour and 77.9 L of carbon dioxide, measured at 1000°C and 200 kPa.

- (a) Calculate the **empirical formula** of the compound. (8 marks)

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Another sample of the compound, weighing 10.71 g, was vapourised in the absence of oxygen. The vapours occupied 1.265 L at 200 kPa and 250°C.

- (b) Use this information and your answer to part (a) to calculate the **molecular formula** of the compound. (3 marks)

Question 38 (continued)

The ULSJ fuel standard is equivalent to a concentration of sulfur 15 ppm (parts per million).

- (c) Calculate the concentration of sulfur in ULSJ fuel in mol L^{-1} if 1L of the fuel weighs 800 g.
(3 marks)

One of the problems associated with the presence of sulfur in fuels is that as rain falls through oxides of sulfur in the atmosphere, they react with the rain. The effect is that the rain becomes acidic.

- (d) With the help of equations, explain how these oxides can cause rainwater to become acidic.
(3 marks)

End of questions

Question number: _____

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Spare answer page

Question number: _____

[illegible]

Spare answer page

Question number: _____

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Question number: _____

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