Year 12

Chemistry

2006

Name: .....

Teacher: .....

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Separate Multiple Choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate

Standard Items: Pens, pencils, eraser or correction fluid, ruler
Special Items: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council for this subject.

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

Part	Format	No. of Questions Set	Number of Questions to be Attempted	Marks available	Suggested working time (minutes)
1	Multiple choice	30	All	60 (30%)	55
2	Short answers	11	All	70 (35%)	60
3	Calculations	5	All	50 (25%)	45
4	Extended answer	1	1	20 (10%)	20
			Total marks	200 (100%)	

Instructions to candidates

1. The rules for the conduct of Tertiary Entrance Examinations are detailed in the booklet *TEE Handbook*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions:

   Part 1 Answer **all** questions, using a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **not** use a ball point or ink pen.

   If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers.

   Feel free to write or do working on the question paper; many students who score high marks in the Multiple Choice Section do this.

   Parts 2, 3 and 4 Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

   Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers for such questions which do not show working will not be awarded full marks.

3. The examiners recommend that you spend your reading time mainly reading the instructions to candidates and Parts 2, 3 and 4.

4. **Chemical equations**

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For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

PART 1: Multiple Choice

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.
This part carries 60 marks out of 200.

1. An ion formed by magnesium will have which of the following?

   (a) Equal numbers of protons and electrons.

   (b) More protons than electrons.

   (c) More electrons than protons.

   (d) There is not enough information to make decisions about the number of electrons and protons.

2. The number of chlorine molecules (Cl_2) that could be obtained from 130 grams of $AlCl_3$ is closest to which of the following?

   (a) 1.5

   (b) 3.0

   (c) 9×10^{23}

   (d) 1.8×10^{24}

3. Which of the following electron configurations represent an element that forms an ion with a charge of (-3)?

   (a) $1s^2\ 2s^1$

   (b) $1s^2\ 2s^2\ 2p^1$

   (c) $1s^2\ 2s^2\ 2p^3$

   (d) $1s^2\ 2s^2\ 2p^6$

4. In which of the following alternatives do the species listed have the same electronic configuration?

   (a) Ca^{2+}, Ar, Cl^-

   (b) S^{2-}, Ne, Cl

   (c) S, Ar, K

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(d) Ca^{2+}, K^{+}, Ne

5. Which of the following is the best description of bonding in NaF?

(a) Electrostatic attraction between ions, electrons and nuclei.
(b) Electrostatic attraction between oppositely charged ions.
(c) Sharing of electrons between non-metal and metal atoms.
(d) Atoms of Na and F held together by ionic bonds.

6. Which of the following best explains why solid silver conducts electricity?

(a) Silver ions are free to move when a current passes through the metal.
(b) Valence electrons can move and create a current when a potential difference is applied.
(c) The atoms of silver become ionised when a potential difference is applied.
(d) The metallic silver lattice breaks down when a current passes through the metal.

7. The table below gives information about the first four ionisation energies of three elements.

Ionisation energies (**1** to **4**) in MJ mol^{-1}

Element	**1**	**2**	**3**	**4**
A	0.7	1.5	7.8	10
B	0.6	1.8	2.7	12
C	0.5	4.6	6.9	9.6

Which of the following could be the elements **A**, **B** and **C** respectively?

(a) Magnesium, aluminium and sodium.
(b) Phosphorus, aluminium and nitrogen.
(c) Sodium, magnesium and aluminium.
(d) Sodium, aluminium and magnesium.

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8. An element has the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$. In what group and period of the periodic table does it belong?

   (a) Group II period 3

   (b) Group III period 2

   (c) Group III period 4

   (d) Group IV period 3

9. Which of the following materials is the softest?

   (a) Graphite

   (b) Diamond

   (c) Silicon

   (d) Silicon dioxide

10. In which of the following pairs do each of them have both covalent and ionic bonding within their overall structures?

    (a) NH_4NO_3, $CuSO_4$

    (b) Cl_2CO, NH_3

    (c) CO_2, NaCl

    (d) KOH, CH_4

11. Which of the following exhibit hydrogen bonding between its molecules?

    (a) H_2

    (b) CH_4

    (c) CH_3OH

    (d) NH_4CH_3COO

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12. A sodium carbonate primary standard solution is prepared by dissolving 7.494 grams of anhydrous sodium carbonate in approximately 100 mL of water. This is then made up to the 500 mL mark in a volumetric flask. What is the approximate concentration of this solution?

    (a) 0.090 mol L^{-1}

    (b) 0.12 mol L^{-1}

    (c) 0.14 mol L^{-1}

. (d) 0.18 mol L^{-1}

13. Which of the following volumes of a 0.040 mol L^{-1} potassium hydroxide solution is required to react exactly with 20.0 mL of a 0.010 mol L^{-1} diprotic acid?

    (a) 1.0 mL

    (b) 5.0 mL

    (c) 10.0 mL

    (d) 20.0 mL

14. Which of the following is most unlikely to act as both a Bronsted - Lowry acid and base?

    (a) OH^-

    (b) HPO_4^{2-}

    (c) HS^-

    (d) NH_4^+

15. Which of the following solutions has the highest pH?

    (a) 0.1 mol L^{-1} sodium chloride.

    (b) 0.2 mol L^{-1} ammonia.

    (c) 0.2 mol L^{-1} sulfuric acid.

    (d) 0.1 mol L^{-1} sodium hydroxide.

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16. Two drops of the indicator phenolphthalein are added to each of two solutions X and Y. Solution X remained colourless, and solution Y turned pink. Which conclusion best supports the observations made?

    (a) X is alkaline and Y is acidic.

    (b) X is acidic and Y is alkaline.

    (c) X can be acidic, neutral or alkaline and Y is alkaline.

    (d) X is either alkaline or neutral and Y is alkaline.

17. Pure water undergoes self-ionisation. The equilibrium constant for the reaction at 95°C is 4.8×10^{-13}. This corresponds to a pH of 6.2. Which of the following statements is true?

    (a) At 95°C the water is acidic.

    (b) At 95°C the water is neutral.

    (c) At 95°C the water is basic.

    (d) The pH has been worked out incorrectly.

18. Which of the following best describes a necessary condition for the system below to be at equilibrium?

$$2NO(g) + O_2(g) \quad \rightleftharpoons \quad 2NO_2(g)$$

    (a) All chemical reactions have stopped.

    (b) The concentrations of $NO(g)$ and $NO_2(g)$ are equal.

    (c) The concentrations of all species are equal.

    (d) Forward and reverse reactions are continuing at equal rates.

19. When a system is at equilibrium the pressure of that system can be altered by changing its volume. Which of the following statements can be made with certainty?

    (a) Increasing the pressure favours the production of reactants.

    (b) Adding an inert gas has no effect on the equilibrium.

    (c) Reducing the volume increases the pressure so it favours the products.

    (d) Decreasing the pressure will increase the rate of reaction.

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20. What is the overall change in oxidation number of sulfur in the Contact Process?

    (a) It remains unchanged.

    (b) It increases by 1.

    (c) It increases by 4.

    (d) It increases by 6.

21. Which of the following has the substances listed in order from weakest to strongest in terms of its oxidising ability?

    (a) Fe^{2+}, Ag^{+}, Br_2, F_2

    (b) F_2, Cl^{-}, Br_2, I^{-}

    (c) Fe^{2+}, Fe^{3+}, Ag^{+}, Cu^{2+}

    (d) Cl^{-}, I^{-}, Fe^{3+}, Cu^{2+}

22. Which of the following statements about commercial cells is correct?

    (a) In the dry cell, zinc gets oxidised and graphite gets reduced.

    (b) Sulfate ions are consumed at both the anode and cathode in the lead - acid accumulator.

    (c) Oxygen gas is the reducing agent and hydrogen gas is the oxidising agent in the hydrogen - oxygen fuel cell.

    (d) Primary cells are rechargeable and secondary cells are non-rechargeable.

23. Which of the following statements concerning the extraction of aluminium is incorrect?

    (a) The first step in the process involves the extraction of alumina from the ore by the Bayer process.

    (b) The second stage involves the extraction of aluminium from alumina by electrolysis in the Hall - Heroult process.

    (c) Cryolite in the electrolytic mixture improves the economics of the process by increasing the melting point.

    (d) The overall redox equation in the electrolytic cell is:

$$3C(s) + 2Al_2O_3(l) \rightarrow 4Al(l) + 3CO_2(g)$$

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24. An electrolytic cell is set up under standard conditions of temperature and pressure. The cell contains a DC power supply, a copper anode, a platinum cathode and a 1.0 mol L^{-1} sodium chloride solution. Which of the following statements is incorrect?

    (a) At the anode, the solution changes from colourless to blue.

    (b) A colourless gas is given off at the cathode.

    (c) The minimum DC voltage to cause electrolysis is 1.77 volts.

    (d) Anions move towards the anode and cations move towards the cathode.

25. Which of the following statements regarding the properties of zinc is incorrect?

    (a) Zinc is a silvery grey metal and is a very good conductor of heat and electricity.
    (b) Under normal exposure to air, it forms a protective oxide layer, but it will burn if finely divided and heated strongly.
    (c) The major use of zinc are in galvanising iron, in dry cells and in alloys such as brass.
    (d) Zinc has a high reduction potential.

26. Which one of the following substances will exhibit geometrical (cis - trans) isomerism?

    (a) $CH_3CCl=CCl_2$
    (b) $CH_3\text{-}(CH_2)_2\text{-}CH=CHCOOH$
    (c) $CH_2=CH\text{-}(CH_2)_4\text{-}CH_3$
    (d) $HOOC\text{-}(CH_2)_2\text{-}COOH$

27. One of the compounds formed when fluorine reacts with ethane is 1,2-difluoroethane. This type of reaction is called:

    (a) an addition reaction.
    (b) a hydrolysis reaction.
    (c) a combustion reaction.
    (d) a substitution reaction.

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28. Which of the following lists do not have the compounds arranged in order of decreasing boiling point?

(a) Pentanal, 1-pentanol, 1-pentanoic acid.

(b) Butanoic acid, butanone, butane.

(c) Hexane, pentane, propane.

(d) Diamond, ammonia, carbon dioxide.

29. Which of the following has been filled in correctly?

		Representation of functional group	**Main intermolecular forces**	**Solubility**
(a)	Haloalkane	RX	dipole - dipole	soluble in fats
(b)	Amine	RNH_2	hydrogen bonding	soluble in water
(c)	Aldehyde	RCHO	hydrogen bonding	soluble in water
(d)	Alkyne	R ≡ R	dispersion forces	soluble in water

30. Which of the following most correctly describes what happens in the manufacture of soaps?

	Main reaction classification	Reactants	By-product(s)
(a)	Saponification	sodium hydroxide, fat	1,2,3-propanetriol
(b)	Hydrolysis	triglyceride, water	glycerol
(c)	Esterification	glycerol, fatty acids	water
(d)	Sulfonation	sulfuric acid, alkyl benzene	water

END OF PART 1

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PART 2: Short Answer

Answer **ALL** questions in Part 2 in the spaces provided below. This part carries 70 marks out of 200.

1. Write equations for any reactions that occur in the following procedures.
If no reaction occurs, write "no reaction".
In each case describe in full what you would observe, including any colours, odours, precipitates (give colour), gases evolved (give colour or describe as colourless).
If no change is observed, you should state this.

(a) Solutions of magnesium chloride and barium hydroxide are mixed.

Equation : .....

Observation : .....

.....

[3 marks]

(b) Copper metal is added to concentrated nitric acid.

Equation : .....

Observation : .....

.....

[3 marks]

(c) Excess sodium hydroxide is added to a suspension of chromium(III) hydroxide.

Equation : .....

Observation : .....

.....

[3 marks]

(d) A little concentrated sulfuric acid is added to a mixture of 3-methyl-1-butanol and ethanoic acid, and the mixture is heated.

Equation : .....

Observation : .....

.....

[3 marks]

2. For each species listed in the table below,

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(a) draw the structural formula, representing all valence shell electron pairs either as : or as - .
(b) indicate the shape of each with a name.

Species	Structural formula (showing all valence electrons)	Shape
NO_2^-		
CH_2O		

[4 marks]

3. Fill in the boxes of the table below with a molecule chosen from the list provided that matches the description in the box.

PH_3, CH_2F_2, CH_4, F_2O, CO_2, HCl, BCl_3, Cl_2

A bent polar species	
Diatomic molecule exhibiting dispersion forces only	
Pyramidal	
Tetrahedral and polar	
Triangular planar and non-polar	

[5 marks]

4. Complete the following table.

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Solute ($0.1\ mol\ L^{-1}$)	pH of solution (< 7, = 7 or > 7)	Explanation
Potassium chloride		
Ammonium chloride		
Sodium carbonate		

[6 marks]

5. In an industrial setting, ammonia is produced by combining nitrogen gas and hydrogen gas in an exothermic reaction.

(a) Write a balanced equation for this process.

.....[1 mark]

(b) What is this process called?

.....[1 mark]

(c) How would you change the value of the equilibrium constant (K) for this reaction?

.....[1 mark]

(d) Outline how you would maximise the yield of product.

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.....[3 marks]

6. Oxygen can be produced in the laboratory by decomposing unstable peroxides. The normally slow decomposition of dilute hydrogen peroxide can be made faster by adding manganese dioxide as a catalyst.

(a) Write a balanced equation for this reaction.

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.....[1 mark]

(b) How would you collect the gas?

..... [1 mark]

(c) What type of redox reaction is this decomposition?

..... [1 mark]

(d) Explain how the manganese dioxide makes the reaction occur faster.

.....

.....[2 marks]

(e) List two other ways in which you can increase the rate of this reaction.

.....

.....[2 marks]

7. In each of the following situations write a balanced half equation to best account for the observations / information.

(a) A solution of acidified potassium permanganate changes colour from purple to brown.

.....[1 mark]

(b) An ammonium iron(II) sulfate solution $(NH_4)_2Fe(SO_4)_2$ (aq) changes colour from pale green to brown.

.....[1 mark]

(c) When a substance is added to bromine water, the mixture changes colour from red to colourless.

.....[1 mark]

(d) The oxidation of sulfurous acid to sulfate ions.

.....[1 mark]

(e) The reduction of CO_2 to $C_6H_{12}O_6$ in a basic environment.

.....[1 mark]

8. Here is a diagram of an electrochemical cell at 25°C.

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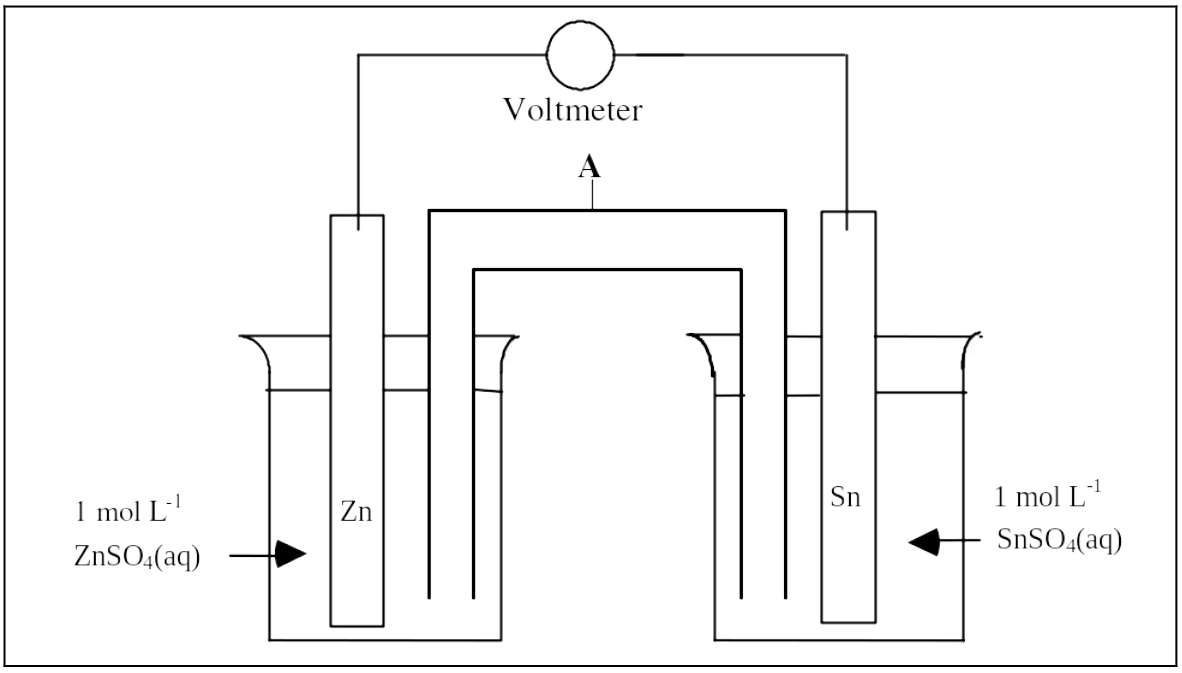
(b)



(a) The component labelled **A** is a salt bridge. What is its role in the operation of the cell?

.....

.....[1 mark]

(b) Which electrode is the cathode? .....[1 mark]

(c) Draw an arrow on the diagram to show the direction of electron flow in the external circuit. [1 mark]

(d) Write the half equation for the reaction happening at the anode.

.....[1 mark]

(e) Under standard conditions what is the expected reading on the voltmeter?

.....[2 marks]

9. In modern times, the extraction of gold involves cyanidation in the carbon-in-pulp process.

(a) What property of gold explains its presence as metallic Au in the ore?

..... [1 mark]

(b) Why is the cyanide ion needed in this process? Include an equation.

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[2 marks]

(c) What is the function of the carbon in the CIP?

.....

.....

[1 mark]

In the extraction of gold by CIP the gold is obtained at the end by electrolysis.

(d) What is the cathode reaction at this stage?

.....

[1 mark]

(e) What is the cathode made from?

.....[1 mark]

(f) What is produced at the anode?

.....[2 marks]

10. 1-butene reacts with water in the presence of the catalyst sulfuric acid to produce 2-butanol.

(a) Draw the structural formula for 2-butanol.

[1 mark]

(b) How many different isomeric alcohols exist for this product?

..... [1 mark]

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(c) Draw the structural formula and name one of these isomers.

Structural formula

Name

[2 marks]

Some of the 2-butanol produced was then reacted with a warm acidified solution of potassium dichromate.

(d) What category of organic substance is produced in this reaction?

..... [1 mark]

(e) What observations would you make while carrying out this reaction?

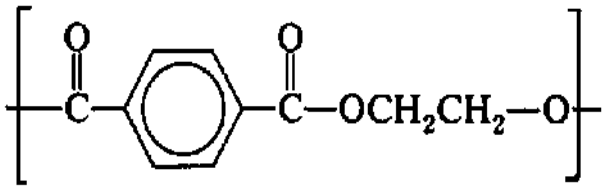
..... [1 mark]

The rest of the 2-butanol was reacted with sodium metal.

(f) Write an equation for this reaction.

.....[1 mark]

11. The structural formula for the repeating unit of the polyester Dacron is shown below:



Dacron (also known as terylene or PET) is produced by condensation polymerisation.

(a) Draw the monomers used in the production of this polymer

[2 marks]

(b) Write equations for the formation of the following addition polymers:

(i) polyethene

.....[1 mark]

(ii) polyvinyl chloride

.....[1 mark]

END OF PART 2

PART 3: Calculations

Answer all questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't you will lose marks. This part carries 50 marks out of 200.

1. A botanist wanted to identify a sugar that was found in a new plant she had discovered. A preliminary investigation showed that the compound contained only the elements carbon, hydrogen and oxygen. A further analysis of the sample was undertaken in a combustion apparatus. A carefully weighed 5.682 grams of the sugar was ignited in an electric furnace and catalysts ensured complete oxidation of carbon to carbon dioxide. The carbon dioxide adsorbing layer increased in mass by 8.333 grams. In the same analysis the hydrogen was converted into water and the water adsorbing layer increased in mass by 3.408 grams.

   (a) Using the data above determine the empirical formula of the sugar. [8 marks]

   (b) A 3.250 gram sample of the sugar was vaporised and found to occupy a volume of

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775 mL at 170°C and 103.0 kPa. What is the molecular formula of the sugar?

[3 marks]

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2. Three important industrial substances namely hydrogen, chlorine and sodium hydroxide are manufactured from the electrolysis of aqueous sodium chloride in the Nelson cell.
If in a single day 100 kL of chlorine gas measured at 30^{o}C and 600 kPa needs to be produced:

(a) What current is needed to produce this amount of chlorine? [6 marks]

(b) What mass of solid sodium hydroxide can be crystallised from the reaction in this time? [2 marks]

(c) What volume of gas is produced at the cathode, if measured at STP? [2 marks]

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3. Iron is often found in the earth's crust as a hydrated iron oxide ($Fe_2O_3.xH_2O$).
A 0.668 gram sample of this ore was dissolved in excess sulfuric acid and all the iron was converted into an iron(II)sulfate solution. This solution was titrated against a 0.050 mol L^{-1} acidified potassium permanganate solution and exactly 25.00 mL of the purple solution was needed to complete the titration. Find the value of x in the hydrated formula above. [9 marks]

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4. 6.00 g of hydrogen sulfide gas was bubbled through 250 mL of a 1.500 mol L^{-1} sodium hydroxide solution.

(a) Write an equation for this reaction. [1 mark]

(b) What is the final concentration of the ionic species at the end of the experiment? [7 marks]

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5. A group of students was given the task of determining the percentage of ethanoic acid in a sample of vinegar. To begin with, they placed a sample of sodium carbonate in an oven at 110^{o}C for twenty four hours. They took a 9.700 gram sample of this sodium carbonate and using distilled water, dissolved it and transferred it into a 500 mL volumetric flask and made it up to the mark. 20.00 mL aliquots of this standard solution were titrated against a HCl solution and the following results were obtained:

Trial	1	2	3	4
Volume of HCl (mL)	20.20	19.90	19.85	19.80

A solution of sodium hydroxide was prepared and standardised against this HCl solution. 25.00 mL aliquots of the HCl solution required an average of 17.50 mL of the sodium hydroxide solution to complete the titration.

25.00 mL of the vinegar solution was transferred to a 250 mL volumetric flask and made up to the mark with distilled water. 20.00 mL aliquots of the dilute vinegar solution were titrated against the standardised sodium hydroxide solution. The following results were obtained:

Trial	1	2	3	4	5

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Initial reading (mL)	0.15	3.75	7.15	10.15	13.15
Final reading (mL)	3.75	7.15	10.15	13.15	16.15

If the density of the pure vinegar was 1.02 g cm^{-3}, determine the percentage by mass of ethanoic acid in the pure vinegar. [12 marks]

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END OF PART 3

PART 4: Extended Answer

Answer the following extended answer question. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing. Marks are awarded for the relevant chemical content of your answer, but you will lose marks if what you write is unclear or lacks coherence.
Your answer should be presented in about 2 pages. This part carries 20 marks out of 200.

Across rows in the periodic table there are general trends in the physical and chemical properties of not just the elements themselves but also of their oxides and hydroxides. The tables below detail some information that may be of importance in identifying such trends within the sodium - argon row.

Table 1: Physical properties of the elements Na to Cl

Element	Sodium	Magnesium	Aluminium	Silicon	Phosphorus	Sulfur	Chlorine
Symbol	Na	Mg	Al	Si	P	S	Cl
Ionisation energy ($kJ\ mol^{-1}$)	502	744	584	793	1018	1006	1257
Atomic radius (nm)	0.19	0.16	0.14	0.12	0.11	0.10	0.09
Melting point (^oC)	98	650	660	1410	44	113	-101
Boiling Point (^oC)	883	1110	2450	3267	280	445	-35
Electronegativity	0.9	1.3	1.6	1.9	2.2	2.6	3.2

Table 2: Properties of hydroxides (Na to Cl)

Formula	$NaOH$	$Mg(OH)_2$	$Al(OH)_3$	$Si(OH)_4$	$PO(OH)_3$	$SO_2(OH)_2$	$ClO_3(OH)$
Acid - base property	strongly basic	strongly basic	amphoteric	weakly acidic	moderately acidic	strongly acidic	strongly acidic
Reaction product with strong acid	H_2O, Na^+	H_2O, Mg^{2+}	H_2O, Al^{3+}	no reaction	no reaction	no reaction	no reaction
Reaction product with strong base	no reaction	no reaction	$[Al(OH)_4]^-$	H_2O, SiO_3^{2-}	H_2O, $PO4^{3-}$	H_2O, SO_4^{2-}	H_2O, ClO_4^-
Reaction product with water	Na^+, OH^-	insoluble	insoluble	insoluble	molecules	H^+, HSO_4^-	H+, ClO_4^-

In addition to general trends, the elements and their hydroxides also have specific properties. This is particularly evident when one studies how the elements and their hydroxides are involved in organic reactions.

Using the information contained within the tables, your chemical knowledge and understandings, and equations to support your answer wherever possible discuss:

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(a) the trends in ionisation energy, atomic radius, melting / boiling points and electronegativity that occur across the third row,

(b) the acid-base properties of the hydroxides of these elements, and,

(c) the role of sodium, sodium hydroxide, chlorine and the sulfur hydroxide [which can be written as H_2SO_4] in organic reactions.

[5, 7 and 8 marks]

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