Year 12

Chemistry

2008

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.

SEE NEXT PAGE

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**

   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: (60 marks)

Answer ALL questions in Part 1 on the Separate Multiple Choice Answer Sheet provided, using a 2B pencil. Each question in this part is worth 2 marks.

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1. A particular isotope of carbon is designated $^{14}_{6}C$. An atom of this isotope contains which of the following?

   (a) 6 protons, 8 neutrons and 6 electrons.

   (b) 8 protons, 14 neutrons and 8 electrons.

   (c) 6 protons, 8 neutrons and 14 electrons.

   (d) 6 protons, 6 neutrons and 14 electrons.

2. Which of the following elements has a partially filled s subshell in its atoms?

   (a) Boron

   (b) Potassium

   (c) Lead

   (d) Barium

3. Which of the following rows contains three correct formulae for the named species?

	oxalate ion	hydrogencarbonate ion	chromate ion
(a)	CO^{2-}	HCO_2^+	CrO_3^-
(b)	CO_2^{2-}	HCO^-	$Cr_2O_7^{2-}$
(c)	$C_2O_2^{2-}$	$H_2CO_3^{2-}$	CrO_2^-
(d)	$C_2O_4^{2-}$	HCO_3^-	CrO_4^{2-}

4. A substance is described as having molecules which are non-polar and linear. Which of the following correctly fits the description?

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(a) Beryllium chloride.

(b) Sodium chloride.

(c) Carbon tetrachloride.

(d) Ammonia.

5. Which of the following pairs of approximately 0.1 mol L^{-1} solutions will produce a coloured precipitate when mixed together?

(a) Ammonium carbonate and barium chloride.

(b) Silver nitrate and copper(II) nitrate.

(c) Iron (III) sulfate and potassium carbonate.

(d) Lithium nitrate and ammonium chloride.

6. Which of the following statements is the best definition of ionisation energy?

(a) It is the energy required to dissociate one mole of ions in the solid phase.

(b) It is the energy absorbed when a mole of an ionic substance dissolves in water.

(c) It is the energy required to form one mole of an ionic substance from its constituent atoms.

(d) It is the energy required to remove a mole of electrons from a mole of atoms or ions of an element in the gaseous phase.

7. Which of the following statements about the boiling point of non-polar covalent molecular substances is true?

(a) Boiling point is the temperature at which there is sufficient energy to overcome the intermolecular dispersion forces.

(b) Boiling point is the temperature at which hydrogen bonds form in the liquid phase.

(c) Boiling point is the temperature at which the covalent bonds within each molecule are overcome.

(d) The boiling point is the temperature at which the valence electrons have been removed from all the atoms in the molecule.

8. Which of the following molecules contains only one lone pair (ie non-bonding pair) of valence shell electrons?

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(a) chlorine gas.

(b) ethane gas.

(c) ammonia gas.

(d) hydrogen gas.

9. Which one of the following molecules contains a double bond and a triple bond?

(a) $HCCCHCH_2$

(b) $H_2CCCHCH_3$

(c) CH_3CH_2CCH

(d) $HCCCH_2CH_3$

10. Which of the following is false for the equilibrium constant, K, for a chemical reaction?

(a) K will alter in value if a change in pressure occurs in the system.

(b) K provides no information about the initial rate of the forward reaction.

(c) If K is small, it indicates that at equilibrium, the concentration of reactants is greater than the concentration of the product.

(d) K will alter if the temperature of the system at equilibrium is altered.

11. Which of the following statements is not true of van der Waals' forces?

(a) They are all intermolecular interactions.

(b) They are generally weaker than ionic and metallic bonding.

(c) They are not significant in covalent network substances, since covalent bonding is much stronger than van der Waals' forces.

(d) They account for the stability of nitrogen gas molecules, which cannot be broken down into separate nitrogen atoms even at high temperature.

12. Which of the following solutions has a pH less than 7?

(a) $Mg(OH)_2(aq)$

(b) $CH_3COOH(aq)$

(c) distilled water

(d) $Na_2CO_3(aq)$

13. In which of the following species is the oxidation number of chromium equal to +6?

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(a) $Cr(OH)_4^-$

(b) Ag_2CrO_4

(c) $Cr(OH)_3$

(d) Cr_2O_3

14. Phenolphthalein indicator is added to a dilute potassium hydroxide solution in a conical flask which is then titrated against a dilute sulfuric acid solution from a burette. Which of the following statements about this titration is true?

(a) The end point will be reached before the equivalence point.

(b) The end point and equivalence point will be reached simultaneously.

(c) The phenolphthalein will remain orange/red until the end point is reached.

(d) The equivalence point will be reached before the end point.

15. *An electrolytic cell contains a mixture of $H^+(aq)$, $Cl^-(aq)$ and $SO_4^{2-}(aq)$ such that each ionic species has a concentrations of approximately 1.0 mol L^{-1}. When electrolysed with inert electrodes, which of the following occurs?*

(a) Chlorine gas is evolved at the anode, and sulfur dioxide gas is evolved at the cathode.

(b) Hydrogen gas is evolved at the cathode, and oxygen gas is evolved at the anode.

(c) Chlorine gas is evolved at the anode, and sulfur is deposited at the cathode.

(d) A mixture of chlorine and sulfur dioxide gases is evolved at each electrode.

16. Balance the unbalanced equation below:

$$....Cu(s) + ...HNO_3(aq) \rightarrow ....Cu(NO_3)_2(aq) + ...H_2O(1) + ...NO(g)$$

Which of the following gives the correct coefficients, reading from left to right in the balanced equation?

(a) 2, 4, 2, 2 and 2

(b) 3, 6, 3, 3 and 2

(c) 3, 8, 3, 4 and 2

(d) 2, 6, 2, 3 and 1

17. Which one of the following compounds boils at the highest temperature?

(a) C_4H_{10}

(b) C_2H_5COOH

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(c) C_3H_7OH

(d) C_2H_5CHO

18. For the titration between dilute ethanoic acid (in a burette) and standardised sodium hydroxide (in a conical flask), which of the following experimental procedures would be inappropriate?

(a) Add a few drops of phenolphthalein indicator to the sodium hydroxide.

(b) Add sulfuric acid catalyst to the conical flask and warm the contents to about 80^oC before commencing the titration.

(c) Prior to adding the acid to the burette, rinse the burette with distilled water and then a small portion of the acid solution.

(d) Pipette out 20.00 mL aliquots of the sodium hydroxide solution into three separate conical flasks which have each been rinsed with distilled water.

19. Which of the following compounds most readily undergoes addition reactions?

(a) benzene

(b) cyclohexane

(c) ethanol

(d) butene

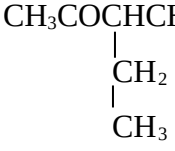
20. Which one of the following does not represent a pair of isomers?

(a) methyl butanoate and butyl methanoate

(b) cis-dichloropropene and trans-dichloropropene

(c) 2-hexene and 2-hexyne

(d) hexane and 2,3-dimethylbutane

21. What is the systematic name for the compound  ?

(a) 3-methyl-2-pentanone

(b) 2-ethyl-3-butanone

(c) 2-hydroxy-3-ethylbutane

(d) 3-methylpentanoate

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22. The repeating section of a condensation polymer molecule is shown below:

— $OC(CH_2)_2COO(CH_2)_3O$ —

Which of the following correctly indicates the monomers which reacted to form the polymer?

(a) $HOOC(CH_2)_2COOH$ and $HO(CH_2)_3OH$

(b) $OH(CH_2)_3COOH$ and $OH(CH_2)_2COOH$

(c) $HOOC(CH_2)_3COOH$ and $HO(CH_2)_2OH$

(d) $CH_3COOCH_2CH_3$ and CH_3COOCH_3

23. 3 - hexanone can be prepared from which of the following lists of substances?

(a) 3-hexanoic acid and 3-hexanol

(b) 3-hexanol and acidified potassium permanganate solution

(c) 3-hexylhexanoate and 3-hexanol

(d) 3-hexanoic acid and acidified potassium dichromate solution

24. Which of the following compounds is the common product of both esterification reactions and condensation polymerisation reactions?

(a) water

(b) carbon dioxide gas

(c) a carboxylic acid

(d) a saturated hydrocarbon

25. Which of the following statements about the Periodic Table of the elements is false?

(a) Elements in the same group of the Table have the same electronic configuration.

(b) The most electronegative element is found in Period 2, Group VII of the Table

(c) Elements become less metallic in nature from left to right across any period.

(d) Elements in Group I and II form hydroxides which are strongly basic.

26. Which of the following statements about oxidising and reducing agents is false?

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(a) Bromine water can oxidise chloride ions to chlorine.

(b) Hydrogen peroxide solution is capable of spontaneous self oxidation - reduction.

(c) Group I metals are good reducing agents.

(d) Copper metal will react with a dilute silver nitrate solution.

27. A compound has an empirical formula of CH_2. At STP, the density of the gaseous compound is 2.504 g L^{-1}. Which of the following is the correct formula of the compound?

(a) C_2H_4

(b) C_3H_6

(c) C_4H_8

(d) $C_{10}H_{20}$

28. Which of the following statements indicates the main advantage of modern detergents over soaps?

(a) Detergents are biodegradeable, whereas soaps are not.

(b) Detergents are not organic compounds whereas soaps are.

(c) Detergents will not form an insoluble scum in hard water, whereas soaps will.

(d) Detergents will dissolve both polar and non-polar substances whereas soaps will only dissolve non-polar substances

29. Read the following statements about polymers.

I Polythene is a condensation polymer, but polyvinyl chloride (PVC) is an addition polymer

II Synthetic polymers which are made from an acid monomer and an alcohol monomer are called polyesters.

III Polyvinyl chloride (PVC) is a harder plastic than polythene due to the presence of chlorine atoms, which tend to increase the strength of dispersion forces between the chains of molecules.

IV Addition polymers are made from long chain alkanes which react by adding functional groups to the ends of the chains.

Which of the above statements is/are correct?

(a) Only statement I is correct.

(b) Only statements I and IV are correct.

(c) Only statement II is correct.

(d) Only statements II and III are correct.

SEE NEXT PAGE

30. Which of the following statements about carbon-containing substances is true?

(a) Carbon atoms in diamonds are bonded covalently to three other carbon atoms in three different directions.

(b) Carbon atoms in graphite bond to four other carbon atoms to produce small planar clusters of atoms held together by dispersion forces..

(c) Carbon atoms in methane bond to four hydrogen atoms to form a tetrahedral shaped molecule with bond angles of 109.5^{o}.

(d) In carbon dioxide, the central carbon atom has two double bonds and two lone pairs of electrons.

END OF PART 1

SEE NEXT PAGE

PART 2 (70 marks)

Answer ALL questions in Part 2 in the spaces provided below.

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1 Write equations for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'.

In each case describe what you would observe, including any
* colour change
* odour
* precipitate (give the colour)
* gas evolution (give the colour or describe as colourless)

If a reaction occurs but the change is not observable, you should state this.

(a) Chlorine gas is bubbled through potassium bromide solution in a test tube.

Equation.....
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Observation.....
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(3marks)

(b) Concentrated nitric acid solution is added to zinc metal filings.

Equation.....
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Observation.....
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(3marks)

(c) Sodium hydroxide solution is added to solid aluminium hydroxide.

Equation.....
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Observation.....
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(3marks)

(d) Some powdered ammonium chloride is shaken with powdered calcium hydroxide in a test tube and gently heated.

SEE NEXT PAGE

Equation.....
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Observation.....
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(3marks)

2. Complete the table below by drawing a structural formula for the named substance, or naming the substance whose structural formula is indicated.

NAME OF SUBSTANCE	STRUCTURAL FORMULA
2-bromo-3-iodo-2-pentene	
	$CH_3(CH_2)_4COCH_3$
trans-1,2-difluoropropene	
	$CH_3CFHCOOH$

(6 marks)

3. In the spaces provided give the reason for each observation listed below. The use of small labelled diagrams will assist your answer.

(i) HCl(g) has a higher boiling point than Cl_2(g) even though chlorine has the higher molecular mass.

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(3 marks)

(ii) PF_3 molecules are polar, but BF_3 molecules are non-polar.

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.....(4 marks)

(iii) Blocks of magnesium metal are sometimes attached to the iron hulls of ocean-going vessels.

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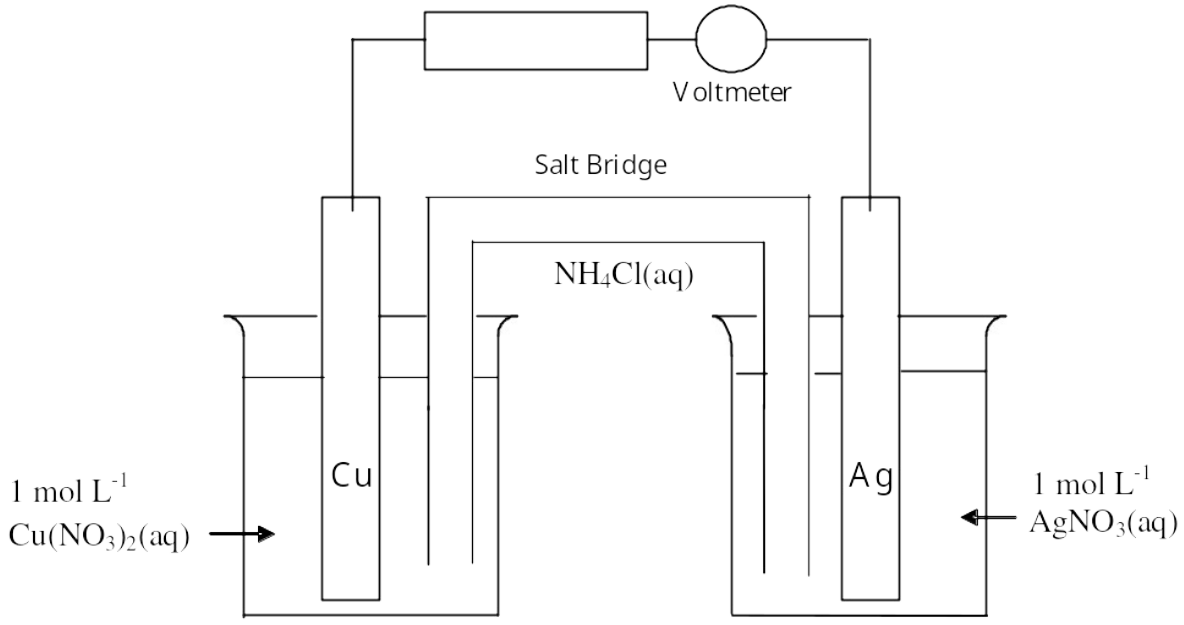
.....(3 marks)

4. Below is a diagram of an electrochemical cell.



(a) Write a half equation to show the reaction at the anode of the cell.

.....(1 mark)

(b) Draw an arrow **in the box** provided on the diagram to indicate the flow of electrons in the external circuit. (1 mark)

(c) Give the formula of one ion that will move from the Cu/Cu^{2+} half cell towards the Ag/Ag^{+} half cell through the salt bridge.

.....(1 mark)

(d) Under standard conditions, what is the maximum expected reading on the voltmeter in the external circuit?

.....(2 marks)

5. Distinguish clearly between the terms **"IONISATION ENERGY" and "ELECTRONEGATIVITY".**

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.....(4 marks)

6. Draw electron-dot diagrams showing the arrangement of all valence electrons in the following chemical species.

a) propanone	b) a carbonate ion.

(6 marks)

7. Nitrogen dioxide (a brown gas) and dinitrogen tetroxide (a colourless gas) establish an equilibrium mixture in a sealed glass container as indicated by the following reversible reaction:

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$2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -61 \text{ kJ mol}^{-1}$

At room temperature and pressure, the appearance of the gas mixture is pale brown.

With reference to the above, certain changes are then imposed on the system at equilibrium. Clearly state what you would observe after each change is made, and apply Le Chatelier's Principle to account for each observation in the spaces allocated on the next page.

(a) The pressure on the gas mixture is doubled by halving the volume of the container.

Observation:.....(1 mark)

Explanation.....
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.....(2 marks)

(b) The temperature of the gas mixture is raised by placing the container in hot water.

Observation: .....(1 mark)

Explanation.....
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.....(2 marks)

8. Explain why methyl orange and not phenolphthalein is a suitable indicator for the titration between hydrochloric acid and ammonia solution. Assume that the indicator is placed with the base in a conical flask and that the acid is added from a burette.

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.....(4 marks)

9. In the spaces below, draw the structural formulae of a secondary alcohol and a tertiary alcohol which each have five carbon atoms in the molecule. Name each alcohol. (4 marks)

10. Zinc metal and zinc oxide are both amphoteric.
Explain what is meant by the term "amphoteric" and write balanced equations which illustrate the amphoteric nature of either one.

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.....(4 marks)

11. Four white crystalline substances in identical unmarked jars need to be identified. The substances are barium hydroxide, magnesium nitrate, sodium sulfate and aluminium carbonate.
Complete the following table giving a relevant distinguishing **chemical** test which will enable you to correctly identify each substance. Give the accompanying observation and your conclusion.
Equations are unnecessary.

Test	Observation	Conclusion
1. To a little of each of the four solid samples, add	…… …… …… ……	…… …… …… ……
2. To a little of each of the three remaining samples add water to dissolve, then…… …… ……	…… …… …… ……	…… …… …… ……
3. To a little of the two remaining samples add water to dissolve, then…… ……. ……..…	…… …… …… ……	…… …… …… ……

(9 marks)

END OF PART 2

PART 3 (50 marks)

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 problem is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't you will lose marks.

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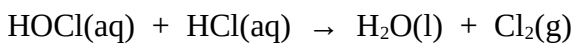
1. One method of preparing chlorine gas in the laboratory is to react hypochlorous acid (bleach) with hydrochloric acid. The following reaction occurs:



$$HOCl(aq) + HCl(aq) \rightarrow H_2O(l) + Cl_2(g)$$

In one such experiment, 150.0 mL of 0.502 mol L^{-1} hydrochloric acid was added to 500.0 mL of a bleach solution which contained 4.00 g of HOCl per litre.

(a) Determine the limiting reagent in this reaction. (4 marks)

(b) Calculate the volume of chlorine gas obtainable from the above experiment if it is measured at 25°C and 94.0 kPa. (4 marks)

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2. In an industrial accident at a chemical factory, 2.00×10^5 L of hydrochloric acid solution spills into a pond which is holding 5.00×10^6 L of pure water. The pH of the pondwater is tested after the spillage and is found to be 0.716.

   (a) Calculate the concentration of the original hydrochloric acid solution. (6 marks)

   (b) It is decided to neutralise the hydrochloric acid in the pond by adding a suitable quantity of pure solid hydrated sodium carbonate ($Na_2CO_3.10H_2O$) to the pond.
   Calculate the mass of the hydrated sodium carbonate needed. (4 marks)

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3. An organic compound containing only carbon, hydrogen, chlorine and oxygen is analysed by combusting a 2.042 g sample in excess oxygen. All the carbon in the compound was converted to carbon dioxide, all the hydrogen it contained was converted to water and the all the chlorine it contained was converted to hydrochloric acid.
The mass of carbon dioxide produced was 2.914 g, the mass of water was 0.9937 g, and the hydrochloric acid required 0.3759 g of ammonia gas to be bubbled through it to neutralise the acid.

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

   (b) When a 2.504 g sample of the compound was vaporised in the absence of air, the vapour occupied 0.607 L at S.T.P. From this data, calculate the molecular formula of the compound. (2 marks)

   (c) Further analysis shows the presence of a C=O group in the molecule. From this information, draw the structural formula of one isomer of the compound and give it a systematic name. (2 marks)

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4. *Many private and commercial spas use automatic bromine generators to produce aqueous bromine whose oxidising ability is then used to kill harmful or unwanted microorganisms in the water. Pure solid sodium bromide is first added to the spa water. The generators are simple low voltage electrolytic cells which convert the bromide ions from the sodium bromide into aqueous bromine according to the anode reaction:*

$$2Br^-(aq) \rightarrow Br_2(aq) + 2e^-$$

In one particular bromine generator, a steady current of 1.50 A is passed continuously through the cell. The spa holds 1.500×10^3 L of water and requires a bromine concentration of 30 ppm (parts per million) to be maintained in the water. Assume that 1.00 L of spa water weighs 1.00 kg.

(a) Calculate the time required for such a generator to produce a bromine concentration of 30 ppm. in the spa. Assume that no initial bromine is present in the water.

(7 marks)

(b) What mass of pure sodium bromide is consumed to produce a bromine concentration of 30 ppm in the spa ? (3 marks)

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5. An analytical chemist is given the task of determining the percentage purity of a sample of potassium permanganate. She takes a representative sample of the compound weighing 2.350 g , dissolves it in water and makes the volume up to 250.0 mL in a volumetric flask. After thorough mixing, the permanganate solution is transferred to a clean dry burette ready for titration.
She then prepares a solution of oxalic acid by dissolving 5.15 g of pure $H_2C_2O_4.2H_2O$ in water and making the volume up to 250.0 mL in another volumetric flask.
The chemist then takes four 20.0 ml aliquots of the oxalic acid solution in four separate conical flasks, adds sulfuric acid catalyst to each, warms the solutions to about 80°C and then performs four titrations by adding the permanganate solution to the conical flasks until the first permanent trace of pink (excess $MnO_4^-(aq)$) appears.
The results of the four titrations are shown in the Titration Table below:

Volume of $KMnO_4(aq)$ added to 20.0 mL oxalic acid

	Titre 1	Titre 2	Titre 3	Titre 4
Initial reading (mL)	1.60	0.05	2.35	1.05
Final reading (mL)	25.80	22.50	24.85	23.45
Added volume (mL)				

Average titre = ...mL

From the above data, calculate the percentage purity of the potassium permanganate sample.

(10 marks)

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PART 4 (20 marks)

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 2 - 2½ pages.

The Chemistry of Carbon and Silicon

Carbon (element 6) and Silicon (element 14) are members of Group IV of the Periodic Table of the elements.
Both elements are found as solids in the pure state. Carbon has two allotropes - graphite and diamond. Silicon exists in only one pure solid form which most closely resembles diamond in structure and properties.
Both elements are found combined in a variety of compounds - carbon exists as a gas (carbon dioxide), in the earth's crust (mainly as calcium and magnesium carbonates) and in many organic compounds such as hydrocarbons and addition polymers.
The elements combine with each other to produce silicon carbide - SiC - a very hard solid with a high melting point.
Silicon is abundant in the earth's crust where it exists mainly as solid silicon dioxide (sand or silica) and silicates where the element is always combined with oxygen, aluminium and a Group I or Group II metal .
A significant difference between the elements is the inability of silicon to form double or triple bonds which are very common with carbon.

With the assistance of small diagrams, compare and contrast the properties of carbon and silicon by discussing the following:

(a) The combining power of each element as Group IV elements (3 marks)

(b) A comparison of the relative strengths of C-C and Si-Si bonding (3 marks)

(c) A comparison of the bonding and physical properties of carbon dioxide and silicon dioxide
Relate the physical properties of each substance to bonding. (6 marks)

(d) A comparison of the bonding and physical properties of graphite, diamond and silicon carbide
Relate the physical properties of each substance to bonding. (6 marks)

(e) The reason why silicon cannot be used to produce addition polymers (2 marks)

END OF PAPER

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