

Year 12

Chemistry

2007

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	14	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

- 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.
- 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.

- The examiners recommend that you spend your reading time mainly reading the instructions to candidates and Parts 2, 3 and 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 $\text{Ag}^+(\text{aq})$], **molecules** [for example $\text{NH}_3(\text{g})$, $\text{NH}_3(\text{aq})$, $\text{CH}_3\text{COOH}(\text{l})$, $\text{CH}_3\text{COOH}(\text{aq})$] or **solids** [for example $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

PART 1: Multiple Choice

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided. Each question in this part is worth 2 marks. This part carries 60 marks out of 200.

1. Which of the following formulae have been named correctly, based on the IUPAC nomenclature?

	Formula of substance	IUPAC name
(a)	$\text{Fe}(\text{NO}_3)_2$	Iron(III) nitrate
(b)	CrPO_4	Chromium(III) phosphate
(c)	AlCl_3	Aluminium(III) chloride
(d)	Na_2CO_3	Sodium(II) carbonate

2. Which of the following particles has 10 electrons, 12 neutrons and 11 protons?

- (a) Na^+
- (b) Ne^-
- (c) Mg^{2+}
- (d) Al^{3+}

3. Which of the following electron configurations of neutrally charged atoms is not from an element in Group II of the periodic table?

- (a) 2
- (b) 2, 2
- (c) 2, 8, 2
- (d) 2, 8, 8, 2

4. X_3Y_2 is the formula of a soluble salt. The dissociation of this salt in water produces which of the following?

- (a) X^{3+} and Y^{2-}
- (b) X^{2+} and Y^{3-}
- (c) $\text{X}(\text{OH})_2$ and H_3Y

d) X_3Y_2 molecules

5. In moving left to right across a period of the periodic table, which of the following generally increases?
- (a) Atomic radius
 - (b) Metallic character
 - (c) Reactivity
 - (d) First ionization energy
6. The following table shows the conductivities of substances L, M and N.

Substance	Electrical conductivity
L	Conducts electricity in solid and molten states
M	Conducts electricity in aqueous and molten states
N	Does not conduct electricity in any state

The substances are most likely to be which of the following?

	L	M	N
(a)	sulfur	potassium chloride	magnesium
(b)	potassium chloride	magnesium	sulfur
(c)	magnesium	potassium chloride	sulfur
(d)	magnesium	sulfur	potassium chloride

7. In which of the following can all the elements mentioned form both strongly ionic and strongly covalent bonds?
- (a) Carbon, hydrogen and silicon.
 - (b) Sodium, chlorine and sulfur.

- (c) Iodine, carbon and sulfur.
- (d) Hydrogen, iodine and sulfur.

8. Which of the following statements are not true?

- I NH_3 contains one pair of non-bonded electrons
- II H_2S contains two pairs of shared electrons
- III CO_2 contains two pairs of shared electrons
- IV CHCl_3 contains no non-bonded electrons

- (a) I and II.
- (b) I and III.
- (c) II, III and IV.
- (d) III and IV.

9. Which of the following lists the substances in order of decreasing strength of intermolecular force?

- (a) CH_3COOH , CH_3CHO , CH_3CH_3
- (b) $\text{CH}_3\text{CH}_2\text{CH}_3$, CH_3COCH_3 , $\text{CH}_3\text{CH}_2\text{COOH}$
- (c) CH_3CH_3 , $\text{CH}_3\text{CH}_2\text{CH}_3$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- (d) CH_3OCH_3 , CH_3CHO , $\text{CH}_3\text{COOCH}_3$

10. Chlorine and oxygen react to form a compound. Which of the following is correct?

- (a) The compound has the formula OCl_2 and is soluble in polar organic solvent.
- (b) The compound is a strong electrolyte and has a low melting point.
- (c) The compound has the formula OCl_2 and is a strong electrolyte.
- (d) The compound has a high melting point and is very soluble in water.

11. Which of the following reactions can occur spontaneously at room temperature?

- (a) $2\text{Fe}^{2+}(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{Fe}^{3+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$
- (b) $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
- (c) $\text{Zn}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \rightarrow \text{Zn}(\text{s}) + \text{Cu}^{2+}(\text{aq})$
- (d) $\text{CuO}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{l})$

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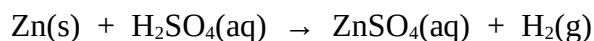
12. An aqueous solution of ethanoic acid can easily react with:

- I magnesium to produce magnesium ethanoate and hydrogen gas
- II potassium carbonate to produce potassium ethanoate and carbon dioxide gas
- III sodium hydroxide solution to produce sodium ethanoate and water
- IV propanol to produce ethyl propanoate and water

Which of the above choices are correct?

- (a) I, II and III only.
- (b) I and IV only.
- (c) II and IV only.
- (d) I, II, III and IV.

13. Zinc granules react with sulfuric acid as shown in the equation:



In the above reaction, the rate of evolution of hydrogen gas decreases with time. This is because:

- (a) the sulfuric acid gets weaker over time.
- (b) the increase in temperature favours the reverse reaction.
- (c) the total surface area of the zinc granules decreases with time.
- (d) the nature of the reactants changes with time.

14. The effect of a catalyst on a chemical reaction is to:

- (a) decrease the enthalpy of the reaction.
- (b) decrease the time taken for equilibrium to be established.
- (c) increase the activation energy of the reaction.

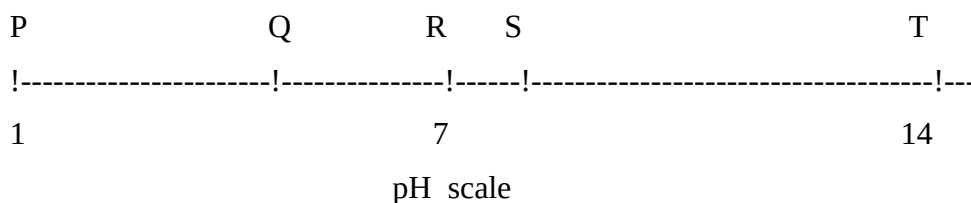
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-
- (d) increase the yield of the reaction.
15. A sealed container contains ammonia solution in equilibrium with ammonia gas. The concentration of the ammonia solution can be increased by which of the following?
- (a) Heating the container.
 - (b) Adding water to the system.
 - (c) Adding ammonia gas to the system.
 - (d) Adding nitrogen gas to the system.
16. Which of the following is true about the chemical properties of acids?
- (a) Acids react with aluminium oxide to produce a salt, water and hydrogen gas.
 - (b) Acids react with potassium hydrogencarbonate to produce a salt, water and carbon dioxide.
 - (c) Acids react with copper metal to produce a salt and hydrogen gas.
 - (d) Acids react with metal hydroxides to produce a salt and hydrogen gas.
17. Which of the following substances could be used to differentiate between solutions of dilute hydrochloric acid and dilute sodium hydroxide?
- (a) Graphite
 - (b) Barium chloride
 - (c) Gold
 - (d) Calcium carbonate
18. Which of the following shows the hydrogencarbonate ion acting as an acid?
- (a) $\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$
 - (b) $\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq}) + \text{OH}^-(\text{aq})$
 - (c) $2\text{HCO}_3^-(\text{aq}) + \text{Cu}^{2+}(\text{aq}) \rightleftharpoons \text{Cu}(\text{HCO}_3)_2(\text{aq})$
 - (d) $\text{Ca}(\text{HCO}_3)_2(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g})$
-

19. Which of the following substances cannot be considered a base?

- (a) Aqueous ammonia
- (b) Potassium nitrate
- (c) Copper(II) oxide
- (d) Sodium carbonate

20. The pH values of solutions P, Q, R, S and T are shown in the diagram below:



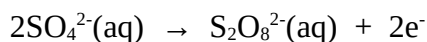
Which of the following represents the most probable solutions for P, Q, R, S and T?

	$\text{Ca}(\text{HSO}_4)_2(\text{aq})$	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{CH}_3\text{COOK}(\text{aq})$	$\text{NaNO}_3(\text{aq})$	$\text{NaOH}(\text{aq})$
(a)	P	Q	R	S	T
(b)	Q	P	S	R	T
(c)	Q	P	T	R	S
(d)	R	P	Q	S	T

21. Which of the following is a redox reaction?

- (a) $\text{H}_3\text{O}^+(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l})$
- (b) $\text{MgSO}_4(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + \text{PbSO}_4(\text{s})$
- (c) $\text{Pb}^{2+}(\text{aq}) + 2\text{Br}^-(\text{aq}) \rightarrow \text{Pb}(\text{s}) + \text{Br}_2(\text{g})$
- (d) $\text{C}_2\text{H}_4(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{C}_2\text{H}_4\text{Cl}_2(\text{aq})$

22. When a solution of potassium hydrogensulfate (KHSO_4) is electrolysed, peroxodisulfate ions are produced according to the half reaction below:



Which of the following statements is true regarding the half reaction?

- I The half reaction occurs at the cathode
- II Sulfate ions are oxidised
- III The oxidation number of the sulfur changes from +6 to +7
- IV The equation above is not balanced electrically (-2 on the left and -4 on the right)

- (a) I, II and III only.
- (b) I and IV only.
- (c) II and III only.
- (d) I, II, III and IV.

23. In the electrolysis of molten lead(II) bromide using carbon electrodes which of the following occurs?

- (a) Bromide ions are oxidized at the cathode.
- (b) Lead(II) ions are reduced at the anode.
- (c) Bromide ions are produced at the cathode.
- (d) Oxidation occurs at the anode while reduction occurs at the cathode.

24. Which of the following statements regarding alcohols is correct?

- (a) The -OH functional group on the alcohols makes them basic.
- (b) The solubility of alcohols in water increases with increasing length of the hydrocarbon chain.
- (c) Primary alcohols are oxidised to acids, secondary alcohols to aldehydes and tertiary alcohols to ketones.
- (d) Primary alcohols have higher boiling points than secondary alcohols which have higher boiling points than tertiary alcohols.

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25. Based on the relevant structural formulae of methyl butane and dimethyl propane which of the following is the same for both compounds?
- (a) Molecular structure
 - (b) Melting point
 - (c) Solubility
 - (d) Content by mass
26. Which of the following best explains why the boiling point and melting point of alkanes increase with an increase in the number of carbon atoms in the molecules of the respective alkanes?
- (a) The number of covalent bonds between carbon atoms increases.
 - (b) The dispersion forces between molecules become stronger.
 - (c) Electrostatic forces of attraction between the ions become stronger.
 - (d) The number of hydrogen atoms increases.
27. Which of the following pairs of compounds are isomers of each other?
- (a) Butane and butene
 - (b) Pentane and methylbutane
 - (c) 2,3-dimethylhexane and 2-methylhexane
 - (d) Cyclohexane and hexane
28. Which one of the following pairs of compounds will react to produce an ester with the molecular formula $\text{C}_2\text{H}_5\text{COOCH}_3$?
- (a) H_2O and $\text{C}_3\text{H}_7\text{COOH}$
 - (b) $\text{C}_2\text{H}_5\text{OH}$ and CH_3COOH
 - (c) $\text{C}_2\text{H}_5\text{OH}$ and HCOOH
 - (d) CH_3OH and $\text{C}_2\text{H}_5\text{COOH}$

29. Which of the following statements is true of soap?

- (a) Soap is a polymer.
- (b) Soap produced from the saponification of oils and fats is usually coloured and fragrant.
- (c) Each molecule of soap is made up of one part consisting of a long chain hydrophilic hydrocarbon and another part that is charged and hydrophobic.
- (d) Soap is produced by means of the hydrolysis of triglyceride esters by a concentrated alkali solution.

30. Which of the following is a monomer for a condensation polymer?

- (a) $\text{CH}_3\text{CH}_2\text{COOH}$
- (b) CH_3CHCH_2
- (c) HOOCCH_2OH
- (d) CH_3OCOOH

END OF PART 1

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) An iron nail is dipped into copper(II) sulfate solution.

Equation :

Observation :

.....

(3 marks)

- (b) Sodium metal is placed into some ethanol.

Equation :

Observation :

.....

(3 marks)

- (c) Cobalt chloride hexahydrate is dissolved in concentrated hydrochloric acid.

Equation :

Observation :

.....

(3 marks)

2. For each species listed in the table below, draw the structural formula, representing all valence shell electron pairs either as : or as - .

Species	Structural formula (showing all valence electrons)
Magnesium carbonate	
Carbon monoxide	

(4 marks)

3. Consider the following chemical substances and complete the table:

BF₃, SO₂, PCl₃, F₂O, Br₂, CH₄, HCN

List all the bent molecules that contain polar bonds	
List all the nonpolar molecules	
List all the linear molecules	

(Note: substances can be listed in more than one category)

(6 marks)

4. A student carries out 4 experiments and makes the following observations:

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Experiment	Observations
1	A green compound is heated strongly to produce a black residue, a brown gas and another gas which rekindles a glowing splint.
2	The black residue is mixed with sulfuric acid and is heated to produce a blue solution.
3	When sodium hydroxide is added to the blue solution a blue precipitate is formed.
4	When zinc powder is added to the blue solution from Experiment 2, a solid is obtained.

- (a) Write an equation showing what happened in Experiment 1

.....(2 marks)

- (b) What is the name/formula of the blue precipitate in Experiment 3?

.....(1 mark)

- (c) What type of reaction is occurring in Experiment 4?

..... (1 mark)

5. Describe what is observed (using equations to assist) when an ammonia solution is added slowly and then to excess, to a solution that contains silver ions.

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.....(4 marks)

6. Explain the difference between the following terms:

- (a) alkali metals and alkaline earth metals.

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.....(2 marks)

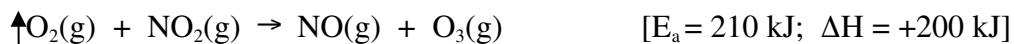
(b) a covalent bond and a dative covalent bond.

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.....(2 marks)

7. Explain why the melting point of HI is higher than the melting point of HCl.

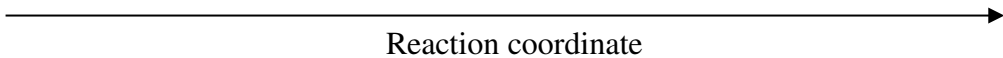
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.....(2 marks)

8. Using the following axes, draw and clearly label a reaction profile for the reaction:



E_p

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(3 marks)

Is the reaction exothermic or endothermic?.....(1 mark)

9. The breakdown of calcium hydrogencarbonate can be represented by the following equilibrium equation:



- (a) Write an expression for the equilibrium constant for this reaction

(2 marks)

- (b) What would be the effect on the equilibrium if you increased the concentration of $\text{CO}_2(\text{g})$?

.....

..... (2 marks)

- (c) Explain, using Le Chatelier's Principle, what would be the effect of increasing the volume of the reaction chamber?

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..... (2 marks)

10. Methanol can be manufactured by combining hydrogen and carbon monoxide in an exothermic reaction. (a) Write the balanced equation for this reaction. (b) List the conditions that would favour a fast reaction rate and the conditions that would favour a high equilibrium yield of methanol in an industrial setting.

(a)

Equation:

(b)

Fast reaction rate	High Equilibrium yield

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(5 marks)

- 11(a) Sketch and clearly label a working electrochemical cell that has zinc and iron electrodes in zinc sulfate and iron(II) chloride solutions respectively. On your sketch, show the movement of ions and electrons.

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- (b) write an equation for the reaction occurring at each electrode.

Cathode	
Anode	

(2 marks)

- (c). Explain what would happen to the cell voltage (assuming standard conditions) if the iron electrode (and only this electrode) is replaced with a copper electrode.

.....

.....

.....(2 marks)

12. To successfully electroplate an iron chain with silver, what are the correct materials to use?

As an Anode	
As a Cathode	
As an Electrolyte	

(4 marks)

13. Complete the following table for these important industrial substances

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Product	Process name	Catalyst used
Sulphuric acid		
Aluminium		

(4 marks)

14. For each of the following reactions, draw the structural formula of the organic product.

Reaction	Structural formula of organic product
Acidified dichromate solution is added to 2-propanol.	
Bromine is mixed with propene.	
Chlorine gas is added to propane and exposed to U.V. light.	

(6 marks)

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. In the reaction between lead(II) nitrate and potassium iodide, lead(II) iodide is formed.

(a) Write an equation for this reaction.

If 2.00 g of lead nitrate is added to 3.00 g of potassium iodide,

(b) identify the limiting reagent.

(c) calculate the mass of lead(II) iodide formed

(d) calculate the mass of excess reactant remaining after the reaction. (9 marks)

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2. A gaseous substance with an empirical formula of C_2H_5 has a density of 2.458 g L^{-1} at 15°C and 101.3 kPa .
- (a) Calculate the relative molecular mass of the substance.
 - (b) Derive the molecular formula of the substance.
 - (c) If 5.00 L CO_2 was produced upon ignition of the substance at 420°C and 101.3 kPa , calculate the volume of the substance consumed, as measured at STP, and also calculate the mass of water produced. (9 marks)

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3. A compound was analysed to determine its empirical formula. The compound contained nickel, chlorine, carbonate and water and had the general formula $\text{Ni}_w\text{Cl}_x(\text{CO}_3)_y \cdot z\text{H}_2\text{O}$.

1.684 g of the compound was heated to drive off the water. The mass of compound was determined a number of times during the heating and the following data was obtained:

Time (hours)	Mass (g)
0	1.684
1	1.401
2	1.386
3	1.383

One third of the anhydrous compound was dissolved and H_2S gas was bubbled through the solution. 0.338 g of NiS was precipitated.

Another one third of the anhydrous compound was treated with silver nitrate producing 0.532 g of silver chloride.

The remaining third of the anhydrous compound was analysed by combustion and 0.082 g of carbon dioxide was produced.

Determine the values of w , x , y and z in the general formula above.

(12 marks)

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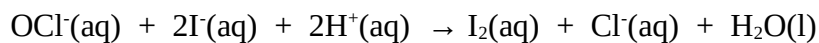
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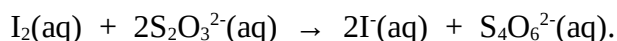
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4. The bleaching agent sodium hypochlorite (NaOCl) is the active ingredient in many household disinfectants. The concentration of this substance in a 20.00 mL sample was determined by adding an acidified solution containing an excess of $\text{I}^-(\text{aq})$ ions to the sample according to the equation:



The iodine formed by this reaction was then titrated against a 0.500 mol L⁻¹ sodium thiosulfate solution (Na₂S₂O₃):



The following titration results were obtained:

	Titration			
	1	2	3	4
Final volume (mL)	26.95	26.46	26.87	26.83
Initial volume (mL)	0.30	1.25	1.76	1.54
Titre volume (mL)				

- Calculate the concentration of OCl^- in the household disinfectant.
- If the density of the original solution was 1.03 g mL^{-1} calculate the percentage by mass of NaOCl in the disinfectant tested.

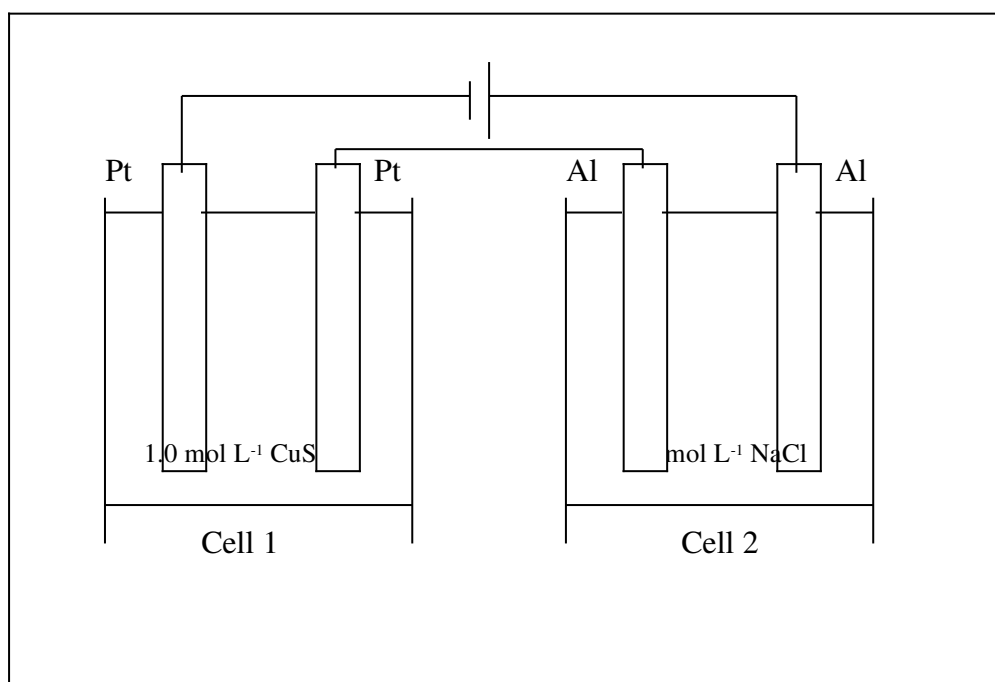
(9 marks)

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5. A steady current is passed through two electrolytic cells connected in series as shown in the diagram below.



After 30.0 minutes, 5.20 g of copper is deposited at the cathode of Cell 1.

- Calculate the change in mass of the anode in Cell 2.
- Calculate the total volume of gas produced in both cells at 25°C and 99.8 kPa .
- Calculate the current being supplied to the cells. (11 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.

Ethanedioic acid is more commonly known as oxalic acid. The anhydrous chemical formula is $\text{H}_2\text{C}_2\text{O}_4$. At room temperature it appears as a white crystal and is frequently prepared and found with a high degree of purity as a dihydrate. Its melting point is 101.5°C .

At 15°C the solubility of ethanedioic acid in water is 9.5 g per 100 mL. In polar organic solvents it is between 2 - 3 g per 100 mL. It is practically insoluble in benzene.

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Ethanedioic acid is a relatively strong diprotic carboxylic acid. It is about 10 000 times stronger than ethanoic acid. A 0.1 mol L⁻¹ aqueous solution has a pH of 1.3. Oxalic acid undergoes all the reactions typified by acids and by carboxylic acids.

Hydrated oxalic acid can be used in volumetric analysis. The oxalate ion is an effective reducing agent and as such is used as a laboratory reagent.

Discuss the physical and chemical properties of ethanedioic acid with reference to the information supplied above.

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