Year 12

Chemistry

2009

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**

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, B or HB pencil. Each question in this part is worth 2 marks.

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1. Element X has the outer shell electron configuration ..s^2 p^2(4). Element Y has the outer shell electron configuration ..s^2p^5(5). The most likely formula of the compound formed by X and Y is which of the following?

   (a) X_3Y_2

   (b) XY_2

   (c) XY_4

   (d) XY

2. The compound formed between elements X and Y in Question 1 above is most likely to be which of the following? X and Y are both in the first three periods of the periodic table.

   (a) A covalent network compound.

   (b) A covalent molecular compound.

   (c) A metallic compound.

   (d) An ionic compound.

3. An element belongs to Group V of the periodic table. Which of the following lists indicates the possible number of protons, neutrons and electrons in an atom of this element?

   (a) 5 protons, 5 neutrons and 5 electrons.

   (b) 10 protons, 12 neutrons and 10 electrons.

   (c) 15 protons, 16 neutrons and 15 electrons.

   (d) 20 protons, 41 neutrons and 20 electrons.

4. Which one of the following has only non polar bonds within its molecules in the liquid phase?

   (a) F_2

   (b) HCl

   (c) C_2H_5OH

(d) H_2O

5. Which of the following molecules contains only single bonds?

(a) CH_2CHCCH

(b) $CHClCH(CH_2)_3CH_3$

(c) $CH_2CClCClCH_2$

(d) $CH_3CHBrCH_3$

6. *Which of the following statements concerning atomic structure is incorrect?*

(a) An orbital is a region of space within the nucleus of an atom.

(b) Atoms which contain the same number of protons, but a differing number of neutrons are said to be isotopes of the same element.

(c) In any shell, p orbitals tend to fill before d orbitals.

(d) The fourth principal energy level of an atom has a maximum number of four sublevels.

7. A 1.00 mol L^{-1} solution of copper(II) chloride (a neutral solution) is electrolysed using inert electrodes. According to the Standard Reduction Table, which of the following gives the correct anode and cathode products respectively?

(a) Copper metal and oxygen gas.

(b) Oxygen gas and hydrogen gas.

(c) Oxygen gas and copper metal.

(d) Hydrogen gas and chlorine gas.

8. A medical test found that a person's blood contained the equivalent of 98.0 milligrams of glucose [$C_6H_{12}O_6$] per 100 mL of blood. Which of the following is the correct value of the concentration of the glucose in the person's blood in mol L^{-1}?

(a) 1.84×10^{-4} mol L^{-1}

(b) 5.44×10^{-3} mol L^{-1}

(c) 1.84×10^{-2} mol L^{-1}

(d) 9.80×10^{-2} mol L^{-1}

9. According to the Standard Reduction Table, which of the following 1.0 mol L^{-1} solutions is able to oxidize silver metal to silver ions?

(a) $F^-(aq)$

(b) $Br_2(aq)$

(c) $Ni^{2+}(aq)$

(d) HOOCCOOH(aq)

10. A chemist added 50.0 mL of 0.010 mol L^{-1} hydrochloric acid to 100.0 mL of 0.100 mol L^{-1} sodium chloride solution. Which one of the following is the correct pH of the resulting solution?

(a) 2.5

(b) 3.0

(c) 3.8

(d) 5.2

11. Which of the following correctly describes a nitrate ion?

	Number of single bonds	Number of double bonds	Number of lone pairs of electrons
(a)	3	0	6
(b)	1	2	4
(c)	1	2	6
(d)	2	1	8

12. One mole of each of the substances listed below is dissolved separately in water to make one litre of solution. Which solution has the highest total concentration of ions?

(a) Ammonia

(b) Ammonium sulfate

(c) Copper(II) sulfate-5-water

(d) Sodium hydroxide

13. Equal volumes of 1.0 mol L^{-1} solutions of ammonia and ammonium ethanoate are mixed. Which of the following statements about the resulting solution is true?

(a) The concentration of hydrogen ions is lower than the concentration of ethanoate ions.

(b) The concentration of both hydrogen ions and ethanoate ions is high.

(c) The concentration of both hydrogen ions and ethanoate ions is low.

(d) The concentration of hydrogen ions is higher than the concentration of ethanoate ions.

14. If 1.80 grams of a compound containing only carbon, hydrogen and oxygen is vaporized and the vapor occupies 1.26 L at STP, which of the following is nearest to the empirical formula of the compound?

(a) CHO

(b) CH_4O

(c) C_2H_4O

(d) $C_2H_6O_3$

15. When 1.0 mol L^{-1} solutions of the following are mixed, which combinations will result in the formation of precipitates?

I $Ba(NO_3)_2$ and NaOH

II K_3PO_4 and Na_2CO_3

III $AgNO_3$ and KOH

IV $Zn(NO_3)_2$ and Li_2CO_3

(a) All of the above

(b) II and III only

(c) II, III and IV only

(d) III and IV only

16. Pure carbon in the form of graphite has a higher melting point than molybdenum, a transition metal. Which of the following best explains this difference?

(a) Graphite is denser than molybdenum so the dispersion forces between the carbon atoms are stronger.

(b) Molybdenum has fewer electrons in its outer shell than graphite, so the dispersion force between its molecules is less.

(c) The extended covalent bonding in graphite is stronger than the metallic bonding in molybdenum.

(d) The molecules in graphite are polar, and the dipole-dipole attraction in graphite is stronger than the metallic bonding in molybdenum.

17. Which of the following statements best describes the cathode of an electrolytic cell?

(a) It is the positive terminal of the cell.

(b) It is the place where a reduction reaction always occurs.

(c) It is the place where corrosion occurs.

(d) It is the terminal where electrons leave the cell and enter the external battery.

18. Which one of the following names is incorrect according to the IUPAC System of nomenclature?

(a) 1,2,4-trichlorocyclohexane

(b) ethanone

(c) 3-hydroxycyclohexene

(d) methanal

19. Which of the following reactions represent disproportionation (self oxidation - reduction)?

I $2CrO_4^{2-}(aq) + H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + OH^-(aq)$

II $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

III $2H^+(aq) + 2e^- \rightarrow H_2(g)$

IV $2Cu^+(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$

(a) I only

(b) II and IV only

(c) III only

(d) IV only

20. The first four ionisation energies of an unknown element are as follows:

$I_1 = 577$, $I_2 = 1820$, $I_3 = 2740$, $I_4 = 11\ 600$. (Units are kJ mol^{-1})

The element is most likely to be which of the following?

(a) Aluminium

(b) Silicon

(c) Phosphorus

(d) Sulfur

21. In which of the following pairs of species do the oxidation number of bromine differ?

(a) NaBr, $ZnBr_2$

(b) Br_2O, BrO^-

(c) $NaBrO_3$, BrO_3^-

(d) $Zn(BrO_3)_2$, $Al(BrO_2)_3$

22. For the titration between dilute ethanoic acid (in a burette) and standardised sodium hydroxide in a conical flask, which of the following procedures is incorrect?

(a) Prior to filling the burette with acid, rinse the burette with distilled water.

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

(c) Rinse the pipette with the standardised sodium hydroxide solution before transferring the first aliquot to the conical flask.

(d) Add a few drops of phenolphthalein to each of the conical flasks containing the sodium hydroxide aliquots.

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

(a) If K is large, it indicates that the forward reaction is exothermic.

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

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

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

24. Which of the following is not true of the halogen family?

(a) They are the elements of the periodic table which have an almost full "p" subshell.

(b) Their chemical activity decreases going down the group.

(c) Their first ionisation energies show an increase going down the group.

(d) They form ionic compounds with metallic elements and and covalent compounds with non-metallic elements.

25. Which one of the following statements about the periodic table of elements is incorrect?

(a) The elements are arranged in increasing order of their atomic numbers.

(b) The nature of the bonding of elements in the third row changes from covalent molecular on the left to metallic on the right.

(c) The electronegativity of elements in the third row tends to increase from left to right across the row.

(d) The metallic nature of elements in group IV tends to increase down the column.

26. A soap can be prepared from which of the following lists of substances?

(a) Sodium hydroxide and 1,2,3-propanetriol.

(b) Acidified potassium permanganate solution and sodium ethanoate.

(c) A triglyceride and sodium hydroxide.

(d) Sodium carbonate and ethanoic acid.

27. Which of the following statements best indicates the way in which a modern detergent cleans a greasy plate?

(a) The detergent molecules contain hydroxyl groups (-OH) and remove the layer of grease from the plate by forming strong hydrogen bonds directly with the polar grease molecules.

(b) The detergent molecules have one end which is non-polar, and attaches to the grease molecules with dispersion force, while the other end is polar and attaches itself to the polar water molecules by dipole-dipole interactions.

(c) The detergent molecules are non-polar and are therefore able to attract the non-polar grease molecules with dispersion forces.

(d) The detergent molecules react with water to form a long chain polymer, which forms hydrogen bonding to the grease molecules and dispersion forces to the water molecules.

28. An organic compound has the semistructural formula indicated below.

$CH_3CH_2\ CHOH(CH_2)_2CH_3$

Which of the following statements is true of the above compound?

(a) It is an aldehyde whose systematic name is 3-hexanal.

(b) It is a primary alcohol whose systematic name is 2-heptanol.

(c) It is a secondary alcohol whose systematic name is 3-hexanol.

(d) It is a ketone whose systematic name is 3-heptanone.

29. Which of the following compounds can exist as different isomers?

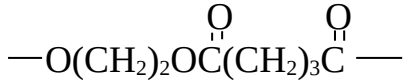
(a) 3-chloropropene.

(b) Propanone.

(c) 2,3-dichloropropene

(d) 1,2-dichloropropene.

30. The repeating section of an acid-alcohol condensation polymer molecule is shown below:



Which of the following correctly names the alcohol monomer which reacted to form the polymer?

(a) 1,2-ethanediol

(b) 3,4-butanediol

(c) 1,5-pentanediol

(d) 1,4-butanediol

END OF PART 1

PART 2 (70 marks)

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

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1. Give fully balanced equations for the reactions which occur (if at all) in the following experiments. Use **ionic equations** where appropriate. In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give the colour or describe as colourless) resulting from the chemical reaction.

(a) 1-pentene is shaken vigorously with a solution of bromine water.

Equation : .....

Observation : .....

.....

[3 marks]

(b) Concentrated ammonia solution is added to solid copper(II) hydroxide.

Equation : .....

Observation : .....

.....[3 marks]

(c) Silver metal is placed in a solution of lead nitrate.

Equation : .....

Observation : .....

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[3 marks]

(d) A solution of ammonium nitrate is added to a solution of potassium hydroxide.

Equation : .....

Observation : .....

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[3 marks]

2. For each of the following descriptions, give the **name** of a suitable example.

Description of substance	Name of example
A colourless liquid which turns pink if added to a solution of pH greater than 8.	
A brown gas which dissolves in water to produce an acidic solution.	
An orange solution which turns yellow when sodium hydroxide solution is added.	
A green solid which is insoluble in water, but which dissolves in hydrochloric acid to produce a colourless, odourless gas and a green solution.	

[4 marks]

3(a) A student has been asked to prepare a sample of methyl butanoate. **Name** three substances necessary for the laboratory preparation of the above compound.

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.....[3 marks]

3(b) Draw the structure of methyl butanoate:

[2 marks]

3(c) Name two isomers of the above substance.

.....and..... [2 marks]

4(a). Write a balanced equation for the reaction between butene gas and chlorine gas.

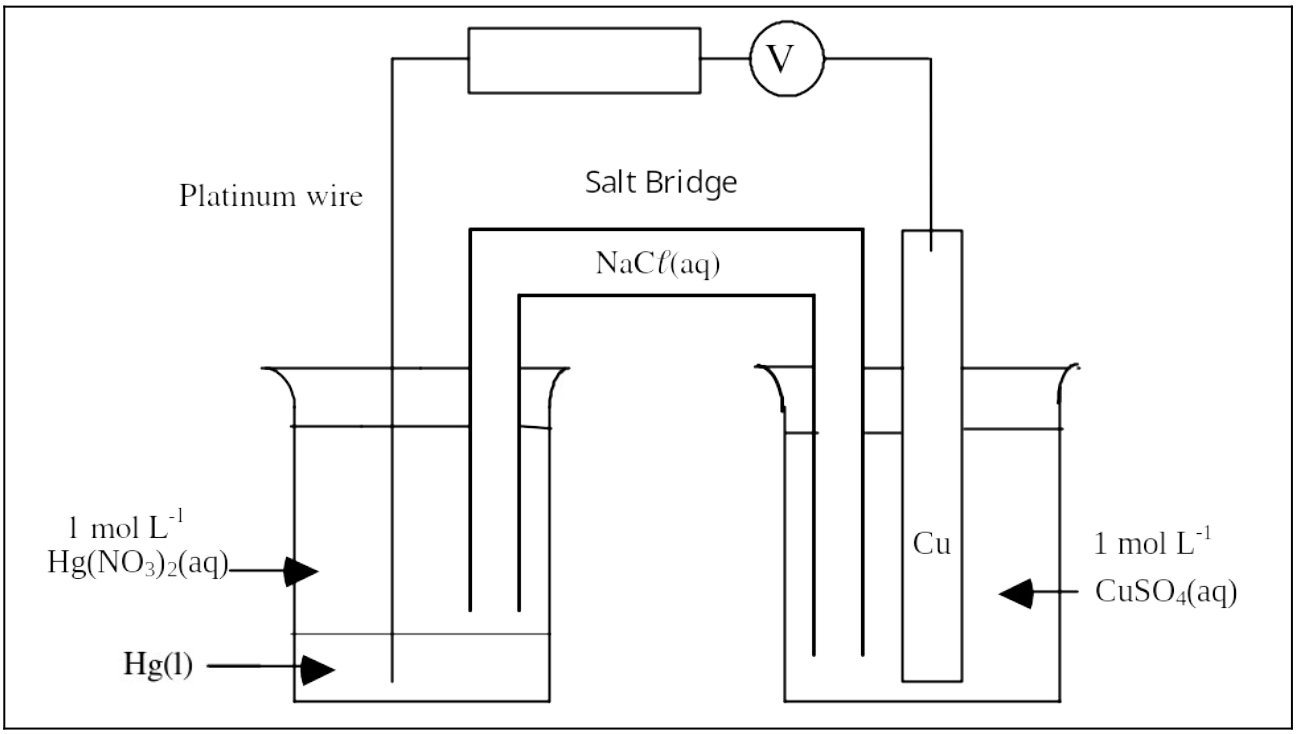
Equation : .....[2 marks]

4(b) Write a balanced equation for the complete combustion of ethyne gas in oxygen gas

Equation : .....[2 marks]

5. Two half-cells are set up according to the diagram below.

(b)



(a) Name the oxidising agent in the reaction which occurs in 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 Hg/Hg^{2+} half cell towards the Cu/Cu^{2+} half cell through the salt bridge.

..... [2 mark]

(d) Write a balanced equation for the anode and cathode reactions

Anode: .....

Cathode: .....

[4 marks]

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

Answer: .....volts [2 marks]

6. For the species below, draw the structural formula, representing all valence shell electron pairs

either as : or — [For example, water H : $\ddot{O}$: H or H—$\bar{O}$—H and so on]

ammonium ion 1-propanamine [6 marks]

7. (a) Explain clearly the difference between the terms "ionisation energy" and "electronegativity".
   (b) What electronegativity would you expect for sodium? Explain your answer.
   (c) State and explain the trend in first ionisation energy (E_1) for the elements of Group VII.

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.....[6 marks]

8. Complete the following table by drawing a structural formula for the named substance, or naming the substance whose structural formula is shown.

Name of substance	Structural formula
(a) 4-bromo-2-fluoro-2-hexene	
(b) 5,5-dichloro-3-methyl-1-pentyne	
(c)	$CH_3CH_2CHBrCOOH$
(d)	$CH_3COCH_2CH_2CH_2CH_2CH_3$

[6 marks]

9. In an acid-base titration, 1.0 mol L^{-1} HCl(aq) (from a burette) is added slowly to 20.0 mL of 1.0 mol L^{-1} NaOH(aq) in a conical flask.

(a) Calculate the pH of the solution in the conical flask after 19.90 mL of the HCl(aq) has been added. Assume the total volume of solution is now 39.90 mL.

(b) Calculate the pH of the solution in the flask after 20.10 mL of the HCl(aq) has been added. Assume the total volume of solution is now 40.10 mL.

(c) On the basis of the above pH changes, explain why both methyl orange and phenolphthalein are suitable indicators for this titration.

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.....[6 marks]

10. In the spaces below, draw a primary alcohol and a tertiary alcohol which have four and five carbon atoms in their molecules respectively. Give the correct systematic name for each alcohol.

Name:	Name: .....
Primary alcohol	Tertiary alcohol [6 marks]

11. Describe one **chemical** test which would enable you to distinguish the above two alcohols. Write a balanced equation for any chemical reaction which occurs.

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

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1. A sample of 2.130 g of a chlorofluorocarbon (a compound containing carbon, fluorine and chlorine only) was analysed as follows:

   All the carbon in the sample was converted into carbon dioxide gas, and all its chlorine was converted into hydrochloric acid. The carbon dioxide weighed 0.9198 g, and the hydrochloric acid formed required 41.0 mL of 1.020 mol L^{-1} sodium hydroxide solution for complete neutralisation.

   Another sample of the same gaseous compound of mass 1.270 g occupied 139.6 mL at S.T.P.

   a) Determine the empirical formula of the compound. [8]

   b) Determine the molecular formula of the compound. [2]

   c) Name and draw a possible structure of the compound. [2]

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2. A solution contains 14.85 grams of pure potassium sulfide per litre. When 120 mL of this solution is added to 250.0 mL of 0.2060 mol L^{-1} cadmium nitrate solution, a yellow precipitate of highly insoluble cadmium sulfide is formed according to the equation: $Cd^{2+}(aq) + S^{2-}(aq) \rightarrow CdS(s)$.

Determine a) the limiting reagent [3 marks]
b) the mass of precipitate formed [2 marks]
c) the concentrations of all ions remaining in the final solution (Assume the final volume of solution is 370.0 mL) [3 marks]

3. The percentage purity of a sample of manganese (IV) oxide, MnO_2, can be found by treatment with an excess of a standard sodium oxalate solution in the presence of dilute sulfuric acid. The Mn^{4+} ions are reduced to Mn^{2+} and the oxalate ions $[C_2O_4^{2-}]$ are oxidized to carbon dioxide gas in this reaction. After the reaction is complete, the excess sodium oxalate is titrated with a standardized potassium permanganate solution. One such impure sample of manganese(IV) oxide of mass 1.325 g was reacted with 150.0 mL of acidified 0.0965 mol L^{-1} sodium oxalate. The mixture was boiled gently to dissolve the solid. After cooling, the solution was titrated with 0.0125 mol L^{-1} potassium permanganate solution. The volume of the potassium permanganate solution required was 21.57 mL. Calculate the percentage purity of the manganese (IV) oxide sample. [10 marks]

4. A solution was prepared by mixing dilute sulfuric acid and dilute tartaric acid. Tartaric acid has the formula HOOCCHOHCHOHCOOH and in acid-base reactions, releases two protons and forms the tartrate ion: $OOCCHOHCHOHCOO^{2-}(aq)$ The mixture of the two acids was analysed as follows:

(i) 25·00 mL of the mixture was taken, and it required 29·8 mL of 0·504 mol L^{-1} NaOH to neutralize both acids.

(ii) A second 25·00 mL of the mixture was treated with excess barium nitrate solution, and resulted in the precipitation of 0.712 g of barium sulfate.

Calculate the concentration of sulfuric acid and tartaric acid in moles per litre in the mixture .

[10 marks]

5. *Sodium hypochlorite, NaOCl, is prepared by the electrolysis of brine (concentrated sodium chloride solution).*

Hydrogen gas is liberated at the cathode along with hydroxyl ions according to the reaction:

$$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

Chlorine gas is produced at the anode according to the reaction:

$$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$$

By agitating the electrolyte, the chlorine gas formed at the anode reacts with the hydroxyl ions produced at the cathode according to the reaction:

$$Cl_2(g) + 2OH^-(aq) \rightarrow OCl^-(aq) + Cl^-(aq) + H_2O(l)$$

A current of 3.00×10^2 A is passed for 6.00 hours through a 2.00×10^3 L brine solution whose concentration is originally 6.50 mol L^{-1}.

(a) Determine the number of moles of sodium hypochlorite which form in the solution

after this quantity of electricity has passed. *[6 marks]*

(b) *Calculate the final concentration of chloride ions in the solution at the end of this reaction.* *[4 marks]*

END OF PART 3

PART 4 (20 marks)

Answer the following extended answer question.
Marks are awarded for the relevant chemical content of your answer, and also for coherence and clarity of expression. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing.

Your answer should be presented in about 1.5 to 2 pages. Commence your answer on page 27.

Read the following information on the **Contact Process** and then answer the questions below.

The Contact Process converts sulfur into sulfuric acid by a series of sequential reactions.

In **Stage 1**, hot liquid sulfur is converted into sulfur dioxide gas by burning it in excess air:

$$S(l) + O_2(g) \rightarrow SO_2(g)$$

No catalyst is used. The reaction is exothermic, as are most oxidation reactions.

In **Stage 2**, the $SO_2(g)$ is further oxidised to $SO_3(g)$ in a reversible reaction:

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) \qquad \Delta H = -196 \text{ kJ mol}^{-1}$$

A catalyst of V_2O_5 is used, a pressure of 1 to 2 atmospheres is chosen, and a "moderate" temperature between 450°C and 500°C is maintained inside the reaction vessel.

The vanadium(V) oxide catalyst reacts with the sulfur dioxide gas to form sulfur trioxide gas and vanadium(IV) oxide, which then reacts with oxygen gas to re-form the V_2O_5.

In **Stage 3**, the $SO_3(g)$ is bubbled into concentrated sulfuric acid, after which a measured amount of water is added to produce the final product:

$$SO_3(g) + H_2SO_4(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$$

1. Discuss using Collision Theory, how changes to the **subdivision** (increasing the surface area) of the sulfur, the air **pressure** and the **temperature** would affect the **rate** of formation of sulfur dioxide gas in **Stage 1.** [6 marks]

2. Explain (using Le Chatelier's Principle where applicable) why a "moderate", rather than a "low" or "high" temperature is chosen in **Stage 2**

[6 marks]

3. Write balanced equations for the chemical changes involving the catalyst during the reaction.

[4 marks]

4. Show how the oxidation number of the sulfur atom changes progressively from its value in the sulfur to its final value in the sulfuric acid. Give the specific values in each compound.

[4 marks]

END OF PAPER