Student

2006

TRIAL HIGHER SCHOOL
CERTIFICATE
EXAMINATION

Chemistry

RECTE ET FORTITER

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

Total marks – 100

Section I Pages 2 - 19

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks
- Attempt Questions 1-15
- Allow about 30 minutes for this part

Part B – 60 marks
- Attempt Questions 16-28
- Allow about 1 hour and 45 minutes for this part

Section II Pages 20 - 31

25 marks
- Attempt ONE Question from Questions 29-33
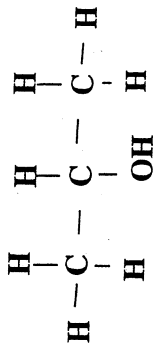- Allow about 45 minutes for this section

1

Student

Multiple Choice Answer Sheet

1. A ◯ B ◯ C ◯ D ◯
2. A ◯ B ◯ C ◯ D ◯
3. A ◯ B ◯ C ◯ D ◯
4. A ◯ B ◯ C ◯ D ◯
5. A ◯ B ◯ C ◯ D ◯
6. A ◯ B ◯ C ◯ D ◯
7. A ◯ B ◯ C ◯ D ◯
8. A ◯ B ◯ C ◯ D ◯
9. A ◯ B ◯ C ◯ D ◯
10. A ◯ B ◯ C ◯ D ◯
11. A ◯ B ◯ C ◯ D ◯
12. A ◯ B ◯ C ◯ D ◯
13. A ◯ B ◯ C ◯ D ◯
14. A ◯ B ◯ C ◯ D ◯
15 A ◯ B ◯ C ◯ D ◯

1 Which of the following is the correct IUPAC name for the molecule below.

$$H - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle OH}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - H$$

(A) 2-propane

(B) 2-hydroxypropane

(C) 2-propanol

(D) 2-hydroxypropanol

2 What is the oxidation state of manganese in potassium permanganate, $KMnO_4$.

(A) -1

(B) +3

(C) +7

(D) +8

3 Which of the following nuclei is most likely to undergo nuclear decay?

(A) carbon-12

(B) potassium-39

(C) cobalt-60

(D) lead-207

4 Which of the following are significant industrial sources of sulfur dioxide?

(A) lightning and bacteria

(B) bacteria and volcanoes

(C) internal combustion engine and air conditioning units

(D) coal burning power stations and metal ore smelting

3

5 Which of the following is the conjugate acid of water?

(A) H_3O^+

(B) OH

(C) H_2O_2

(D) Cl

6 Which of the following is the common name for 2-hydroxypropane-1,2,3-tricarboxylic acid?

(A) acetic acid

(B) citric acid

(C) ascorbic acid

(D) sulfuric acid

7 Who defined an acid as a substance containing replaceable hydrogen?

(A) Lavoisier

(B) Davy

(C) Arrhenius

(D) Lowry and Brönsted

8 Which of the following equations describes a buffer?

(A) $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

(B) $CH_3COOH(aq) + H_2O(l) \Leftrightarrow CH_3COO^-(aq) + H_3O^+(aq)$

(C) $H_2SO_4(aq) + H_2O(l) \Leftrightarrow HSO_4^-(aq) + H_3O^+(aq)$

(D) $NH_3(aq) + H_2O(l) \Leftrightarrow NH_4^+(aq) + OH^-(aq)$

9 What is the pH of a $1.5 \times 10^{-4}\,mol\,L^{-1}$ solution of sulfuric acid assuming complete ionization?

(A) 4.0

(B) 3.8

(C) 3.5

(D) 1.5

4

10   Which of the following pairs are isomers?

(A)   graphite and diamond

(B)   carbon-12 ($^{12}_{6}C$) and carbon-14 ($^{14}_{6}C$)

(C)   cyclohexane and cyclohexene

(D)   cyclohexane and 1-hexene

11   Which of the following statements about cellulose is correct?

(A)   Cellulose is a condensation biopolymer synthesized from glucose monomers.

(B)   Cellulose is an addition biopolymer synthesized from glucose monomers.

(C)   Cellulose is a natural monomer from which many useful products are made.

(D)   Cellulose is a monomer that contains a carbon chain structure similar to that found in most fuels.

12   To which area has Atomic Absorption Spectroscopy contributed the most?

(A)   The analysis of organic water pollutants.

(B)   The identification and effects of trace elements.

(C)   The analysis of pollutant gas levels in the atmosphere.

(D)   The identification of metal ions in water.

13   Which of the following is the major origin of *Halons* in the atmosphere?

(A)   Air conditioning units.

(B)   Dry cleaning processes.

(C)   Aerosol cans.

(D)   Fire extinguishers.

14   The table below gives the results of some tests performed on water from four different sites.

Test	Site Q	Site R	Site S	Site T
Total dissolved solids (ppm)	550	120	50	635
Phosphate (ppm)	2.2	0.02	0.01	1.1
Dissolved oxygen (ppm)	2.5	5.0	7.0	3.5
Micro-organisms (CFU/100 mL^a)	190	220	1	2

Which site is most likely to be down stream from a farm?

(A)   Site Q

(B)   Site R

(C)   Site S

(D)   Site T

15   A student performed an investigation to measure the sulfate content of ammonium sulfate lawn fertilizer by precipitating the sulfate as barium sulfate (BaSO$_4$) and weighing the precipitate. His results are tabulated below.

What was weighed	Mass (g)
Ammonium sulfate fertiliser sample	2.00
Clean filter paper	1.05
Filter paper + dry barium sulfate precipitate	1.88
	0.85

What is the percentage of sulfate, by mass, in the measured ammonium sulfate fertilizer?

(A)   17.1 %

(B)   24.4 %

(C)   41.5 %

(D)   72.7 %

Section I (continued)

Part B – 60 marks
Attempt Questions 16 – 28
Allow about 1 hour and 45 minutes for this part.

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (6 marks)

Ethanol can be produced by *the addition of water to ethylene* OR by *fermentation of sugars*.

(a)   Give the equation for the production of ethanol by the addition of water to ethylene.

.... **1**

(b)   Outline how ethanol can be produced by fermentation in the school laboratory.

Cotton plug

.... **2**

....

....

(c)   Discuss ONE advantage and ONE disadvantage of the potential wide-scale use of ethanol as an alternative fuel to petrol in cars.

only 10% in conventional car engines **3**

....

....

....

....

Question 17 (6 marks)

A student set up the apparatus below to determine the molar heat of combustion of three liquid alkanols.
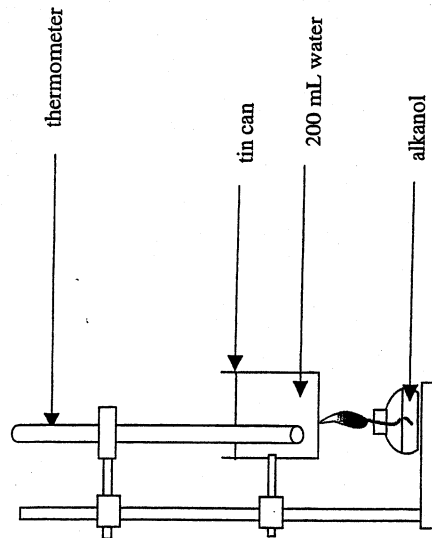
Her results are tabulated below.

Alkanol	Water temperature (°C)		Mass of spirit burner containing alkanol (g)		Molar Heat of Combustion (kJmol⁻¹)
	Initial	Final	Initial	Final	
Ethanol	20	35	42.6	41.8	x
1-propanol	20	44	42.1	40.9	-1206
1-butanol	20	52	45.4	44.7	-1256

Marks

(a) Calculate the molar heat of combustion for ethanol from the student's data provided in the table.

....

....

....

3

(b) Explain the trend in heat of combustion for the three alkanols.

....

....

1

(c) The value obtained by the student for 1-butanol is significantly lower than the theoretical value of –2676kJ mol⁻¹.

which > ment from expected.

2

Describe and explain ONE way that the student could modify the experiment to obtain a more accurate result.

draft heat shield

lied

aluminium can

....

....

....

S/hm at heat transfer.

conduction

convection

radiation

Marks

Question 18 (4 marks)

A Galvanic cell may be constructed by placing one half-cell in a porous pot inside another half-cell as shown below.

— Glass container
— Sn(s)
— Porous pot
— Sn²⁺(aq)
— Ag(s)
— Ag⁺(aq)
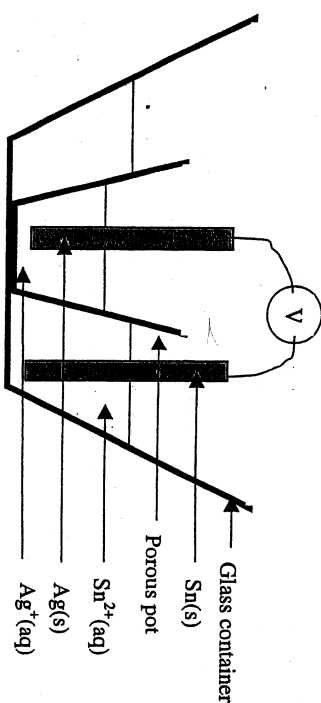
(a) Identify the *anode*.

.... Sn ....

1

(b) Use the standard potentials supplied to calculate the theoretical voltage of this cell.

....

1

(c) Explain the function of the *porous pot*.

....

....

....

....

....

2

Question 19 (6 marks)

$$A(g) + B(g) \rightleftharpoons X(g)$$
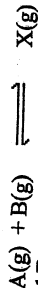
When two gases, A and B, are reacted, partial conversion to product X occurs according to the equation above. The following data provide information about the percentage composition of the gaseous mixture at equilibrium under various conditions.

At constant pressure:

Temperature (°C)	100	200	300	400	500
Percentage of X in the mixture	50	35	23	14	8

At constant temperature:

Pressure (MPa)	5	10	15	20	25
Percentage of X in the mixture	12	18	25	34	44

(a) From the above data, is the formation of X from A and B endothermic or exothermic? Briefly explain your answer. **2**

_____

_____

_____

(b) State qualitatively what combination of temperature and pressure conditions (i.e. high or low) would give the highest percentage of X at equilibrium. **2**

Temperature: _____

Pressure: _____

(c) Suggest a means of increasing the amount of product in this reaction other than by altering the temperature or pressure. Explain your answer. **2**

_____

_____

_____

Question 20 (3 marks)

Special techniques are used to ensure accuracy when preparing a standard solution and conducting a titration.

Describe TWO such techniques for the preparation of the standard solution OR TWO such techniques for conducting the titration.

Explain how each assists in obtaining a precise result.

electronic balance

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Question 21 (4 marks)

During this course you will have studied the use of catalysts in a number of different reactions and processes.

(a) Identify one chemical reaction or process that uses a catalyst. **1**

....

(b) Name the catalyst used. **1**

....

(c) Explain how the catalyst functions in this process. **2**

....

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Question 22 (7 marks)

Copper carbonate (CuCO₃) is decomposed to carbon dioxide and copper (II) oxide when heated.

The volume of carbon dioxide produced can be measured by displacing water.

CuCO₃

CO₂

H₂O
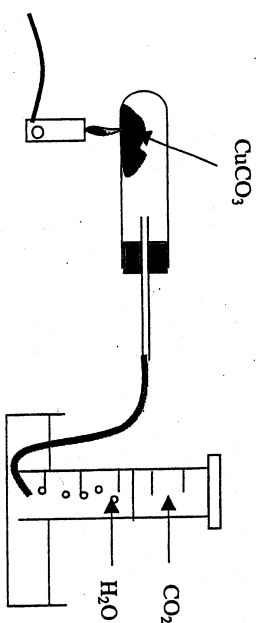
The results of an investigation into the decomposition of copper(II)carbonate are tabulated below.

Time (sec)	Gas Volume at 25°C and 100 kPa (mL)
10	20
30	66
50	84
70	90
100	92
130	92

Question 22 (continued)

Marks

(a) Write the equation for the decomposition of copper carbonate.

....

$CuCO_3 (s) \rightarrow CuO + CO_2$

1
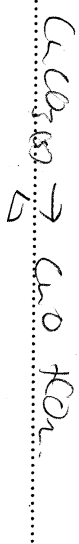
(b) Graph the results from this experiment.

Time

3
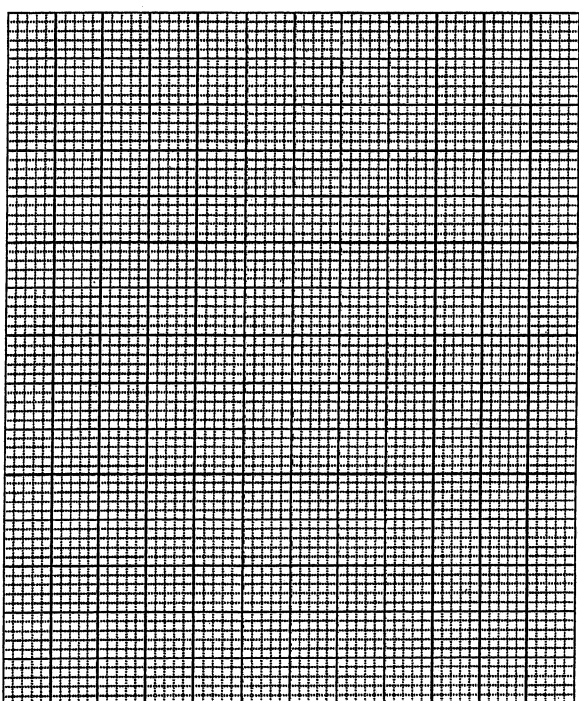
(c) Calculate the initial mass of copper carbonate heated.

....

use

....

2

(d) Assess the validity of the procedure for collecting the gas.

....

not valid

....

$H_2O + CO_2 \rightleftharpoons H_2CO_3$

CO_2 conc.

1

volume ... conc. ... no left in tube

volume ... lower than actual ... conc

Question

Question 24 (10 marks)

Marks

(a) (i) Define acids and bases according to the Bronsted-Lowry theory.

2

(ii) In the following two reactions, state whether HCO_3^- behaves as an acid or a base. Explain your answer in each case.

1. $H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$
2. $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$

2

(b) The pH of a 0.001 $molL^{-1}$ solution of hydrochloric acid and the pH of a 0.056 $molL^{-1}$ of ethanoic acid is 3.

(i) Compare the concentration of each acid. Explain your answer.

2

(ii) Compare the strength of each acid. Explain your answer.

2

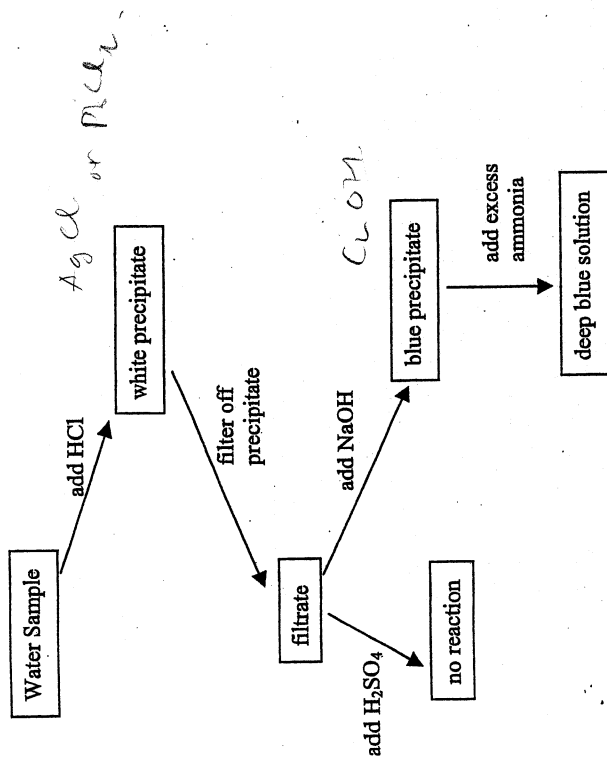(iii) Compare the hydrogen ion concentration in the solutions of each acid. Explain your answer.

2

16

Question 23

A chemist performed the tests shown in the flow chart below to determine the cation(s) present in a water sample.

Water Sample

add HCl → white precipitate   *Ag Cl or Pb Cl₂*

white precipitate → filter off precipitate → filtrate

filtrate → add NaOH → blue precipitate   *Cu OH*

filtrate → add H₂SO₄ → no reaction

blue precipitate → add excess ammonia → deep blue solution

(i) What cation(s) is/are present in the solution?

1

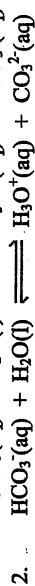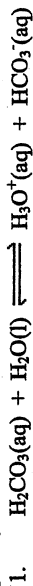(ii) Write balanced chemical equations for the FIRST TWO reactions in the flow chart sequence.

2

15

Question 25 (4 marks)

Ions such as lead, phosphate and copper can move from farms and industry into the environment where they can cause problems.

Describe :   evidence for the need to monitor levels of ONE named ion used by society.

....   2

....

....

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....

....

Question 26 (3 marks)

Hydronium, H_3O^+, ammonium, NH_4^+, and ozone, O_3, each have a *coordinate covalent bond*.

(a) . Define *coordinate covalent bond*.

....   1

....

(b)   Draw a Lewis electron dot structure of one of these molecules/ions and identify the position of the *coordinate covalent bond*.   2

Question 27 (6 marks)

Ozone is being gradually removed from the stratosphere by our use of CFC's.

(a)   Identify ONE CFC molecule that has caused problems.

....   1

                                                                    $C F Cl_3$ ....

(b)   Give equations to demonstrate the removal of ozone from the atmosphere by this CFC.   2

....

....

....

(c)   Evaluate the effectiveness of replacement chemicals for CFC's.   3

....

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Section II

25 marks
Attempt ONE question from Questions 28, 29.
Allow about 45 minutes for this section.

Answer in a writing booklet. Extra booklets are available.

Show all relevant working in questions involving calculations.

Question 28   Industrial Chemistry ....

Question 29   Shipwrecks, Corrosion and Conservation ....

	Marks

Question   – Industrial Chemistry (25 marks)

(a)   (i)   Identify a natural product, (not a fossil fuel), that is a shrinking world resource.   **1**

(ii)   Discuss the issues associated with the increasing need for this resource.   **3**

(iii)   Identify a possible replacement for this resource or outline current research into finding a replacement.   **1**

(b)   Dinitrogen tetroxide (N_2O_4) is a colourless gas. It exists in equilibrium with nitrogen dioxide (NO_2), a brown gas.

$$N_2O_4(g) \Leftrightarrow 2NO_2(g) \qquad K = 5.5 \times 10^{-3} \text{ at } 25°C$$

(i)   Write the expression for the equilibrium constant for this reaction.   **1**

(ii)   Some pure NO_2 is placed in a gas syringe at 25°C and allowed to reach equilibrium. Keeping the volume constant, the temperature is then raised to 35°C. The brown colour becomes more intense.   **2**

Explain whether the forward reaction is endothermic or exothermic.

(iii) 2×10^{-3} moles of N_2O_4 was placed in a 100 mL syringe at 25°C and given time to come to equilibrium with NO_2. Two minutes later 6×10^{-4} moles of NO_2 were measured in the container.   **2**
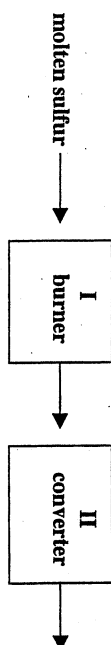
Calculate whether the system had reached equilibrium.

Question   continues

Question 29 (continued)

(c) Sulfuric acid can be produced from mined sulfur via the Contact Process.

The first two stages in the industrial production of sulfuric acid by this process are represented below.
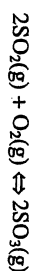
molten sulfur → | I burner | → | II converter | →

(i) Give a reason why, in stage I, the molten sulfur is sprayed into the burner rather than being allowed to flow through it. **1**

(ii) A conflict is involved in choosing the best temperature to be used in stage II, where the reaction is:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Describe the nature of the conflict and explain how the conflict is resolved. **2**

(iii) Describe by using an equation/s a specific example of sulfuric acid acting as an oxidizing agent. **1**

(iv) What are the safety precautions necessary for the transport and storage of concentrated (98%) sulfuric acid? Explain the reasons for the precautions you specify. **3**
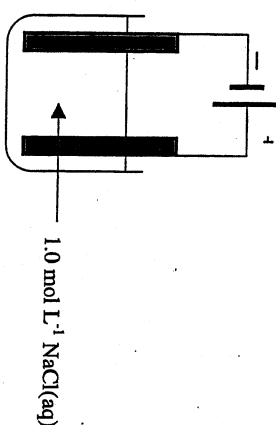
Question 29 (continued)

(d) A student carries out the electrolysis of a 1.0 mol L⁻¹ solution of sodium chloride using inert graphite electrodes.

The setup for this experiment is shown below.

1.0 mol L^{-1} NaCl(aq)

(i) Write a half-equation for the reaction that would occur at the cathode. **1**

(ii) Two different gases are produced at the anode.

Write a half-equation for a reaction that results in the production of one of these gases. **1**

(iii) Using the same current and electrodes, the student carries out a second electrolysis, this time of molten sodium chloride instead of a solution. What difference, if any, would you expect in the products formed at the anode and cathode? **2**

Give equations for any different relevant oxidation and/or reduction reactions occurring.

(e) Sodium hydroxide and chlorine are the products of the chlor-alkali industry. Three types of electrolytic cell can be used to produce these products.

(i) State two problems associated with the use of the diaphragm cell. **2**

(ii) State one advantage and one disadvantage of using the mercury cell. **2**

## Question 29 – Shipwrecks, Conservation and Corrosion (25 marks)

Marks

(a) In 1780 Luigi Galvani generated an electric current by taking two wires made of different metals, at one end joining them together and at the other end placing them on a dissected frog's leg muscle.

The muscle contracted, prompting Galvani to coin the term *animal electricity*.

Outline how a more recent chemist, Alessandro Volta, interpreted Galvani's results and describe how he built on Galvani's work.   **3**

(b) The experiment below was set up to investigate the factors that affect the rate of electrolysis.

Pt electrodes

KBr ($1 \cdot$ mol L^{-1})
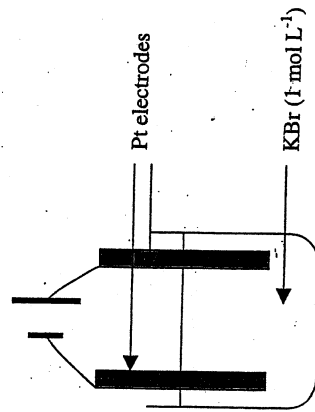
(i) Give the half-equation for the reaction occurring at the cathode.   **1**

(ii) Calculate the voltage required for the reaction to proceed.   **1**

(iii) In some investigations, reaction rate can be measured by recording the change in temperature.

Describe what the investigator could have recorded as a measure of reaction rate in this investigation.   **1**

(iv) Identify one other factor that the investigator may have varied and give the likely result of varying this factor on reaction rate.   **2**

(c) Describe how the process of *cathodic protection* minimizes rusting of iron in marine environments in terms of oxidation and reduction.   **4**

Question 29 continues

23

Question 29 – Shipwrecks, Conservation and Corrosion (25 marks)

Marks

(d) (i) Describe the mechanism of corrosion of iron.   **4**

(ii) Explain how coating the surface of iron with zinc can offer protection from corrosion. Include in your explanation the equation that describes this protection.   **4**

(e) (i) The electrodes in an electrolytic cell are given the names anode and cathode. What processes occur at the surface of these electrodes in electrolysis?   **2**

(ii) List three factors that can affect the products that are formed in an electrolysis reaction.   **3**

24