BOARD OF STUDIES
NEW SOUTH WALES

2002

HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 9, 13, 17 and 21

Total marks – 100

Section I Pages 2–23

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 16–27
- Allow about 1 hour and 45 minutes for this part

Section II Pages 25–30

25 marks

- Attempt ONE question from Questions 28–32
- Allow about 45 minutes for this section

Section I
75 marks

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

Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

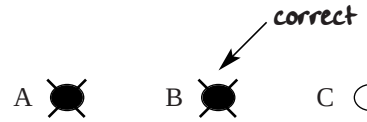
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



A ⊗ B ⊗ C ○ D ○

1 Which conditions would be best for the fermentation of sugars by yeast?

(A) Low oxygen concentration and a temperature between 25°C and 35°C

(B) High oxygen concentration and a temperature between 25°C and 35°C

(C) Low oxygen concentration and a temperature between 45°C and 60°C

(D) High oxygen concentration and a temperature between 45°C and 60°C

2 What is the catalyst for the conversion of ethanol to ethene?

(A) NaOH

(B) H_2SO_4

(C) HNO_3

(D) Pt

3 Which explanation best describes why an understanding of electrolysis has made a significant impact on the production of materials?

(A) Electrolysis reactions do not require an energy source.

(B) Electrolysis can be used to split water into hydrogen and oxygen.

(C) Electrolysis provides a way to make non-spontaneous reactions occur.

(D) Electrolysis can be used to produce aluminium.

4 Which statement concerning galvanic cells is correct?

(A) Oxidation occurs at the anode.

(B) They are also known as electrolytic cells.

(C) The cathode is assigned a negative charge.

(D) An external power source must be present.

5 What arrangement of an electrolytic cell would electroplate a silver coin with copper?

	Cathode	*Anode*	*Electrolyte*
(A)	copper	silver coin	copper sulfate
(B)	silver coin	copper	silver nitrate
(C)	copper	silver coin	silver nitrate
(D)	silver coin	copper	copper sulfate

6 Which is amphiprotic?

(A) H_2SO_4

(B) NH_4^+

(C) HCO_3^-

(D) SO_4^{2-}

7 What did the Brönsted–Lowry definition of acids identify that made it a significant improvement over earlier definitions?

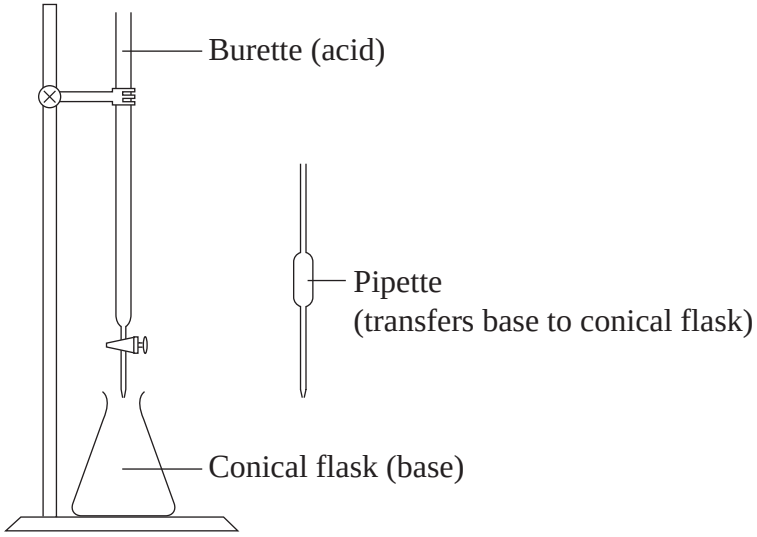
(A) Acids contain hydrogen.

(B) Acids are proton donors.

(C) Acids contain oxygen.

(D) Acids are electron-pair acceptors.

8 In a titration, an acid of known concentration is placed in a burette and reacted with a base that has been pipetted into a conical flask.



What should each piece of glassware be rinsed with immediately before the titration?

	Burette	*Pipette*	*Conical flask*
(A)	acid	base	water
(B)	water	water	water
(C)	acid	base	base
(D)	water	water	base

9 The following list of steps refers to an experimental plan for making an ester in a flask. Some of the steps in the list may NOT be required for this experiment. The steps are NOT in the correct sequence.

1. Heat the mixture under reflux.
2. Add three drops of concentrated sulfuric acid.
3. Add 1 mL of ethanol.
4. Add 1 mL of ethene.
5. Add 1 mL of ethanoic acid.
6. Distil the mixture.
7. Add three drops of phenolphthalein indicator.

Which alternative is the best sequence for making an ester?

(A) 3, 5, 7, 1

(B) 4, 3, 7, 6

(C) 5, 4, 2, 6

(D) 5, 3, 2, 1

10 Which equation represents esterification?

(A) $CH_3—\overset{\overset{O}{\|}}{C}—O—CH_3 + H_2O \xrightarrow{H^+} CH_3—OH + CH_3—\overset{\overset{O}{\|}}{C}—OH$

(B) $CH_3—\overset{\overset{O}{\|}}{C}—O—H + NaOH \longrightarrow H—\overset{\overset{O}{\|}}{C}—ONa + CH_3—OH$

(C) $CH_3—OH + CH_3—\overset{\overset{O}{\|}}{C}—OH \xrightarrow{H^+} CH_3—CH_2—O—\overset{\overset{O}{\|}}{C}—H + H_2O$

(D) $CH_3—OH + CH_3—\overset{\overset{O}{\|}}{C}—OH \xrightarrow{H^+} CH_3—O—\overset{\overset{O}{\|}}{C}—CH_3 + H_2O$

11 A car engine burns fuel with insufficient air. Which substance would be emitted in the exhaust in higher levels than from an engine with a correct fuel to air ratio?

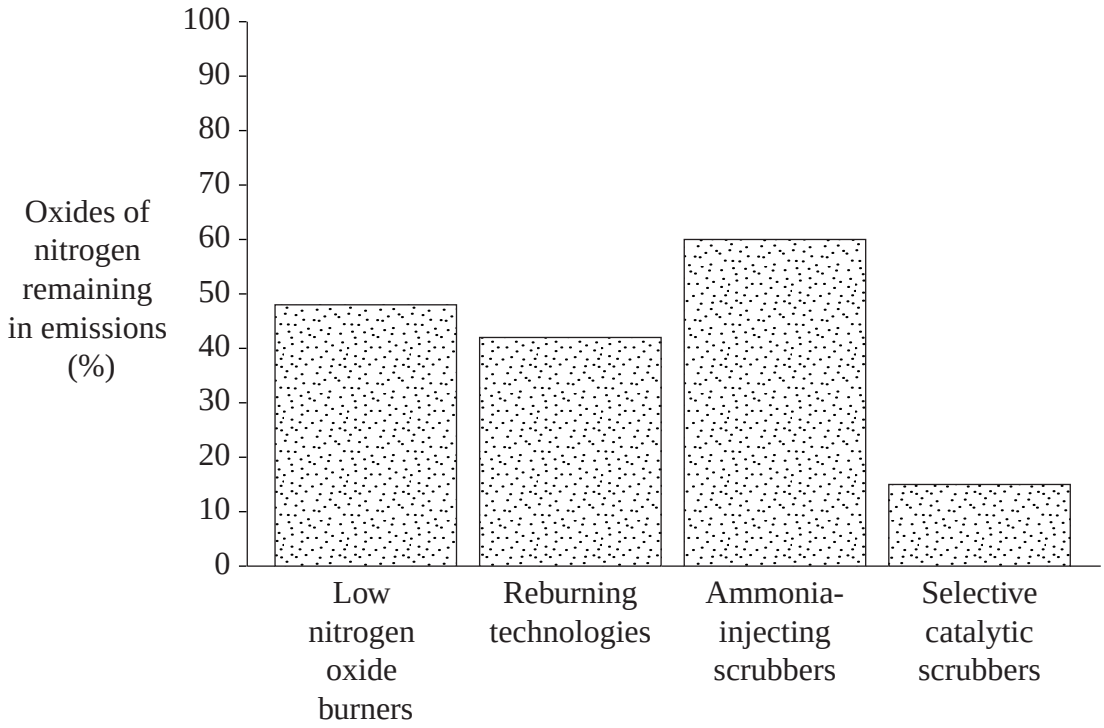
(A) Carbon dioxide

(B) Carbon monoxide

(C) Oxygen

(D) Water

12 Oxides of nitrogen are produced by the combustion of coal. The percentage of these compounds remaining in emissions can be reduced using the methods named in the graph.



Which of the following is the most effective method for removing oxides of nitrogen produced by the combustion of coal?

(A) Low nitrogen oxide burners

(B) Reburning technologies

(C) Ammonia-injecting scrubbers

(D) Selective catalytic scrubbers

13 The Haber Process for producing ammonia was developed early in the twentieth century. What was the major advantage of its development?

(A) A government sold the process to other governments.

(B) The inventor sold the process for a great deal of money.

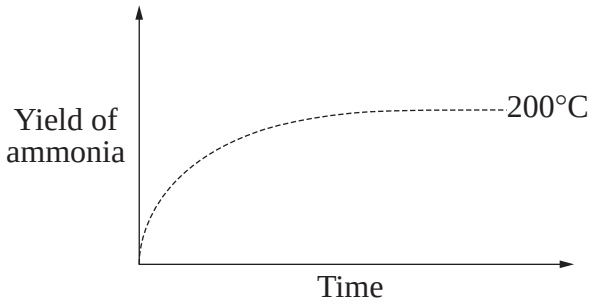
(C) It provided a source of nitrogen for farming and industry.

(D) It provided jobs for many who were unemployed.

14 Ammonia is produced from hydrogen and nitrogen, according to the equation:

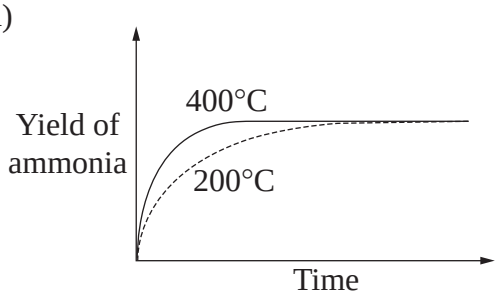
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The graph shows the yield of ammonia produced at 200°C and 100 kPa.

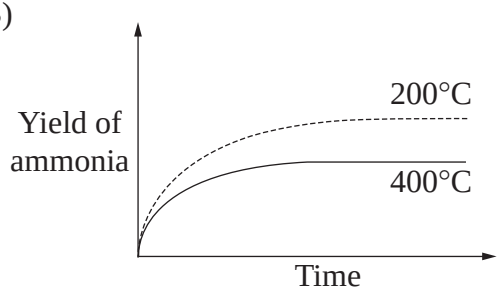


Which graph shows a correct comparison of the yield of ammonia produced at a temperature of 400°C and 100 kPa with the yield produced at 200°C and 100 kPa?

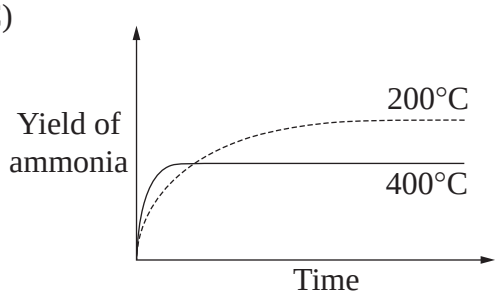
(A)



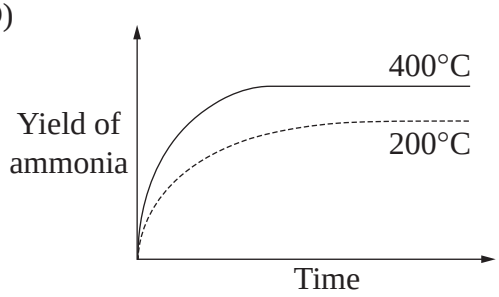
(B)



(C)



(D)



15 The table gives the results of chemical tests for some cations and anions.

(ppt = precipitate)

Ion	*Add cold* 0.1 M HCl	*Add* 0.1 M KSCN	*Add* 0.1 M Na_2CO_3	*Add* 0.1 M $AgNO_3$
Ca^{2+}	no change	no change	white ppt	no change
Fe^{3+}	no change	red colour	brown ppt	no change
Ba^{2+}	no change	no change	white ppt	no change
Pb^{2+}	white ppt	no change	white ppt	no change
Cl^-	no change	no change	no change	white ppt

When a group of students performed the above tests on an unknown solution they obtained the following results:

Add cold 0.1 M HCl	*Add* 0.1 M KSCN	*Add* 0.1 M Na_2CO_3	*Add* 0.1 M $AgNO_3$
no change	no change	white ppt	white ppt

Which conclusion is consistent with these results?

(A) The sample contained both $CaCl_2$ and $BaCl_2$.

(B) The sample contained both $CaCl_2$ and $PbCl_2$.

(C) The sample contained both $FeCl_3$ and $PbCl_2$.

(D) The sample contained both $FeCl_3$ and $BaCl_2$.

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Chemistry

Centre Number

Student Number

Section I (continued)

Part B – 60 marks
Attempt Questions 16–27
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)

You have carried out a first-hand investigation to compare the reactivity of an alkene with its corresponding alkane.

(a) State the name of the alkene. **1**

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(b) Outline a procedure to compare the reactivity of this alkene with its corresponding alkane. **2**

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(c) Describe the results obtained from this first-hand investigation and include relevant chemical equations. **3**

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Marks

Question 17 (3 marks)

Explain why alkanes and their corresponding alkenes have similar physical properties, but very different chemical properties. **3**

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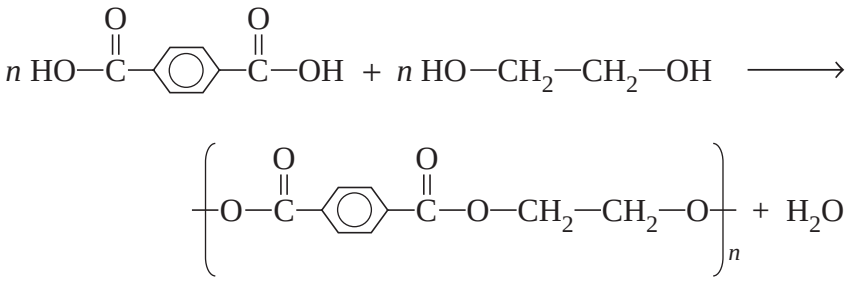
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Marks

Question 18 (6 marks)

(a) Name the type of polymerisation shown in the following reaction: **1**



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(b) Assess current developments in the use of biopolymers. **5**

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Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 19 (5 marks)

(a) Describe the conditions under which a nucleus is unstable. **2**

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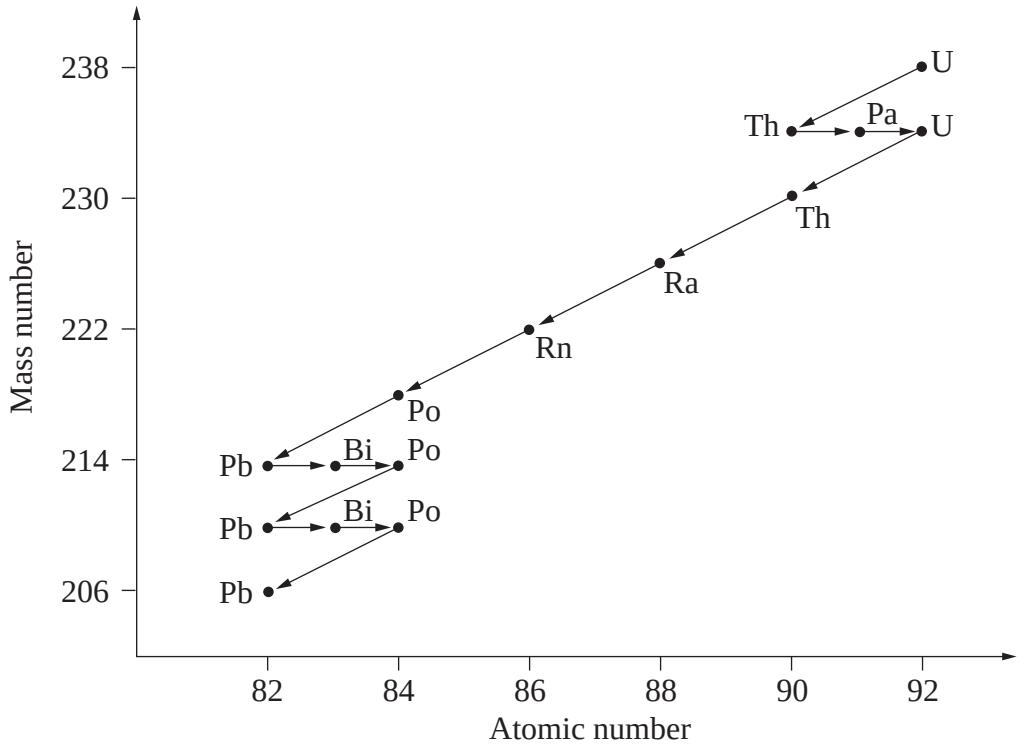
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Question 19 continues on page 14

Marks

Question 19 (continued)

(b) The following is a flow diagram showing the sequence of products released during the decay of uranium. **3**



Use examples from the flow diagram to describe processes by which an unstable isotope undergoes radioactive decay.

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End of Question 19

Marks

Question 20 (4 marks)

(a) Identify ONE common household base. **1**

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(b) A student used indicators to determine whether three colourless solutions were acidic or basic. The indicators used are shown in the table. **3**

Indicator	*Colour change*	pH *range*
Methyl orange	red to yellow	3.2–4.4
Methyl red	red to yellow	4.8–6.0
Thymol blue	yellow to blue	8.0–9.6
Alizarin	red to purple	11.0–12.4

Samples of each solution were tested with the indicators. The colours of the resulting solutions are shown in the table.

Indicator added	*Colour of solution* A	*Colour of solution* B	*Colour of solution* C
Methyl orange	yellow	yellow	yellow
Methyl red	yellow	yellow	yellow
Thymol blue	blue	blue	yellow
Alizarin	purple	red	red

The student concluded that each of the three solutions tested was basic. Assess the validity of this conclusion.

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Marks

Question 21 (7 marks)

Evaluate the impact of industrial sources of sulfur dioxide and nitrogen oxides on the environment, making use of appropriate chemical equations. **7**

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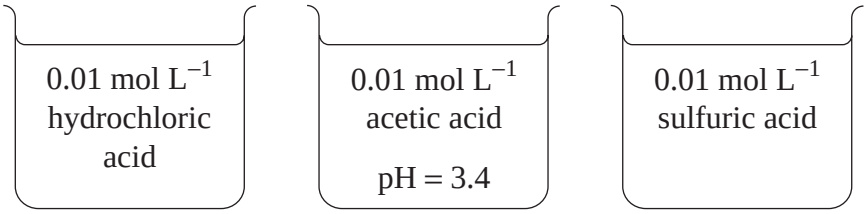
Section I – Part B (continued)

Student Number

Marks

Question 22 (5 marks)

Solutions of hydrochloric acid, acetic acid and sulfuric acid were prepared. Each of the solutions had the same concentration (0.01 mol L^{-1}). The pH of the acetic acid solution was 3.4.



(a) Calculate the pH of the hydrochloric acid solution. **1**

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(b) Compare the pH of the sulfuric acid solution to the pH of the hydrochloric acid solution. Justify your answer. (No calculations are necessary.) **2**

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(c) Explain why the acetic acid solution has a higher pH than the hydrochloric acid solution. **2**

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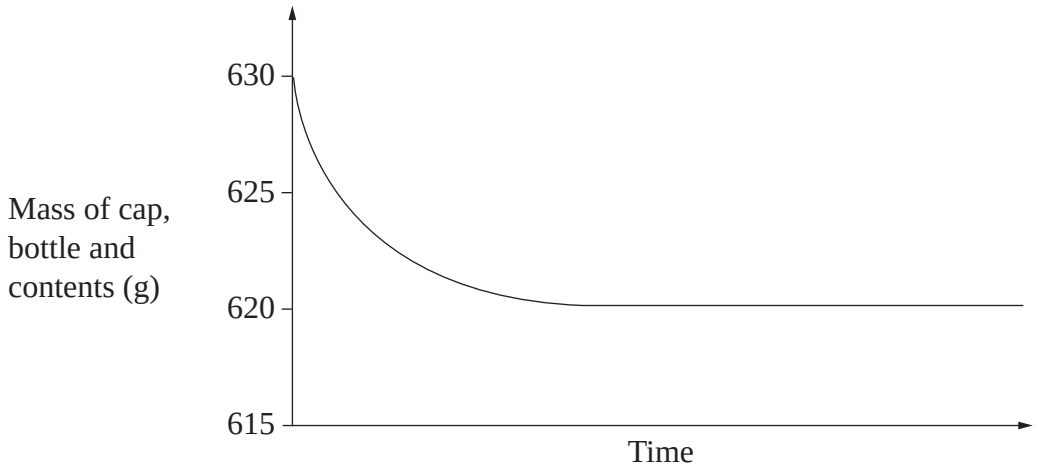
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Marks

Question 23 (4 marks)

A bottle of soft drink was placed on an electronic balance and weighed. The cap was removed and placed next to the bottle on the balance. The mass of the cap, bottle and its contents was monitored. The results are shown in the graph. The experiment was conducted at 25°C and 101.3 kPa. Assume that no evaporation has occurred.



(a) Identify the gas released. **1**

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(b) Calculate the volume of the gas released. **3**

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Marks

Question 24 (4 marks)

Assess the impact of atomic absorption spectroscopy (AAS) on the scientific understanding of the effects of trace elements. **4**

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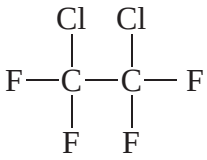
Section I – Part B (continued)

Student Number

Marks

Question 25 (6 marks)

(a) What is the systematic name of the CFC in the diagram? **1**



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(b) Identify the bonding within ozone, using a Lewis electron-dot diagram. **2**

(c) Discuss how CFCs damage the ozone layer, using relevant equations. **3**

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Marks

Question 26 (5 marks)

Water can be described as either ‘hard’ or ‘soft’.

(a) Describe a test you have used to determine whether a given sample of water is ‘hard’ or ‘soft’. **2**

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(b) A sample of hard water contains 6×10^{-4} mol L^{-1} of magnesium carbonate. **3**

Calculate the mass, in mg, of magnesium carbonate in 150 mL of this sample.

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Marks

Question 27 (5 marks)

Describe the physical and chemical processes needed to purify and sanitise a town water supply. **5**

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 28–32
Allow about 45 minutes for this section

Answer the question in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Page

Question 28 Industrial Chemistry 26

Question 29 Shipwrecks and Salvage 27

Question 30 The Biochemistry of Movement 28

Question 31 The Chemistry of Art 29

Question 32 Forensic Chemistry 30

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) (i) Define *saponification*. **1**

(ii) Account for the cleaning action of soap. **3**

(b) One of the reactions used to form sulfuric acid is the reaction of oxygen with sulfur dioxide under equilibrium conditions to form sulfur trioxide. **4**

Before the reaction, the concentration of sulfur dioxide was 0.06 mol L^{-1} and the concentration of oxygen was 0.05 mol L^{-1}. After equilibrium was reached, the concentration of sulfur trioxide was 0.04 mol L^{-1}.

Calculate the equilibrium constant, K, for the reaction. Show relevant working.

(c) (i) Use a chemical equation to describe what happens when sulfuric acid is added to water in a laboratory. **2**

(ii) Describe the use of sulfuric acid as an oxidising agent, as a dehydrating agent and as a means of precipitating sulfates. Use chemical equations to illustrate your answer. **3**

(d) During your practical work, you performed a first-hand investigation involving an equilibrium reaction.

(i) Outline the procedure you used. **2**

(ii) Explain how you analysed the equilibrium reaction qualitatively. **4**

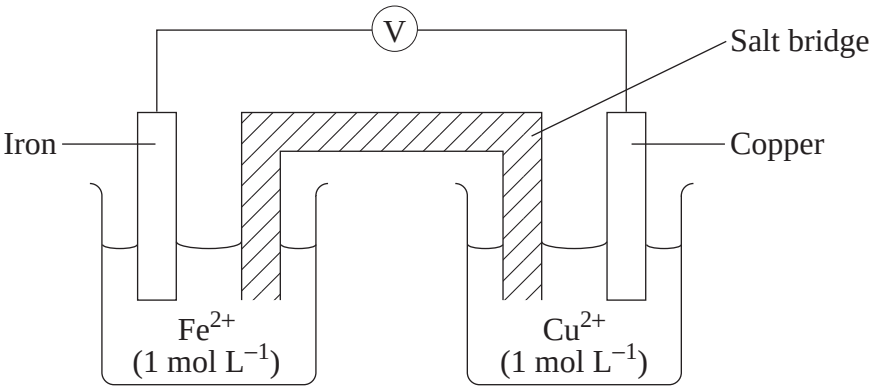
(e) Evaluate changes in industrial production methods for sodium hydroxide. **6**

Marks

Question 29 — Shipwrecks and Salvage (25 marks)

(a) (i) Name the type of electrochemical cell that produces a spontaneous reaction. **1**

(ii) Calculate the voltage required to operate the cell shown in the diagram as an electrolytic cell, showing relevant half-equations in your working. **3**



(b) Describe how the work of early scientists increased our understanding of electron transfer reactions. **4**

(c) (i) Name ONE method for removing salt from an artefact recovered from a wreck. **1**

(ii) Explain, using an example, chemical procedures used to clean and preserve artefacts from wrecks. **4**

(d) During your practical work you performed a first-hand investigation to compare and describe the rate of corrosion of materials in different acidic and neutral solutions.

(i) Outline the procedure used. **2**

(ii) It is hypothesised that acidic environments accelerate the corrosion of shipwrecks. **4**

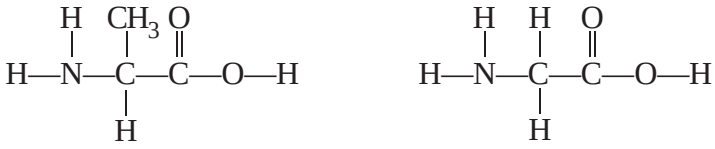
Explain how data obtained from the procedure in part (d) (i) does or does not support this hypothesis.

(e) Analyse the effect of ocean depth on corrosion of metallic objects. **6**

Marks

Question 30 — The Biochemistry of Movement (25 marks)

(a) (i) To what class of compounds do these molecules belong? **1**



(ii) Using the two compounds in part (a) (i), describe the formation of a peptide bond, illustrating your answer with a chemical equation. Clearly indicate the peptide bond. **3**

(b) Explain why triacylglycerols (TAGs) are an important energy store for humans. **4**

(c) (i) Name the acid that builds up in muscles in anaerobic respiration. **1**

(ii) Discuss the characteristics of muscle cells used for light exercise and those of muscle cells used for heavy exercise. **4**

(d) During your practical work you performed a first-hand investigation to demonstrate the effect of various factors on the reaction of a named enzyme.

(i) Name the enzyme and outline the procedure used to demonstrate the effect of ONE of these factors on the reaction. **2**

(ii) Explain how the results obtained from the experiment in part (d) (i) can be used to indicate changes in the structure of the enzyme investigated. **4**

(e) Discuss the oxidation of fatty acids as an inhibitor of the conversion of pyruvate to acetyl CoA, with reference to the dietary needs of sprinting athletes. **6**

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) (i) Identify the metal ion that will produce a yellow colour in a flame test. **1**

(ii) Explain how some metal ions produce a characteristic colour in a flame. **3**

(b) Using an example from medicine or biological research, describe the bonding in a coordination complex. **4**

(c) (i) Explain what is meant by a reflectance spectrum. **2**

(ii) Outline how infrared light and ultraviolet light are used to determine the chemical composition of pigments. **3**

(d) During your practical work you performed a first-hand investigation to determine the oxidising strength of potassium permanganate.

(i) State the electronic configuration of manganese in terms of subshells. **1**

(ii) Outline the procedure used to determine the oxidising strength of potassium permanganate. **2**

(iii) Using your results from the procedure in part (d) (ii), justify a conclusion about the oxidising strength of potassium permanganate. Use half-equations in your answer. **3**

(e) Analyse trends in the physical properties of the first transition series. **6**

Marks

Question 32 — Forensic Chemistry (25 marks)

(a) (i) Identify the functional group in glycerol. **1**

(ii) Compare the reactions of both glycerol and 1-propanol when they react with cold dilute $KMnO_4$. **3**

(b) Discuss the value of electron spectroscopy and scanning tunnelling microscopy in the analysis of small samples in forensic chemistry. **4**

(c) (i) What class of compounds is used to break proteins into fragments of different lengths? **1**

(ii) Describe the processes of electrophoresis and chromatography in separating organic compounds. **4**

(d) During your practical work you performed a first-hand investigation to describe the emission spectrum of sodium.

(i) Name the piece of equipment you used to analyse the emission spectrum of sodium in the laboratory. **1**

(ii) Outline the procedure that you used in this investigation. **2**

(iii) Explain how the emission spectrum was produced. **3**

(e) Discuss the uses of DNA analysis in forensic chemistry. **6**

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DATA SHEET

Avogadro's constant, N_A ..... 6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas: at 101.3 kPa (1.00 atm) and
at 273 K (0°C) ..... 22.41 L
at 298 K (25°C) ..... 24.47 L
Ionisation constant for water at 298 K (25°C), K_w ..... 1.0×10^{-14}
Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (4th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — Symbol of element — Atomic Weight — Name of element

Example: 79 Au 197.0 Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.