BOARD OF STUDIES
NEW SOUTH WALES

2010

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, 11, 13, 15, 17, 19, 21 and 23

Total marks – 100

Section I Pages 2–24

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21–31
- Allow about 1 hour and 40 minutes for this part

Section II Pages 25–36

25 marks

- Attempt ONE question from Questions 32–36
- Allow about 45 minutes for this section

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1–20.

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1 Water is released during a polymerisation reaction.

Which monomer is likely to have been involved in the reaction?

(A) Ethene

(B) Glucose

(C) Styrene

(D) Vinyl chloride

2 Which of the following is an example of a transuranic element?

(A) C–14

(B) Co–60

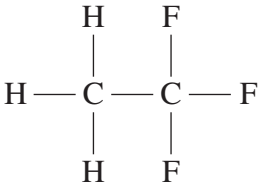
(C) U–238

(D) Cm–249

3 Which substance shows the correct indicator colour?

	Substance	*pH*	*Indicator*	*Colour*
(A)	Stomach acid	2	Methyl orange	Yellow
(B)	Lemon juice	3	Phenolphthalein	Pink
(C)	Soda water	4	Phenolphthalein	Pink
(D)	Seawater	8	Methyl orange	Yellow

4 The diagram shows the structural formula of a gas.



How many isomers does this compound have?

(A) 1

(B) 2

(C) 3

(D) 4

5 An imbalance of which two substances causes the eutrophication of waterways?

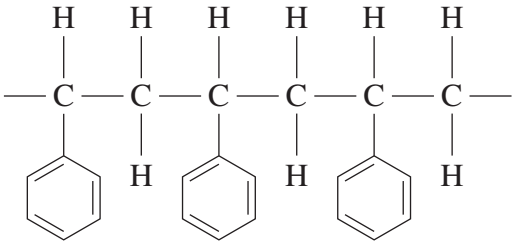
(A) H^+ and OH^-

(B) Mg^{2+} and Ca^{2+}

(C) Oxygen and ozone

(D) Phosphorus and nitrogen

6 The diagram shows a section of a polymer.



What is the systematic name of the monomer?

(A) Polybenzene

(B) Benzylethene

(C) Ethylbenzene

(D) Ethenylbenzene

7 Equal volumes of four 0.1 mol L^{-1} acids were titrated with the same sodium hydroxide solution.

Which one requires the greatest volume of base to change the colour of the indicator?

(A) Citric acid

(B) Acetic acid

(C) Sulfuric acid

(D) Hydrochloric acid

8 In a research report a student wrote, 'Acids are compounds that contain hydrogen and can dissolve in water to release hydrogen ions into solution.'

Who originally stated this theory of acids?

(A) Arrhenius

(B) Brönsted–Lowry

(C) Davy

(D) Lavoisier

9 What types of reaction occur in the Haber process during the production of ammonia?

(A) Redox and synthesis

(B) Hydration and redox

(C) Decomposition and oxidation

(D) Reduction and decomposition

10 A sample of water from a stream, suspected to be contaminated with metal ions, was analysed.

The results of some tests on the water are recorded in the table.

Test	*Result*
Add dilute HCl	No change
Add Na_2SO_4 solution	White precipitate formed
Flame test	Pale green colour

What is the most likely contaminant in the water?

(A) Ba^{2+}

(B) Ca^{2+}

(C) Cu^{2+}

(D) Fe^{3+}

11 An organic liquid, when reacted with concentrated sulfuric acid, produces a compound that decolourises bromine water.

What is the formula of the organic liquid?

(A) C_6H_{12}

(B) C_6H_{14}

(C) $C_6H_{11}OH$

(D) $C_5H_{11}COOH$

12 In which of the following reactions does the metal atom show the greatest change in oxidation state?

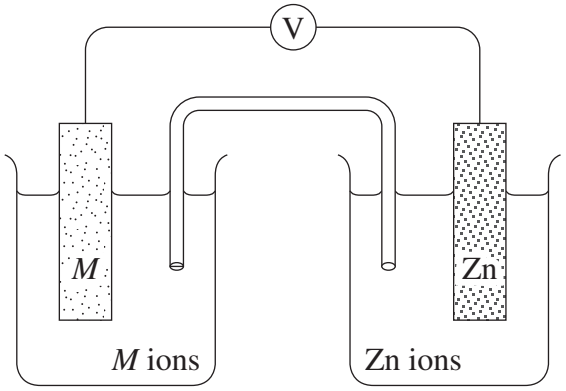
(A) MnO_4^- to Mn^{2+}

(B) MnO_2 to $Mn(OH)_3$

(C) PbO_2 to $PbSO_4$

(D) VO_2^+ to VO^{2+}

13 The diagram shows a galvanic cell.



Which of the following metals (*M*) acting as an anode would produce the lowest theoretical potential for the cell?

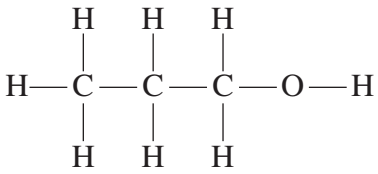
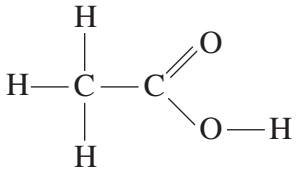
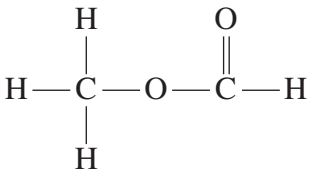
(A) Calcium

(B) Copper

(C) Iron

(D) Manganese

14 The table shows information about three carbon compounds.

Compound	*Structural formula*	*Molecular weight*	*Boiling point*
X		60	97°C
Y		60	118°C
Z		60	?

What is the best estimate for the boiling point of compound *Z*?

(A) 31°C

(B) 101°C

(C) 114°C

(D) 156°C

15 What mass of ethanol is obtained when 5.68 g of carbon dioxide is produced during fermentation, at 25°C and 100 kPa?

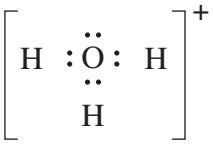
(A) 2.95 g

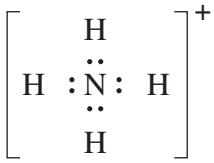
(B) 5.95 g

(C) 33.6 g

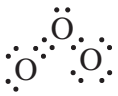
(D) 147.2 g

16 Which of the following Lewis structures does NOT contain a coordinate covalent bond?

(A) 

(B) 

(C) 

(D) 

17 A student completed an experiment to determine the amount of energy absorbed by a volume of water.

The following data were recorded.

Mass of beaker	215.6 g
Mass of beaker plus water	336.1 g
Final temperature of water	71.0°C
Energy absorbed	21.2 kJ

What was the initial temperature of the water?

(A) 15°C

(B) 25°C

(C) 29°C

(D) 42°C

18 Chromate and dichromate ions form an equilibrium according to the following equation.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Which solution would increase the concentration of the chromate ion $\left(CrO_4^{2-}\right)$ when added to the equilibrium mixture?

(A) Sodium nitrate

(B) Sodium chloride

(C) Sodium acetate

(D) Ammonium chloride

19 Sodium azide is used in automobile airbags to provide a source of nitrogen gas for rapid inflation in an accident.The equation shows the production of nitrogen gas from sodium azide.

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

What mass of sodium azide will produce 40 L of N_2 at 100 kPa and 0°C?

(A) 70 g

(B) 76 g

(C) 114 g

(D) 172 g

20 Solutions containing copper ions were analysed by AAS. A standard solution of 10 ppm copper had an AAS absorbance of 0.400. A second solution of unknown concentration was found to have an absorbance of 0.500.

100 mL of this second solution was reacted with excess sodium carbonate solution. The precipitate was then dried and weighed.

What mass of precipitate was formed?

(A) 1.25×10^{-3} g

(B) 2.43×10^{-3} g

(C) 1.54 g

(D) 2.43 g

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Chemistry

Centre Number

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Section I (continued)

Part B – 55 marks
Attempt Questions 21–31
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (3 marks)

A 0.001 mol L^{-1} solution of hydrochloric acid and a 0.056 mol L^{-1} solution of ethanoic acid both have a pH of 3.0. **3**

Why do both solutions have the same pH?

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Question 22 (6 marks)

A student prepared the compound methyl propanoate in a school laboratory.

(a) Give a common use for the class of compounds to which methyl propanoate belongs. **1**

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(b) In the preparation of this compound a few drops of concentrated sulfuric acid were added to the starting materials. The mixture was then refluxed for a period of time. **2**

Why was it necessary to reflux the mixture?

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(c) Name the TWO reactants used in preparing the methyl propanoate and draw their structural formulae. **3**

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Question 23 (3 marks)

(a) Write a balanced chemical equation for the complete combustion of 1-butanol. **1**

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(b) A student measured the heat of combustion of three different fuels. The results are shown in the table. **2**

Fuel	*Heat of combustion* (kJ g^{-1})
A	–48
B	–38
C	–28

The published value for the heat of combustion of 1-butanol is 2676 kJ mol^{-1}.

Which fuel from the table is likely to be 1-butanol? Justify your answer.

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Question 24 (4 marks)

In the margarine industry, alkenes are often hydrogenated to convert unsaturated oils into solid fats that have a greater proportion of saturated molecules.

(a) Using ethene as an example, write an equation for this reaction and state the type of reaction this represents. **2**

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(b) Describe a test that could be used to confirm that all the ethene has been converted. **2**

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Section I – Part B (continued)

Question 25 (5 marks)

What is the relationship between dissolved oxygen and biochemical oxygen demand and why is it important to monitor both in natural waterways? **5**

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Section I – Part B (continued)

Question 26 (4 marks)

A gas is produced when 10.0 g of zinc is placed in 0.50 L of 0.20 mol L^{-1} nitric acid. **4**

Calculate the volume of gas produced at 25°C and 100 kPa. Include a balanced chemical equation in your answer.

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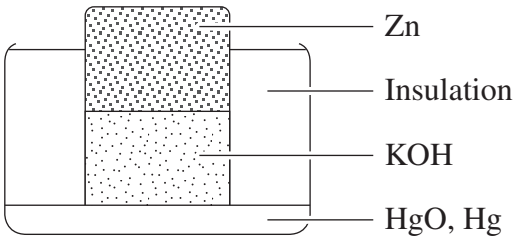
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Question 27 (2 marks)

The diagram shows a particular cell with relevant half equations. **2**



$$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$$

$$HgO(s) + H_2O(l) + 2e^- \rightarrow Hg(l) + 2OH^-(aq)$$

Identify the anode, cathode and electrolyte for this cell.

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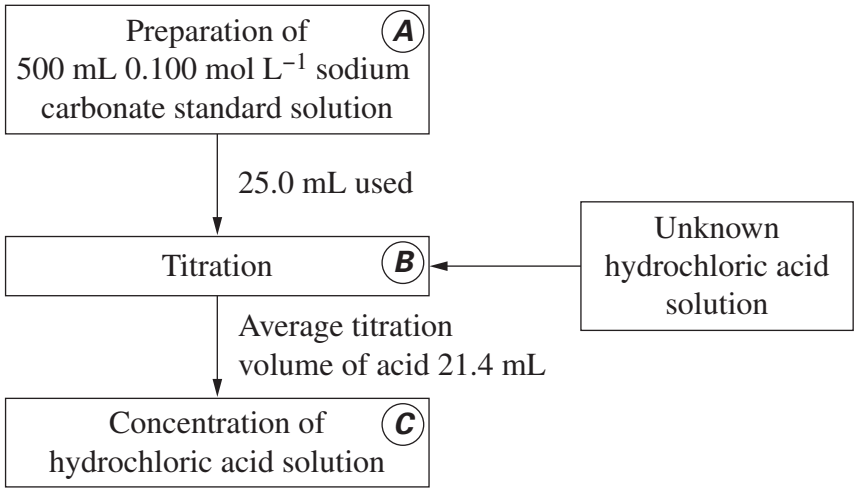
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Question 28 (8 marks)

The flowchart shown outlines the sequence of steps used to determine the concentration of an unknown hydrochloric acid solution. **8**



Describe steps ***A***, ***B*** and ***C*** including correct techniques, equipment and appropriate calculations. Determine the concentration of the hydrochloric acid.

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Question 28 continues on page 18

Question 28 (continued)

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End of Question 28

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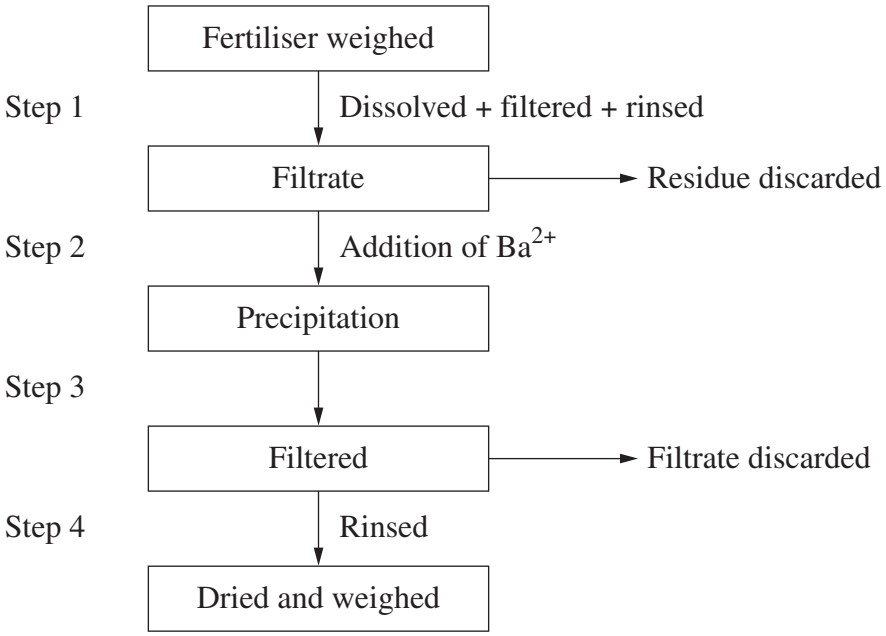
Section I – Part B (continued)

Question 29 (6 marks)

Please turn over

Question 29 (6 marks)

The flowchart shown outlines the process used to determine the amount of sulfate present in a sample of lawn fertiliser.



(a) What assumptions were made and how do these affect the validity of this process? **3**

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(b) It was found that 4.25 g had a sulfate content of 35%. **3**

What is the mass of the dried precipitate at Step 4? Include a chemical equation in your answer.

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Section I – Part B (continued)

Question 30 (8 marks)

(a) Compare the process of polymerisation of ethylene and glucose. Include relevant chemical equations in your answer. **3**

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Question 30 continues on page 22

Question 30 (continued)

(b) Explain the relationship between the structures and properties of THREE different polymers from ethylene and glucose, and their uses. **5**

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End of Question 30

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Question 31 (6 marks)

(a) A student collected a 250 mL sample of water from a local dam for analysis. The data collected are shown in the table.

Mass of filter paper	0.23 g
Mass of filter paper and solid	0.47 g
Mass of evaporating basin	43.53 g
Mass of basin and solid remaining	44.67 g

(i) The water was filtered and the filtrate evaporated to dryness. **2**

Calculate the percentage of the total dissolved solids in the dam sample.

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(ii) It is suspected that the water in the dam has a high concentration of chloride ions. **2**

Describe a chemical test that could be carried out on the water sample to determine the presence of chloride ions. Include an equation in your answer.

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Question 31 continues on page 24

(b) Name an ion other than chloride that commonly pollutes waterways, and identify its source and the effect of its presence on water quality. **2**

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End of Question 31

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 32–36
Allow about 45 minutes for this section

Answer parts (a)–(c) of the question in a writing booklet. Answer parts (d)–(e) of the question in a SEPARATE writing booklet.

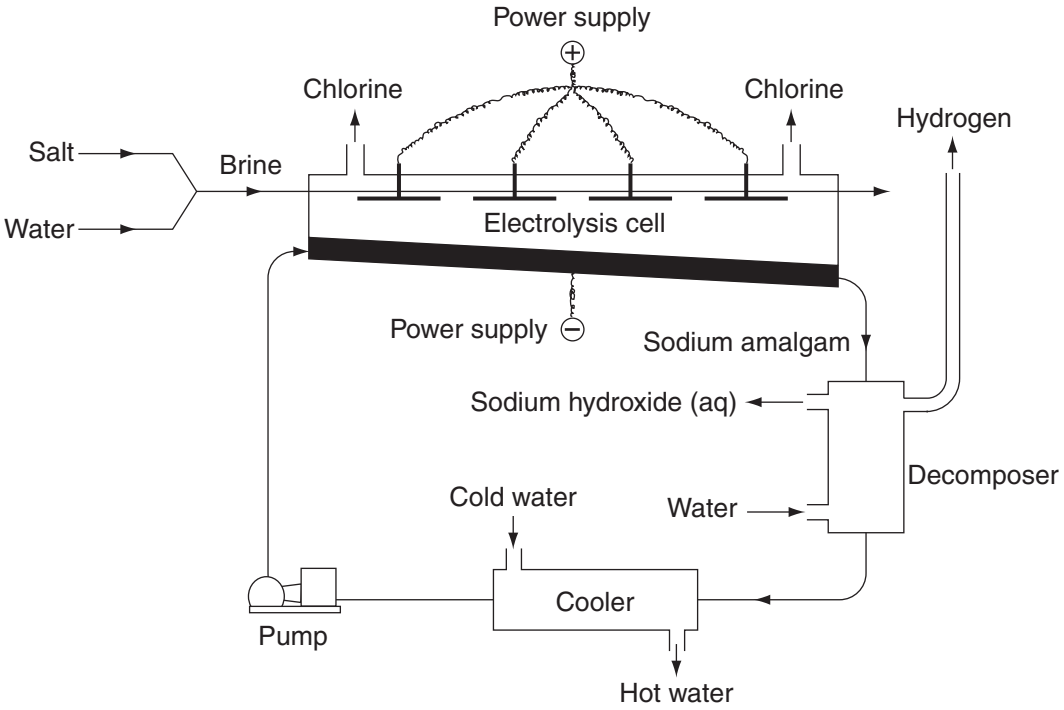
Show all relevant working in questions involving calculations.

		Pages
Question 32	Industrial Chemistry	26–27
Question 33	Shipwrecks, Corrosion and Conservation	28–29
Question 34	The Biochemistry of Movement	30–31
Question 35	The Chemistry of Art	32–33
Question 36	Forensic Chemistry	34–36

Question 32 — Industrial Chemistry (25 marks)

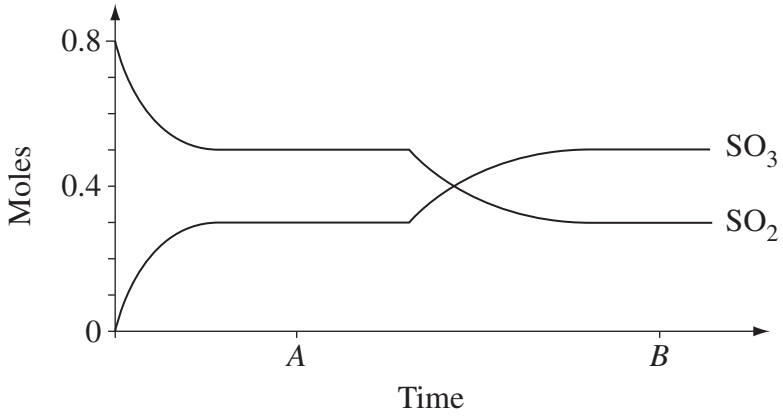
Answer parts (a)–(c) in a writing booklet.

(a) Identify the type of cell shown and outline the process used in the extraction of sodium hydroxide. **3**



(b) Compare the electrolysis of molten sodium chloride and aqueous sodium chloride. Write the relevant half equations and overall reaction for each process. **5**

(c) At room temperature 0.80 moles of SO_2 and 0.40 moles of O_2 were introduced into a sealed 10 L vessel and allowed to come to equilibrium.



(i) Write the equilibrium constant expression and calculate the value for the equilibrium constant at time *A*. **3**

(ii) Explain why a new equilibrium position was established at time *B*. **2**

Question 32 continues on page 27

Question 32 (continued)

Answer parts (d)–(e) in a SEPARATE writing booklet.

(d) The equation represents a reaction that can be performed in a school laboratory.

$$\text{Oil} + 3\boxed{\text{A}} \rightarrow 3\text{KO}\overset{\overset{\text{O}}{\|}}{\text{C}}(\text{CH}_2)_{14}\text{CH}_3 + \text{Glycerol}$$

(i) Identify both this type of reaction and the reactant *A*. **2**

(ii) Describe how this type of reaction could be carried out in a school laboratory including specific safety precautions for this process. **3**

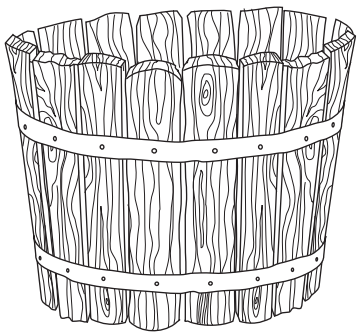
(e) Assess both the importance and resulting environmental impacts of using limestone in the Solvay Process. **7**

End of Question 32

Question 33 — Shipwrecks, Corrosion and Conservation (25 marks)

Answer parts (a)–(c) in a writing booklet.

(a) The following artefact was retrieved from a ship that sank 150 years ago off the coast of New South Wales. **3**



Outline the effect that the marine environment would have had on the artefact.

(b) (i) Use a fully labelled diagram to show the electrolysis of an aqueous solution of potassium chloride. Write the relevant half equations and the overall reaction for the cell. **4**

(ii) How would the cathode be identified? **1**

(c) The following table shows the composition of four types of steel. **5**

Steel	*Composition*
1	99.8% Fe, 0.2% C
2	98.5% Fe, 1.5% C
3	94% Fe, 4% C, 1% Mn, 1% Si
4	75% Fe, 15% Cr, 10% Ni

Explain how the composition of each type of steel determines its properties and uses.

Question 33 continues on page 29

Answer parts (d)–(e) in a SEPARATE writing booklet.

(d) (i) An investigation into environmental factors that affect the rate of corrosion of iron can be performed in a school laboratory. **4**

Describe how you could perform this investigation in relation to THREE environmental factors.

(ii) Explain how the effect of ONE of the factors could be reduced in a marine environment. **1**

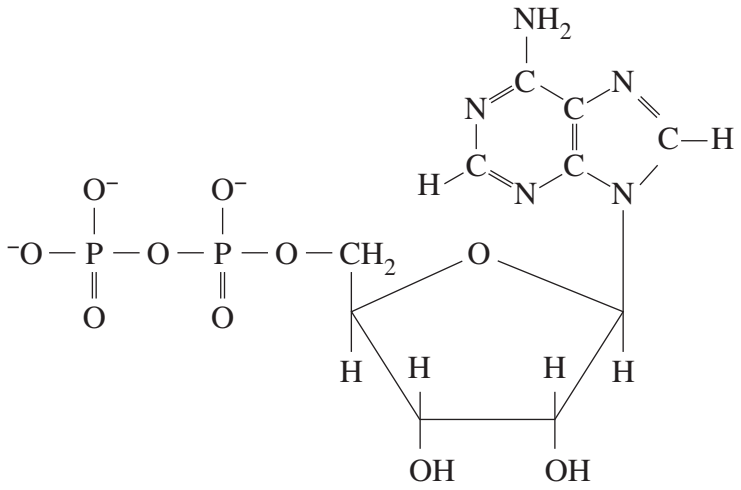
(e) Evaluate the suitability of techniques used for restoring and conserving wooden and copper artefacts that have been immersed in salt water for at least 100 years. **7**

End of Question 33

Question 34 — The Biochemistry of Movement (25 marks)

Answer parts (a)–(c) in a writing booklet.

(a) Identify this molecule and outline its importance in cellular metabolism. **3**

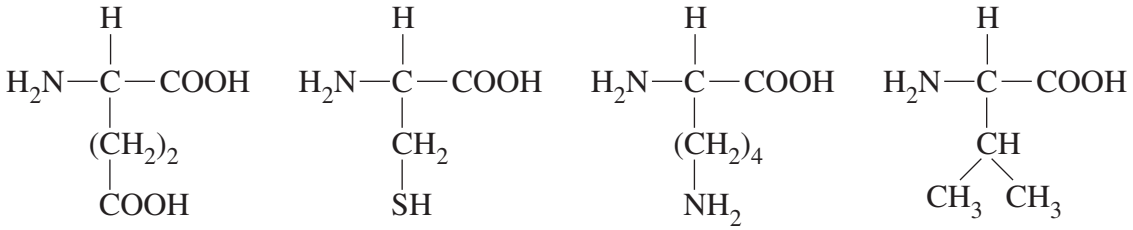


(b) (i) If the oxidation of glucose in the body occurred as rapidly as when glucose is combusted in air, the sudden release of this large amount of energy could not be utilised by cells. **2**

How do cells overcome this problem?

(ii) Explain the change in cellular pH during anaerobic respiration. Include a balanced chemical equation in your answer. **3**

(c) Explain in terms of chemical bonding how the secondary and tertiary structures of a protein depend on the amino acids in its primary structure. In your answer, make specific reference to the structures shown. **5**



Question 34 continues on page 31

Answer parts (d)–(e) in a SEPARATE writing booklet.

(d) Construct a flowchart that summarises the steps in aerobic respiration and account for the total energy output. **5**

(e) Analyse how an understanding of the structure and function of skeletal muscle cells has influenced training programs for athletes. **7**

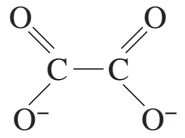
End of Question 34

Question 35 — The Chemistry of Art (25 marks)

Answer parts (a)–(c) in a writing booklet.

(a) Identify the element in period 3 of the periodic table that has the highest electronegativity and justify your choice. **3**

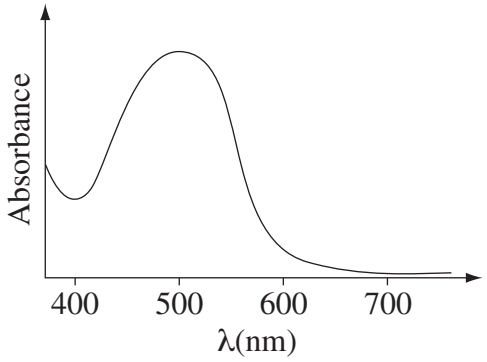
(b) (i) What type of ligand is represented by the oxalate ion shown? **1**



(ii) The oxalate ion forms complex ions with both Cu^{2+} and Cu^{+}. **4**

State whether each of these complex ions is coloured or not and justify your answer.

(c) (i) The absorbance spectrum of a commercial pigment is shown. **2**



Draw the resulting reflectance spectrum for this pigment and predict its colour.

(ii) Outline the use of infra-red radiation in both the analysis and identification of pigments. **3**

Question 35 continues on page 33

Question 35 (continued)

Answer parts (d)–(e) in a SEPARATE writing booklet.

(d) Experimental evidence from emission line spectra of gaseous atoms has highlighted both the merits and the limitations of Bohr's atomic model. **5**

Discuss Bohr's atomic model with reference to this evidence.

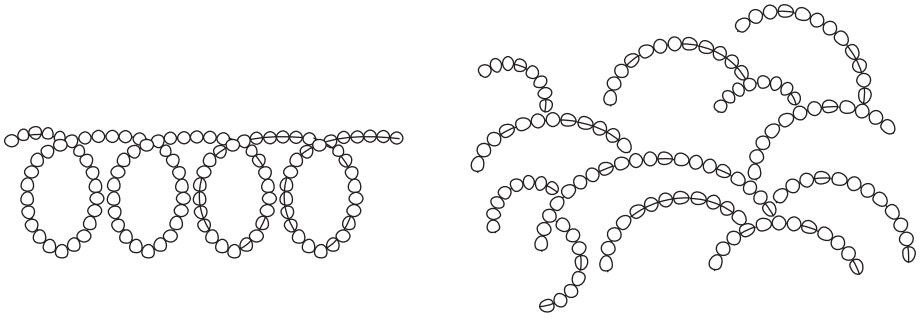
(e) Evaluate the potential health risks associated with the use of a range of cosmetics by ancient cultures. **7**

End of Question 35

Question 36 — Forensic Chemistry (25 marks)

Answer parts (a)–(c) in a writing booklet.

(a) The diagrams show the arrangement of glucose units in two polysaccharides. **3**



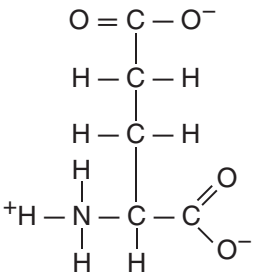
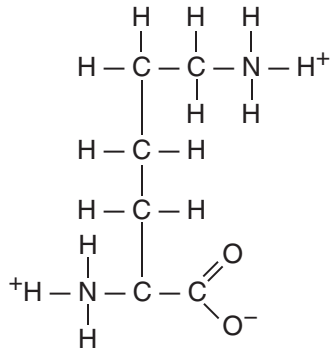
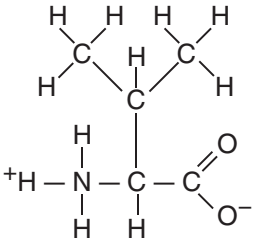
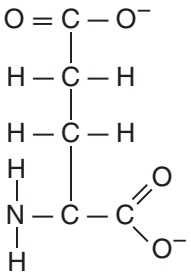
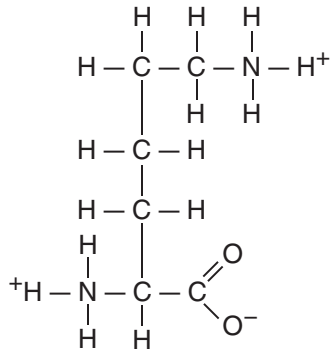
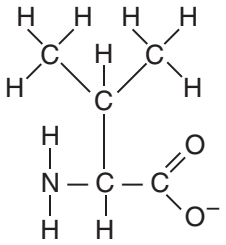
A *B*

○ Single glucose unit

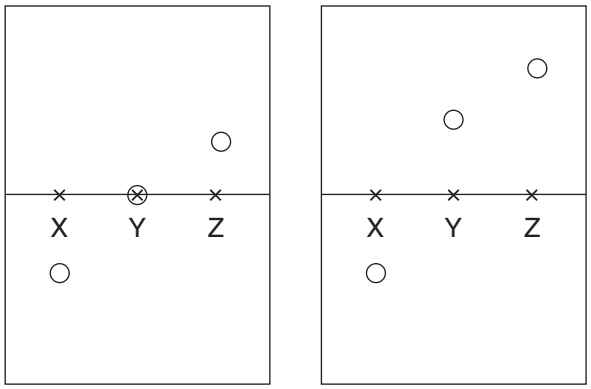
Identify *A* and *B* and outline their differences in structure and origin.

Question 36 continues on page 35

(b) The structures of three amino acids at pH 6 and pH 8 are shown.

	Glutamic acid	Lysine	Valine
pH 6			
pH 8			

Samples of each amino acid underwent electrophoresis at pH 6 and pH 8. The results are shown below.



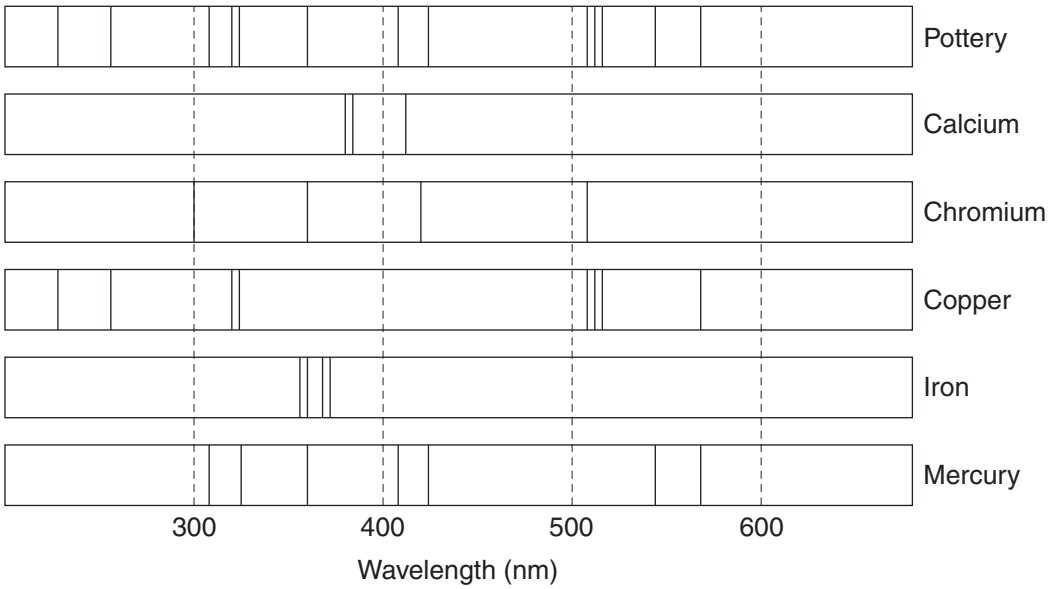
pH 6 **pH 8**

(i) Outline the process of electrophoresis used in identifying amino acids. **2**

(ii) Identify the amino acids **X**, **Y** and **Z** and justify your answer. **3**

Question 36 continues on page 36

(c) The following emission spectra were used to identify the manufacturer of a piece of pottery.



Manufacturer	*Metal atoms in pottery*
A	copper, chromium
B	copper, mercury
C	calcium, chromium

(i) Which manufacturer made the pottery – A, B or C? **1**

(ii) Explain the production and use of emission spectra in identifying the manufacturer of this pottery. **4**

Answer parts (d)–(e) in a SEPARATE writing booklet.

(d) A forensic chemist analyses soil from a pair of shoes worn by a person suspected of committing a crime.

(i) Identify FOUR properties of soil a forensic chemist would investigate. **2**

(ii) Describe both an organic and an inorganic test that could be performed on the soil that could match it to soil at the crime scene. **3**

(e) Describe the techniques used to analyse DNA and the applications of these techniques in forensic analysis. **7**

End of paper

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DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), 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* (5th 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

