BOARD OF STUDIES
NEW SOUTH WALES

2006

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, 15, 17, 21 and 25

Total marks – 100

Section I Pages 2–27

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 29–40

25 marks

- Attempt ONE question from Questions 29–33
- 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.

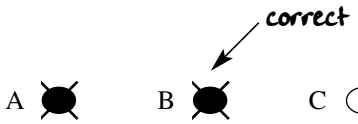
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 is the main industrial source of ethylene?

(A) Ethanol

(B) Glucose

(C) Petroleum

(D) Polyethylene

2 Catalysts are required for the production of both ethanol from ethylene and ethylene from ethanol.

$$\text{ethylene} + \text{water} \underset{\text{Catalyst } B}{\overset{\text{Catalyst } A}{\rightleftharpoons}} \text{ethanol}$$

What are the identities of Catalyst *A* and Catalyst *B*?

	Catalyst A	*Catalyst B*
(A)	dilute H^+	conc H^+
(B)	dilute H^+	dilute H^+
(C)	conc H^+	conc H^+
(D)	conc H^+	dilute H^+

3 Which set contains only stable nuclei?

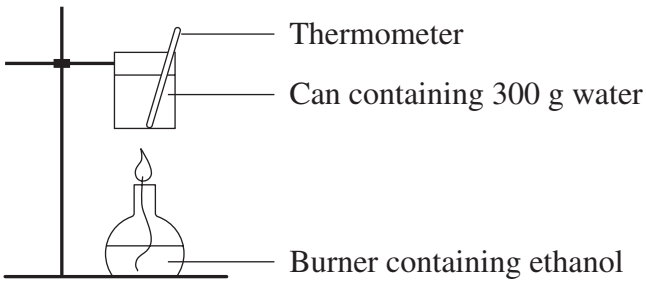
(A) $^{2}_{1}H$ $^{12}_{6}C$ $^{238}_{92}U$

(B) $^{16}_{8}O$ $^{39}_{19}K$ $^{12}_{6}C$

(C) $^{65}_{30}Zn$ $^{18}_{8}O$ $^{24}_{12}Mg$

(D) $^{14}_{6}C$ $^{16}_{8}O$ $^{1}_{1}H$

4 A student used the apparatus shown to determine the molar heat of combustion of ethanol.



The following results were obtained.

Initial mass of burner	133.20 g
Final mass of burner	132.05 g
Initial temperature of water	25.0°C
Final temperature of water	45.5°C

What is the molar heat of combustion calculated from this data?

(A) 22.4 kJ mol^{-1}

(B) 25.7 kJ mol^{-1}

(C) 1030 kJ mol^{-1}

(D) 1180 kJ mol^{-1}

5 How many isomers are there for $C_3H_6Cl_2$?

(A) 3

(B) 4

(C) 5

(D) 6

6 Glucose ($C_6H_{12}O_6$) is a monomer that can form naturally occurring polymers.

The approximate atomic weights for the elements which make up glucose are shown in the table.

Element	*Approximate atomic weight*
Carbon	12
Hydrogen	1
Oxygen	16

Using data from the table, what would be the approximate molecular weight of a polymer made from 5 glucose monomers?

(A) 810

(B) 828

(C) 882

(D) 900

7 Which class of compounds typically has a sweet smell?

(A) Esters

(B) Alkenes

(C) Haloalkanes

(D) Alkanoic acids

8 Acid *X* is 0.1 mol L^{-1} hydrochloric acid.

Acid *Y* is 1.0 mol L^{-1} acetic acid (ethanoic acid).

How does acid *X* compare with acid *Y*?

(A) *X* is weaker and more dilute than *Y.*

(B) *X* is stronger and more dilute than *Y.*

(C) *X* is weaker and more concentrated than *Y.*

(D) *X* is stronger and more concentrated than *Y.*

9 Which statement best describes the equivalence point in a titration between a strong acid and a strong base?

(A) The point at which the first sign of a colour change occurs

(B) The point at which equal moles of acid and base have been added together

(C) The point at which equal moles of H^+ ions and OH^- ions have been added together

(D) The point at which the rate of the forward reaction equals the rate of the reverse reaction

10 Phosphorus pentoxide reacts with water to form phosphoric acid according to the following equation.

$$P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$$

Phosphoric acid reacts with sodium hydroxide according to the following equation.

$$H_3PO_4(aq) + 3NaOH(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

A student reacted 1.42 g of phosphorus pentoxide with excess water.

What volume of 0.30 mol L^{-1} sodium hydroxide would be required to neutralise all the phosphoric acid produced?

(A) 0.067 L

(B) 0.10 L

(C) 0.20 L

(D) 5.0 L

11 In 1884, Svante Arrhenius proposed a definition for acids. His definition was soon accepted as superior to that put forward by earlier chemists.

Why was Arrhenius' definition seen as a major improvement?

(A) It explained why some acids do not contain oxygen.

(B) It showed how the solvent can affect the strength of an acid.

(C) It showed the relationship between pH and the concentration of H^+ ions.

(D) It could be used to explain why some acids are strong and others are weak.

12 Which statement explains why catalysts are often used in chemical reactions?

(A) Catalysts increase the rate of reactions.

(B) Catalysts increase the yield of products of reactions.

(C) Catalysts increase the purity of products of reactions.

(D) Catalysts increase the activation energies of reactions.

13 Why are microscopic membrane filters useful for water purification?

(A) They can kill bacteria.

(B) They adjust the pH of water to 7.

(C) They are composed of biodegradable polymers.

(D) They can remove very small particles from water.

14 A scientist used atomic absorption spectroscopy (AAS) to analyse the concentration of iron in a sample of water. The scientist analysed the sample five times and obtained the absorbances shown in the table.

Analysis	*Absorbance*
1	0.390
2	0.392
3	0.249
4	0.387
5	0.394

The scientist needed an average absorbance to determine the concentration of iron from a calibration curve.

Which value should the scientist use?

(A) 0.362

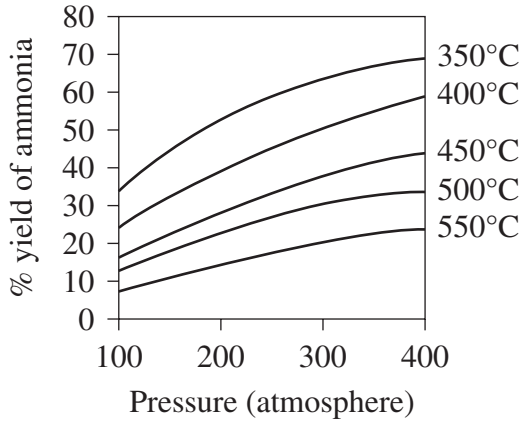
(B) 0.3624

(C) 0.39075

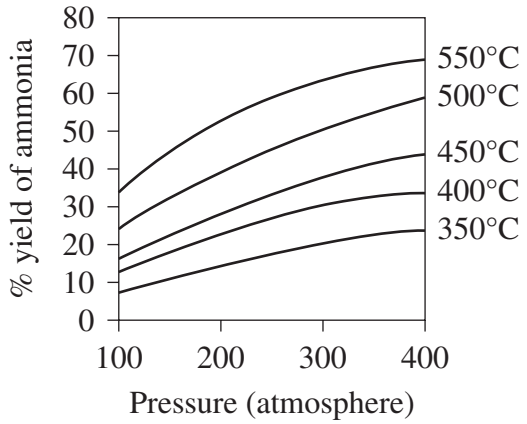
(D) 0.391

15 Which graph shows how pressure and temperature affect the yield of ammonia produced by the Haber process?

(A)



(B)



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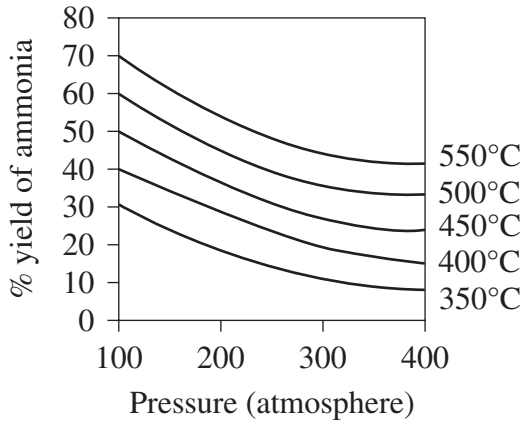
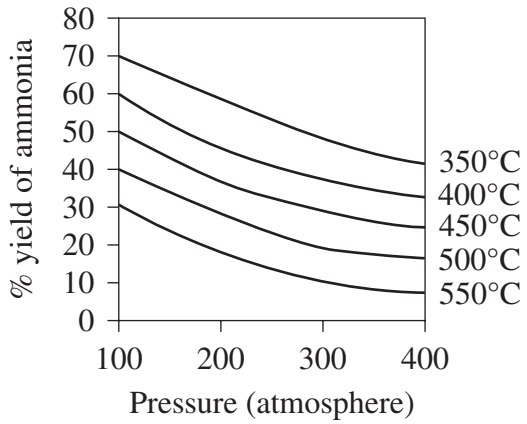


(D)



Chemistry

Centre Number

Student Number

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 (3 marks)

Describe how technology has enabled the transuranic elements to be produced. **3**

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Marks

Question 17 (4 marks)

(a) Calculate the pH of a 0.2 mol L^{-1} solution of hydrochloric acid. **1**

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(b) Calculate the pH after 20 mL of 0.01 mol L^{-1} sodium hydroxide is added to 50 mL of 0.2 mol L^{-1} hydrochloric acid. Include a balanced chemical equation in your answer. **3**

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Marks

Question 18 (4 marks)

A student studying the mass change that occurs during fermentation added glucose, water and yeast to a flask and stoppered the flask with some cotton wool.

The student measured the mass of the flask daily for seven days. The table shows the data collected.

Day	*Mass* (g)
1	381.05
2	376.96
3	373.42
4	370.44
5	370.42
6	370.40
7	370.39

(a) Calculate the moles of CO_2 released between days 1 and 7. **1**

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(b) Calculate the mass of glucose that underwent fermentation between days 1 and 7. Include a balanced chemical equation in your answer. **3**

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Marks

Question 19 (7 marks)

A student was asked to perform a first-hand investigation to measure the difference in potential of various combinations of metals in an electrolyte solution. The student was provided with three metals: aluminium, zinc and silver; and three electrolyte solutions: aluminium nitrate, zinc nitrate and silver nitrate.

(a) Identify which combination of the metals supplied should give the highest potential difference. **1**

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(b) Sketch and label a diagram of an experimental setup that the student could use with the combination of metals identified in part (a). **2**

(c) Write a balanced chemical equation for the overall reaction for the metals identified in part (a), and calculate the expected potential difference. **2**

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Question 19 continues on page 13

Marks

Question 19 (continued)

(d) The measured potential difference obtained varied from the theoretical value. **2**

Outline steps the student could have taken to minimise this variation.

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End of Question 19

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Chemistry

Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 20 (7 marks)

Analyse why ethylene is such an important starting material for the chemical industry. In your answer, include relevant chemical equations, and a description of new materials and fuels that can be prepared from ethylene. **7**

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Marks

Question 21 (3 marks)

You performed a first-hand investigation to identify the pH of a range of salt solutions.

(a) Identify an acidic salt you used. **1**

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(b) Explain the acidic nature of the salt you selected. Include a balanced chemical equation in your answer. **2**

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 22 (4 marks)

The atmosphere contains acidic oxides of sulfur which have been increasing in concentration since the Industrial Revolution. **4**

Discuss the evidence for this statement, and include relevant balanced chemical equations.

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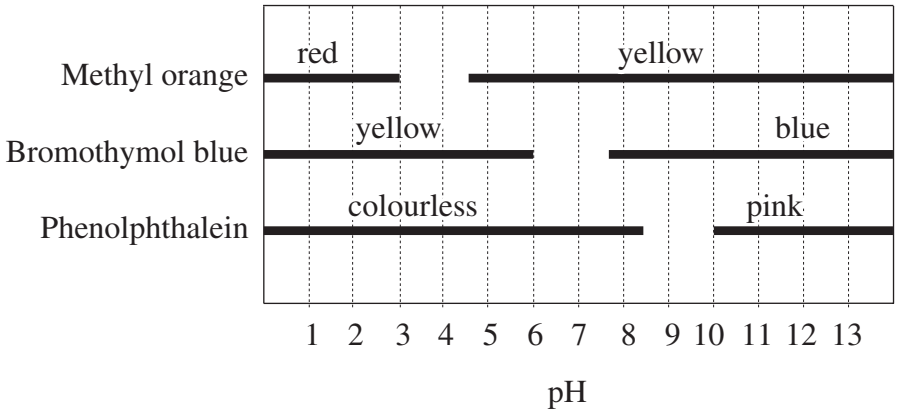
Marks

Question 23 (6 marks)

Correct swimming pool maintenance requires regular monitoring of the pH level of the water.

(a) Select the best indicator from the graph to check that the pH of swimming pool water lies within the correct range of 7.0 – 7.6. Justify your choice. **3**



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Question 23 continues on page 19

Marks

Question 23 (continued)

(b) Another part of swimming pool maintenance is adjusting chlorine levels in the pool. 'Liquid chlorine' is a solution of sodium hypochlorite (NaOCl) which can be used to do this. Upon addition of sodium hypochlorite to the pool, the following equilibrium reaction occurs:

$$OCl^-(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + OH^-(aq)$$

(i) State a reason for the regular chlorination of swimming pool water. **1**

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(ii) Explain how the addition of sodium hypochlorite will affect the pH of the water in the pool. **2**

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End of Question 23

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Marks

Question 24 (5 marks)

Early in the twentieth century, Fritz Haber developed a method for preparing ammonia.

(a) Write a balanced chemical equation for the preparation of ammonia using the Haber process. **1**

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(b) Evaluate the significance of Haber's discovery at that time in world history. **4**

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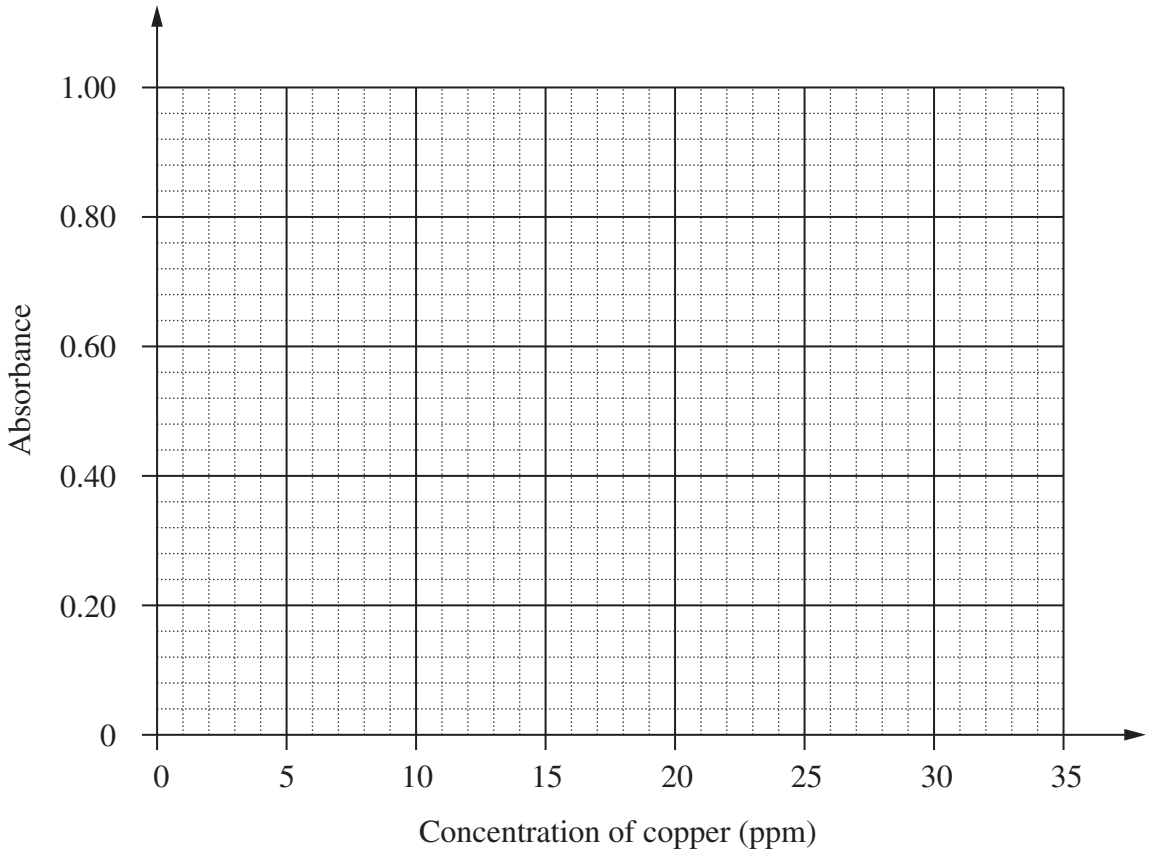
Marks

Question 25 (5 marks)

Atomic absorption spectroscopy was used to analyse a set of standard solutions of copper. The results are presented in the table.

Concentration of copper (ppm)	*Absorbance*
0	0
5	0.20
10	0.39
15	0.52
20	0.64
25	0.77

(a) Draw an appropriate graph of the data. **2**



Question 25 continues on page 23

Marks

Question 25 (continued)

(b) An analysis of two samples containing copper was then performed. The results are given in the table. **3**

Sample	*Absorbance*
1	0.44
2	0.90

Use your graph to estimate the concentration of copper present in the samples, and assess the validity of each of your estimates.

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End of Question 25

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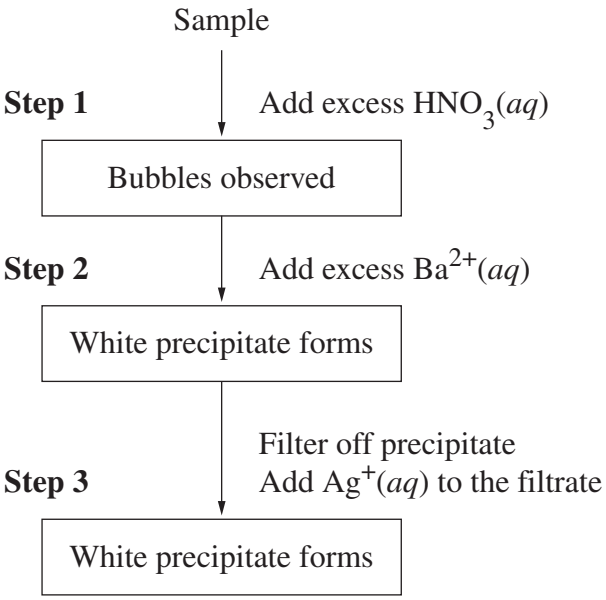
Marks

Question 26 (4 marks)

The flow diagram shows a series of tests that can be used to identify carbonate, chloride and sulfate ions present in a sample.



(a) Identify the gas observed during Step 1. **1**

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(b) Explain why the analysis must be performed in the sequence given. **3**

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Marks

Question 27 (4 marks)

One of the most common methods for determining the concentration of metal ions in water samples involves titration with a reagent called EDTA. In alkaline solution EDTA is present as an anion with a 4 – charge. In this form it reacts with metal ions such as calcium and magnesium in a 1 : 1 ratio:

$$Ca^{2+} + EDTA^{4-} \rightarrow Ca(EDTA)^{2-}$$

When the reaction between the metal ions and $EDTA^{4-}$ is complete, an indicator also present in the solution changes colour.

A student used the following procedure to determine the concentration of calcium in a sample of water:

- 50.0 mL of water sample was pipetted into a conical flask
- 5.0 mL of ammonia/ammonium ion buffer and two drops of indicator were added
- Sample was titrated with 0.0200 mol L^{-1} $EDTA^{4-}$ until indicator changed colour
- The above procedure was repeated a further three times
- The average volume of $EDTA^{4-}$ used in the four titrations was 24.0 mL

(a) What is the average number of moles of $EDTA^{4-}$ added to reach the end point? **1**

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(b) The student used the answer to part (a) to calculate the concentration of Ca^{2+} in the water sample in mg L^{-1}. **2**

What concentration was obtained?

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(c) The concentration of Ca^{2+} in the water sample was also determined by atomic absorption spectroscopy, and found to be 16% lower than the value obtained by titration with $EDTA^{4-}$. **1**

Suggest a reason why the concentration of Ca^{2+} determined by EDTA titration was higher.

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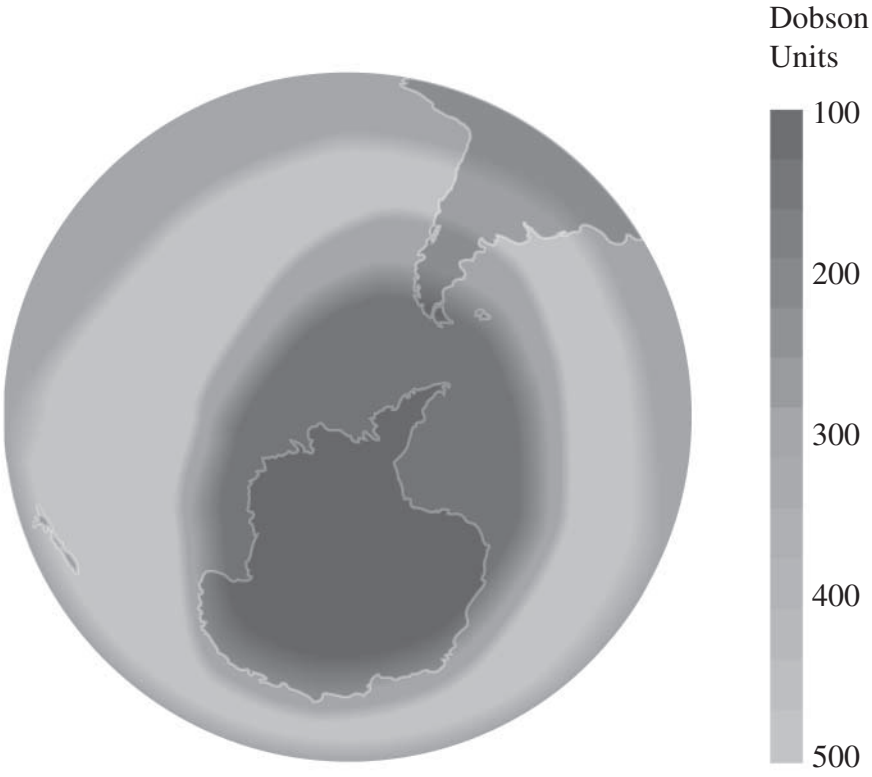
Marks

Question 28 (4 marks)

The diagram shows recent atmospheric ozone concentrations above Antarctica. **4**



Explain how this information was obtained, and outline the changes that have occurred in atmospheric ozone concentrations above Antarctica during the past twenty years.

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 29–33
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.

		Pages
Question 29	Industrial Chemistry	30–31
Question 30	Shipwrecks, Corrosion and Conservation	32–33
Question 31	The Biochemistry of Movement	34–36
Question 32	The Chemistry of Art	37–38
Question 33	Forensic Chemistry	39–40

Marks

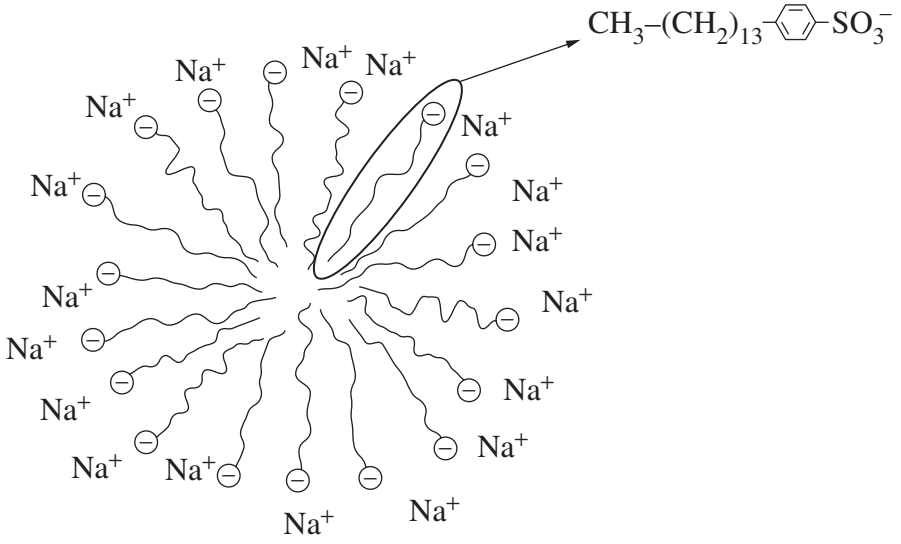
Question 29 — Industrial Chemistry (25 marks)

(a) During your practical work you performed a first-hand investigation to identify the products of electrolysis of sodium chloride.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Provide a conclusion based on one set of observations from your first-hand investigation. **2**

(b) The diagram represents how one class of molecules assembles in water to form a structure called a *micelle*.



(i) Identify the class of molecules shown. **1**

(ii) Account for the formation of a micelle. **2**

(iii) Explain what happens when oil is added to water containing these molecules. **3**

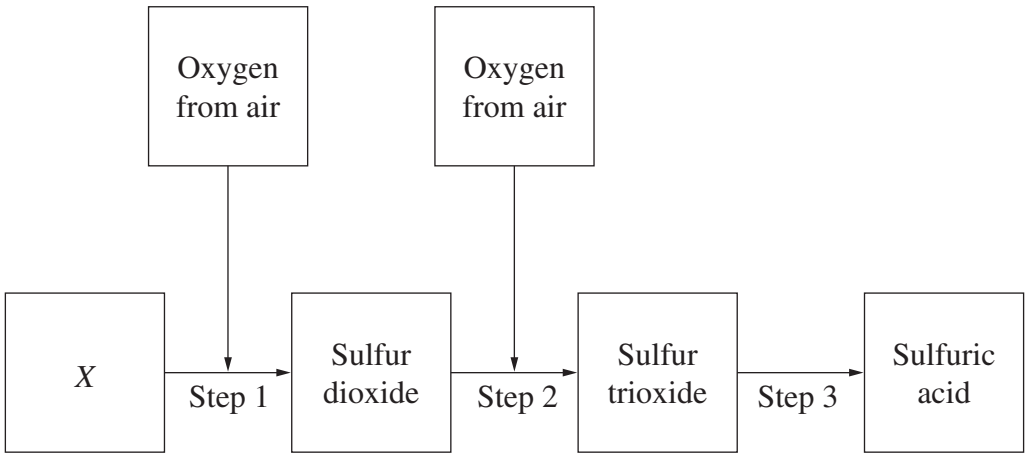
(c) In this option you studied one natural product that was not a fossil fuel. **7**

Describe the issues associated with shrinking world supplies of this natural product, and evaluate progress being made to solve the problems identified.

Question 29 continues on page 31

Question 29 (continued)

(d) The diagram summarises the steps in the Contact process.



(i) Identify the starting material, *X*, for the first step in the Contact process. **1**

(ii) Outline the chemistry involved in the conversion of sulfur trioxide to sulfuric acid. **2**

(iii) Justify the conditions you would use to maximise the rate and yield of the second step in the Contact process. Include a balanced chemical equation in your answer. **4**

End of Question 29

Marks

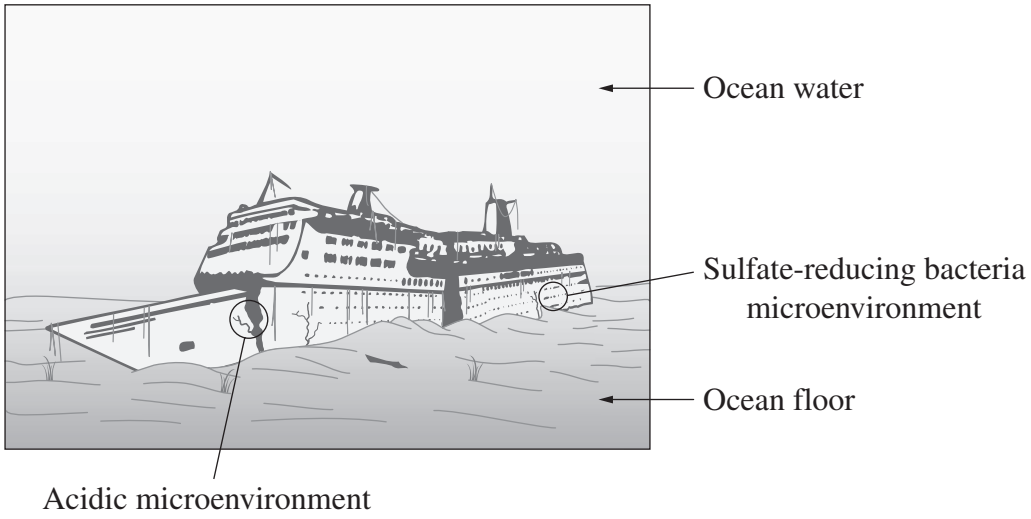
Question 30 — Shipwrecks, Corrosion and Conservation (25 marks)

(a) During your practical work you performed a first-hand investigation to identify the factors that affect the rate of an electrolysis reaction.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Provide a conclusion based on one set of observations from your first-hand investigation. **2**

(b) The diagram shows the wreck of an iron ship sitting on the bottom of the ocean at a great depth.



(i) Identify the gas dissolved in water that causes corrosion. **1**

(ii) Outline the effect of temperature and pressure on the solubility of gases in water. **2**

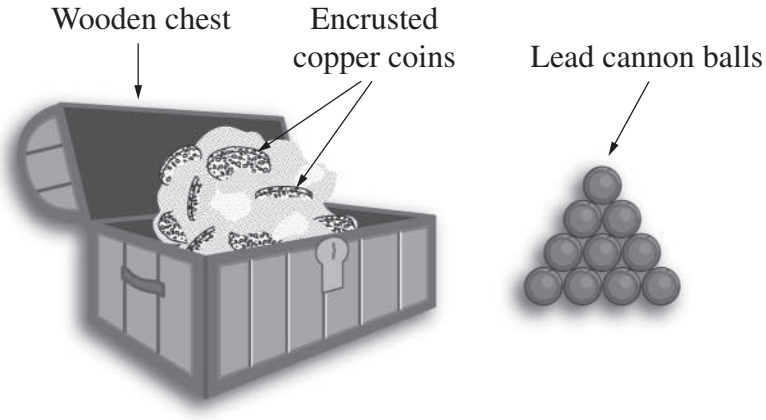
(iii) Microenvironments are localised areas where conditions are different from those in the surrounding areas. **3**

Explain the effect of each microenvironment on the rate of corrosion of the iron ship. Include at least one balanced chemical equation in your answer.

Question 30 continues on page 33

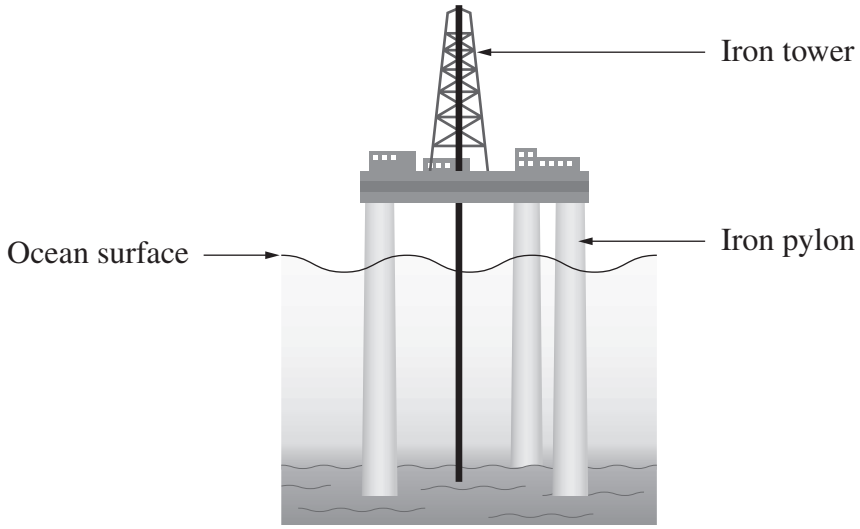
Question 30 (continued)

(c) The diagram shows artefacts recovered from a shipwreck. **7**



Describe how these artefacts may have been affected by prolonged exposure to the marine environment, and analyse the role of chemistry in procedures used for restoration of such objects.

(d) The diagram shows that iron is an important construction material for an oil rig.



(i) Identify the name for alloys composed of iron and carbon. **1**

(ii) Outline the process of rusting. **2**

(iii) Describe TWO methods for preventing corrosion of iron, and assess their suitability for use in different parts of the oil rig. **4**

End of Question 30

Marks

Question 31 — The Biochemistry of Movement (25 marks)

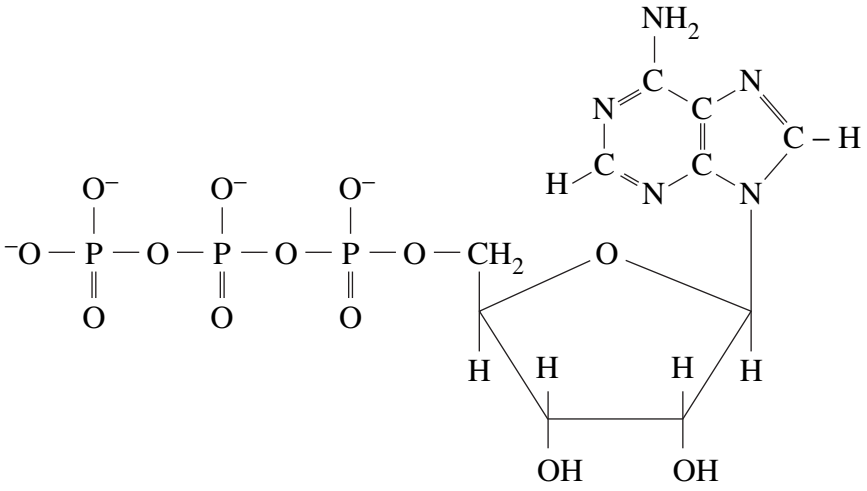
(a) During your practical work you performed a first-hand investigation to observe the effect of changes in pH and temperature on the reaction of an enzyme.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Provide a conclusion based on one set of observations from your first-hand investigation. **2**

(b) (i) Identify the part of the cell where glycolysis occurs. **1**

(ii) The diagram shows ATP which is used in many metabolic processes. **2**



Account for the widespread use of ATP in metabolism.

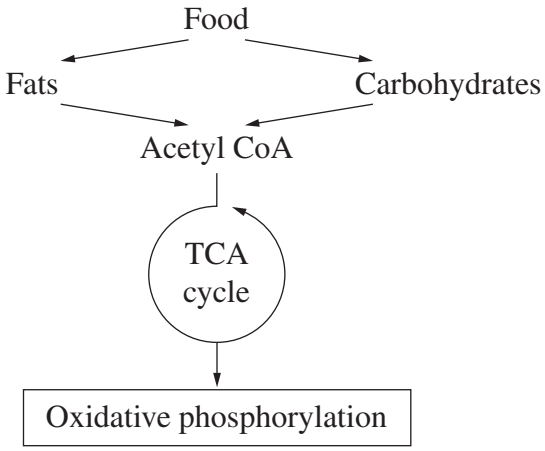
(iii) Enzymes usually show a high degree of substrate specificity in the reactions they catalyse. **3**

Explain how this specificity is achieved.

Question 31 continues on page 35

Question 31 (continued)

(c) Increased understanding of how the body produces energy has led to a number of weight loss diets. Several of these promote a diet low in carbohydrates. The diagram summarises how two of the food groups used by the body are metabolised to produce energy. **7**

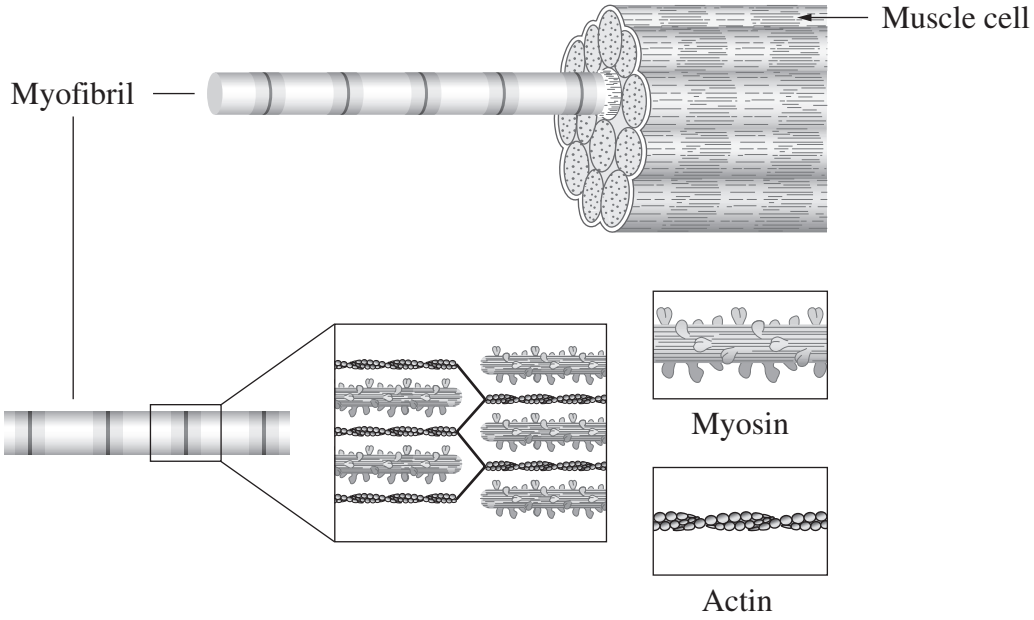


Describe how carbohydrates and fats are metabolised to produce energy, and explain how a diet low in carbohydrates might lead to weight loss.

Question 31 continues on page 36

Question 31 (continued)

(d) The diagram represents the structure of a relaxed skeletal muscle cell.



(i) Identify the class of molecules to which myosin and actin belong. **1**

(ii) Contrast the appearance and function of type 1 and type 2 skeletal muscle cells. **2**

(iii) Describe how muscle contractions occur, and explain how a contraction would change the appearance of the muscle cell in the diagram above. **4**

End of Question 31

Marks

Question 32 — The Chemistry of Art (25 marks)

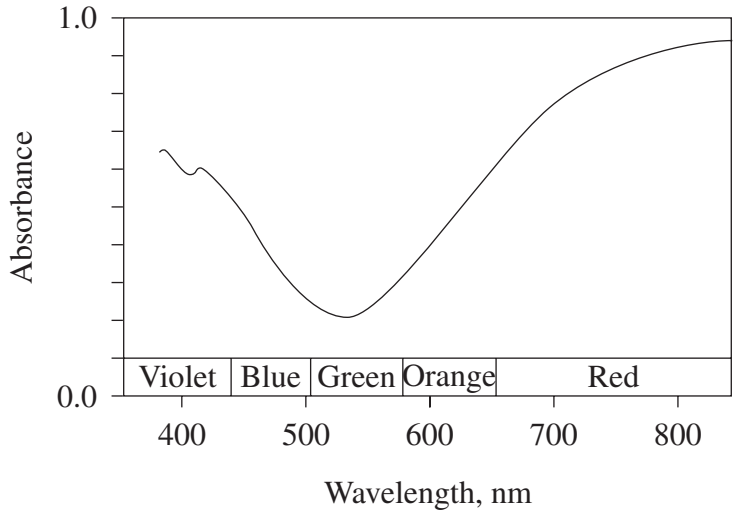
(a) During your practical work you performed a first-hand investigation to gather information about the oxidising strength of $KMnO_4$.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Provide a conclusion based on one set of observations from your first-hand investigation. **2**

(b) (i) Identify a pigment commonly used in an ancient culture, such as early Egyptian or Roman. **1**

(ii) The diagram shows the absorption spectrum of a pigment used in a painting found inside an ancient Egyptian tomb. **2**



Use the spectrum to identify the colour of this pigment. Justify your choice.

(iii) Explain why many minerals containing transition metal ions have been used as pigments. **3**

(c) Evaluate the contributions of Bohr, Pauli and Hund in developing our current understanding of the arrangement of electrons around the nuclei of atoms. **7**

Question 32 continues on page 38

Question 32 (continued)

(d) (i) Name the block in the Periodic Table occupied by the transition metals. **1**

(ii) Account for the observation that some transition metal complex ions can act as strong oxidising agents. **2**

(iii) The formulae of a number of complex ions are shown. **4**

$[Cu(H_2O)_6]^{2+}$

$[Fe(CN)_6]^{4-}$

$[Co(NH_3)_4Cl_2]^{+}$

$[Ni(H_2O)_6]^{2+}$

$[Fe(H_2O)_4Cl_2]^{+}$

Identify a feature of all ligands that enables them to form bonds to metal ions, and explain the bonding in one of the above complex ions. Include a Lewis diagram in your answer.

End of Question 32

Marks

Question 33 — Forensic Chemistry (25 marks)

(a) During your practical work you performed a first-hand investigation using flame tests and/or spectroscope analysis to identify and describe the emission spectra of elements including sodium and mercury.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Provide a conclusion based on one set of observations from your first-hand investigation. **2**

(b) Carbohydrates are a general class of compounds that includes monosaccharides such as glucose, and polysaccharides such as glycogen and cellulose.

(i) What is the general formula of carbohydrates? **1**

(ii) Compare the composition of glycogen and cellulose, and where they occur in nature. **2**

(iii) Explain the differences in structure between glycogen and cellulose. **3**

(c) The diagram shows a crime scene where there has been a fire. No identification was found on the body. A small amount of residue was extracted from the tin for analysis. **7**

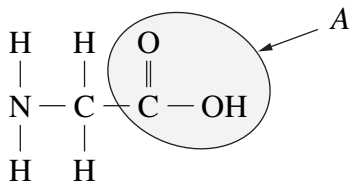
Describe TWO modern forensic chemistry techniques that could be used to examine evidence from this crime scene, and analyse why these techniques are suitable for forensic investigations.

Question 33 continues on page 40

Marks

Question 33 (continued)

(d) The structure of the amino acid glycine is shown.



(i) Identify the functional group *A*. **1**

(ii) Use structural formulae to write a balanced chemical equation to show the formation of a dipeptide containing two glycine molecules. **2**

(iii) The amino acid sequences of two proteins are shown. **4**

Protein *A*	Cysteine – Tyrosine – Isoleucine – Glutamine – Asparagine – Cysteine – Proline – Leucine – Glycine
Protein *B*	Cysteine – Tyrosine – Phenylalanine – Glutamine – Asparagine – Cysteine – Proline – Arginine – Glycine

Describe a chemical test for proteins, and explain how enzymes could be used to distinguish between Proteins *A* and *B*.

End of paper

Chemistry

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

$$\text{pH} = -\log_{10}[\text{H}^+] \qquad \Delta H = -m\,C\,\Delta T$$

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

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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 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 [97.91] 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 [209.0] 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 [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

KEY

Atomic Number — 79 — Symbol of element
Atomic Weight — 197.0 — Name of element
Au — Gold

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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.