BOARD OF STUDIES
NEW SOUTH WALES

2004

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 13, 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 16–27
- Allow about 1 hour and 45 minutes for this part

Section II Pages 29–38

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.

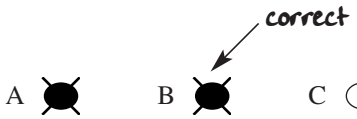
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 Ethanol can be reacted with ethanoic acid to produce ethyl ethanoate. What type of reaction is this?

(A) Esterification

(B) Hydration

(C) Polymerisation

(D) Reduction

2 Why is research into synthetic biopolymers attracting great interest?

(A) They decompose more easily than traditional synthetic polymers.

(B) They can be produced more cheaply than traditional synthetic polymers.

(C) They have superior physical properties compared to traditional synthetic polymers.

(D) They have superior chemical properties compared to traditional synthetic polymers.

3 Which of the following cations can be identified using a flame test?

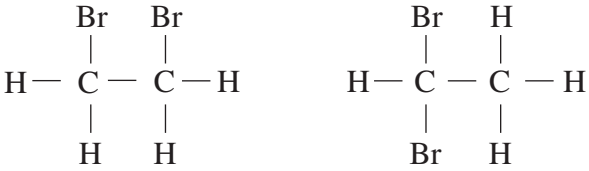
(A) Al^{3+}

(B) Cu^{2+}

(C) Mg^{2+}

(D) Zn^{2+}

4 Which term describes the relationship between the compounds shown below?



(A) Allotropes

(B) Isomers

(C) Isotopes

(D) Monomers

5 Which statement best represents Davy's definition of an acid?

(A) Acids contain oxygen.

(B) Acids are proton donors.

(C) Acids contain replaceable hydrogen.

(D) Acids ionise in solution to form hydrogen ions.

6 Which of the following is the Lewis electron dot formula for ozone?

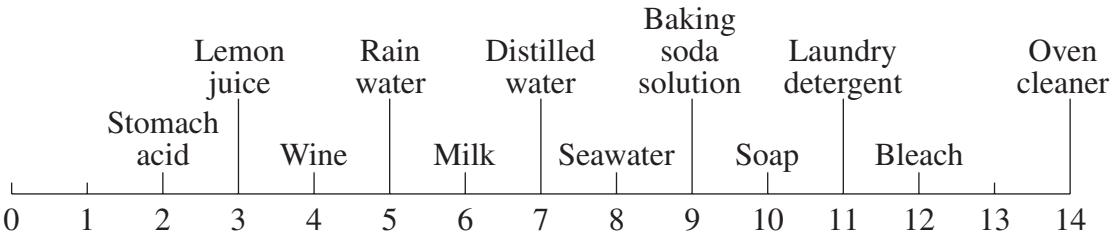
(A) 

(B) 

(C) 

(D) 

7 The figure shows the pH values of some substances.



Based on the pH values shown in the figure, which of the following statements about the concentration of hydrogen ions is correct?

(A) It is twice as great in milk as that in lemon juice.

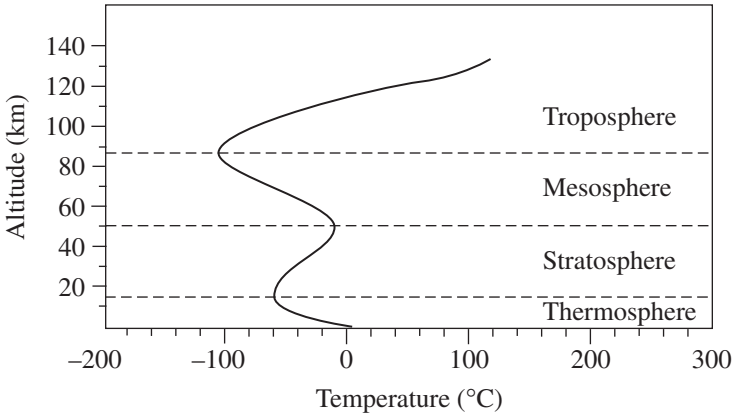
(B) It is 1 000 000 times greater in soap than in wine.

(C) It is three times greater in wine than in bleach solution.

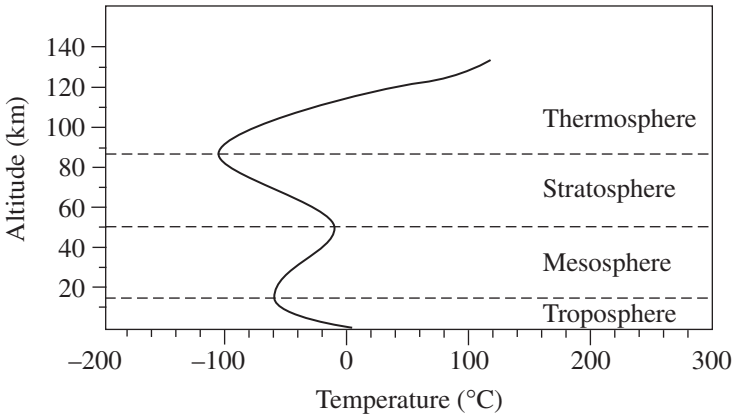
(D) It is 1 000 times greater in distilled water than in soap.

8 Which of the following graphs illustrates the layered structure of the atmosphere?

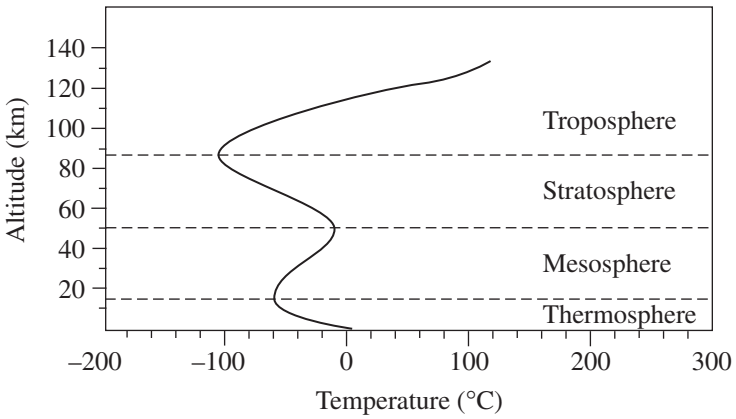
(A)



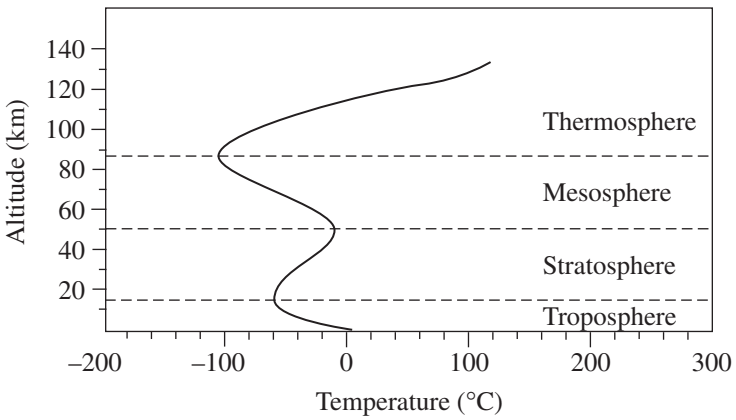
(B)



(C)



(D)



9 Ozone reacts with nitric oxide according to the equation

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$$

0.66 g $NO(g)$ was mixed with 0.72 g $O_3(g)$.

What is the maximum volume of $NO_2(g)$ produced at 0°C and 100 kPa?

(A) 0.34 L

(B) 0.37 L

(C) 0.45 L

(D) 0.50 L

10 Phosgene is prepared from the reaction of carbon monoxide and chlorine in the presence of a catalyst:

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g) \qquad \Delta H = -9.93 \text{ kJ mol}^{-1}$$

Which of the following sets of conditions would produce the highest yield of phosgene?

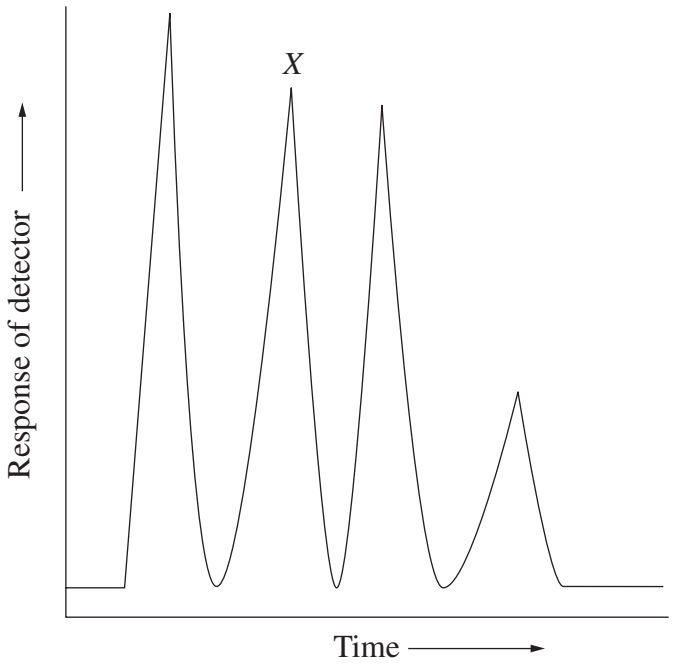
(A) High temperature, high pressure

(B) Low temperature, low pressure

(C) Low temperature, high pressure

(D) High temperature, low pressure

11 In gas chromatography, compounds may be separated based on their molecular weight. The smaller the molecular weight the more quickly the compound is detected. A gas chromatographic analysis was performed on a mixture of 1-hexanol, 1-octanol, 1-heptanol and 1-pentanol. The results are shown in the diagram.



Which substance does peak *X* correspond to?

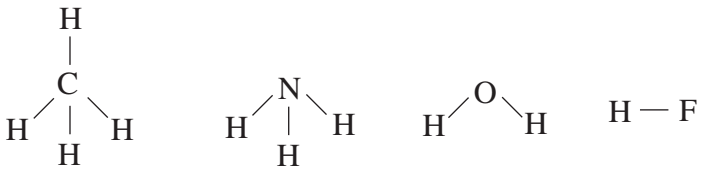
(A) 1-hexanol

(B) 1-octanol

(C) 1-heptanol

(D) 1-pentanol

12 Two of the compounds shown below react together to form a new compound with a coordinate covalent bond.



Which of the following compounds react this way?

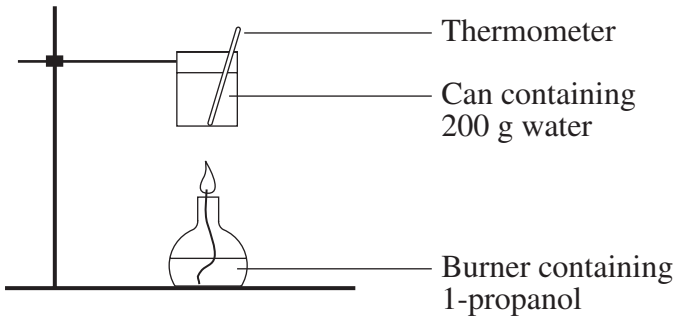
(A) Methane and ammonia

(B) Methane and water

(C) Hydrogen fluoride and ammonia

(D) Hydrogen fluoride and methane

13 A student used the apparatus below to determine the molar heat of combustion of propanol.



The following results were obtained:

Mass of 1-propanol burnt	=	0.60 g
Mass of water heated	=	200 g
Initial temperature of water	=	21.0°C

The molar heat of combustion of 1-propanol is 2021 kJ mol^{-1}. Assuming no heat loss, what would be the final temperature of the water?

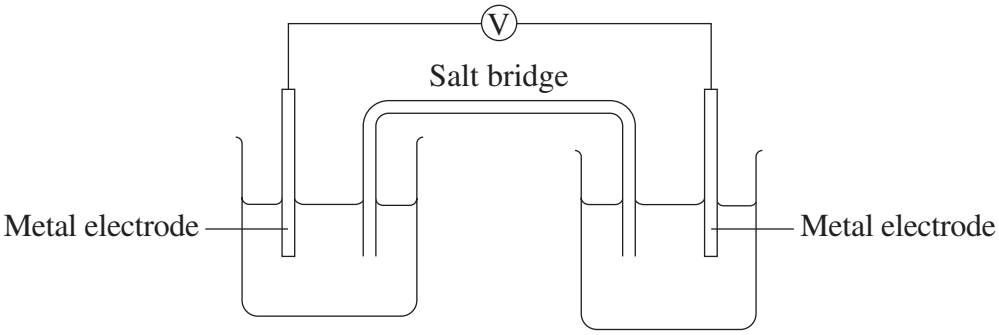
(A) 24.2°C

(B) 29.1°C

(C) 45.2°C

(D) 48.4°C

14 Four metals Pb, *x*, *y* and *z*, were connected in pairs and the voltage was recorded.



The results obtained are set out in the table below.

Negative terminal	*Positive terminal*	*Voltage* (V)
Pb	*x*	0.35
y	Pb	1.10
z	Pb	2.60

What is the order of increasing ease of oxidation of the metals?

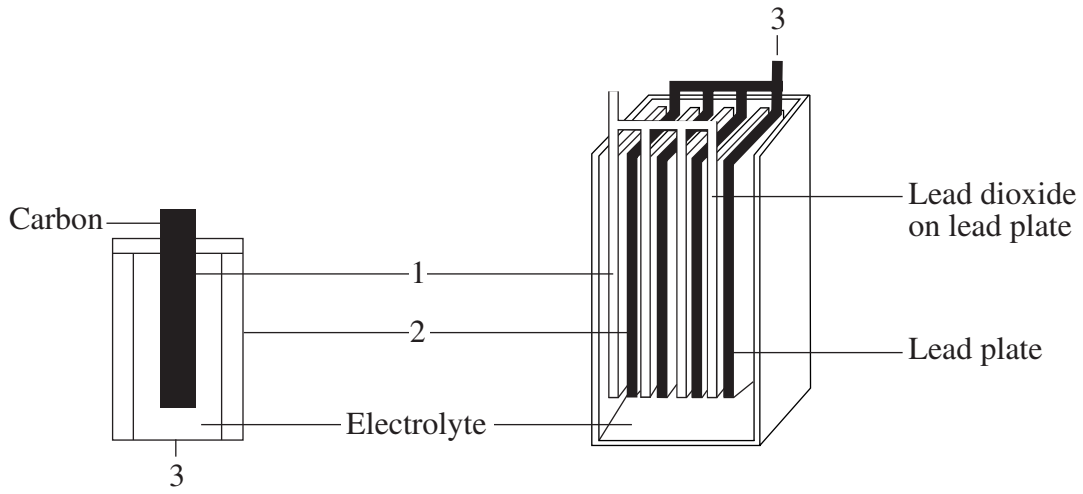
(A) *z*, *y*, Pb, *x*

(B) Pb, *x*, *y*, *z*

(C) *x*, *y*, Pb, *z*

(D) *x*, Pb, *y*, *z*

15 Diagram *A* shows a dry cell. Diagram *B* shows a lead-acid cell.



Which of the following shows the correctly labelled parts?

	LABELS		
	1	2	3
(A)	anode	cathode	negative terminal
(B)	cathode	anode	negative terminal
(C)	anode	cathode	positive terminal
(D)	cathode	anode	positive terminal

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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 (5 marks)

(a) Outline the procedure you would use to prepare a standard solution of sodium hydrogen carbonate from solid sodium hydrogen carbonate. **3**

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(b) Calculate the mass of solid sodium hydrogen carbonate required to make 250 mL of 0.12 mol L^{-1} solution. **2**

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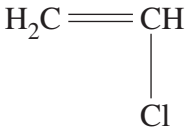
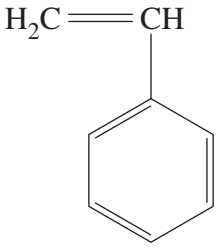
Marks

Question 17 (5 marks)

The structures of two commercially significant monomers are shown.





(a) Identify the common name of ONE of the monomers. **1**

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(b) The uses of polymers are dependent on their properties. **3**

Discuss this statement with reference to a polymer made from one of the above monomers.

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(c) Draw the structure of a polymer made from one of the above monomers. **1**

Marks

Question 18 (4 marks)

Analyse the relationship between the position of elements in the Periodic Table, and the acid–base behaviour of their oxides. **4**

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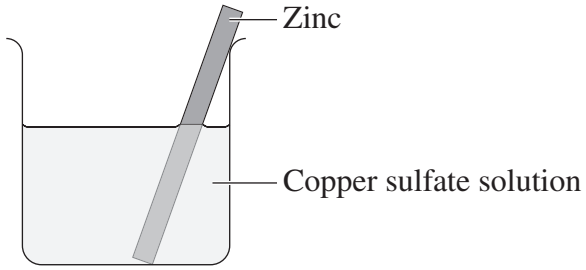
Please turn over

Marks

Question 19 (6 marks)

The following experiment was performed to investigate the relative activity of metals. The beaker initially contained 250.0 mL of 0.050 mol L^{-1} copper sulfate solution.



After several hours the dark blue colour of the solution had become lighter and a red-brown deposit had formed on the piece of zinc metal.

(a) Account for the changes observed. Provide a balanced oxidation–reduction equation in your answer. **3**

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The red-brown deposit was removed from the piece of zinc metal and dried. It was found to weigh 0.325 g.

(b) Calculate the concentration of copper sulfate solution remaining in the beaker. **3**

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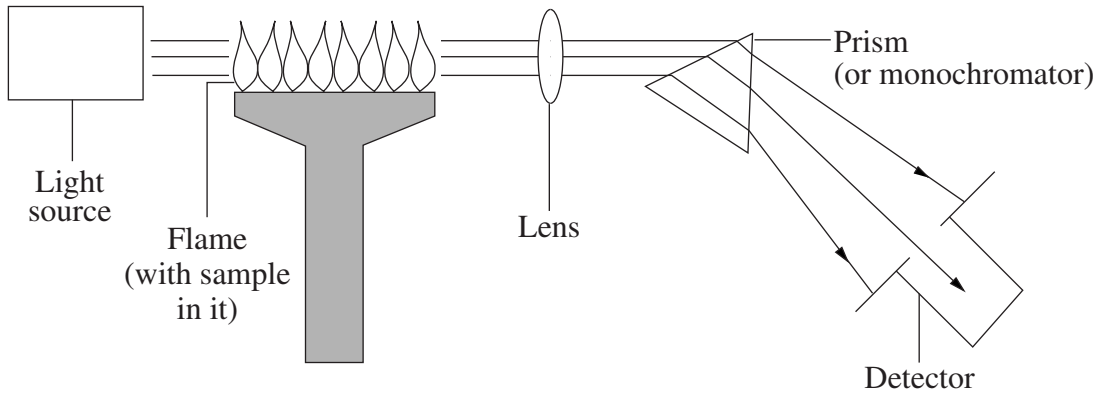
Marks

Question 20 (6 marks)

A schematic figure of an atomic absorption spectrophotometer is shown.



Roland Smith, 2000, Conquering Chemistry, 3rd edition (C) McGraw - Hill Australia Pty Ltd.

(a) What is the purpose of the light source and the flame in the figure? **2**

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Question 20 continues on page 18

Question 20 (continued)

Soil from an industrial site was suspected of being contaminated with mercury. A single sample of the soil was extracted using an approved method. The resulting solution was analysed five times by atomic absorption spectroscopy (AAS). The results are shown in the table.

Measurement number	*Absorbance at 259 nm*
1	0.90
2	0.89
3	0.89
4	0.64
5	0.91

The concentration of mercury in the soil sample was calculated using an average absorbance of 0.85.

(b) Assess the validity and reliability of the concentration of mercury determined using this procedure. **4**

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End of Question 20

Marks

Question 21 (7 marks)

You have performed first-hand investigations on water samples using qualitative and quantitative analyses.

(a) Distinguish between *qualitative analysis* and *quantitative analysis*. **2**

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(b) Describe TWO factors that affect the concentrations of ions in natural bodies of water. **2**

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(c) Complete the following table to show how the anions listed can be identified. **3**

Anion	*Reagent*	*Observations if anion is present*
Cl^-		
PO_4^{3-}		
SO_4^{2-}		

Marks

Question 22 (3 marks)

(a) Define the term *amphiprotic*. **1**

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(b) Write TWO chemical equations to show that the dihydrogen phosphate ion ($H_2PO_4^-$) is amphiprotic. **2**

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 23 (3 marks)

A natural indicator was made by heating yellow flowers with water. The resulting yellow solution was tested with a range of substances. The results are recorded below. **3**

Substance	*Colour*
0.1 M hydrochloric acid	Red
0.1 M ammonia	Yellow
Lemon juice	Orange
Oven cleaner	Yellow
Pure water	Yellow

Assess the usefulness of the yellow solution as an acid–base indicator.

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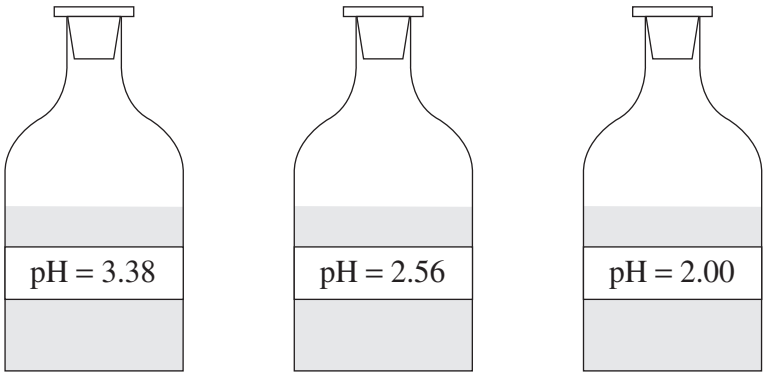
Marks

Question 24 (5 marks)

The diagram shows three reagent bottles containing acids.



0.01 mol L^{-1} Acetic acid | 0.01 mol L^{-1} Citric acid | 0.01 mol L^{-1} Hydrochloric acid

(a) Calculate the pH after 10.0 mL of 0.01 mol L^{-1} hydrochloric acid solution is diluted by the addition of 90.0 mL of distilled water. **1**

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(b) Explain the use of acetic acid and citric acid as food additives. **2**

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Question 24 continues on page 23

Marks

Question 24 (continued)

(c) Explain the difference in pH between the three acids in the diagram. **2**

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End of Question 24

Please turn over

Marks

Question 25 (5 marks)

The table shows properties of some fuels. **5**

Fuel	*Main sources*	*Heat of combustion* (kJ g^{-1})	*Boiling point* (°C)
Methane	• Petrochemical industry	55.6	–161.5
Propane	• Petrochemical industry • Natural gas	50.3	–42.1
Octane	• Refined from crude oil	47.9	125.7
Ethanol	• Hydration of ethene • Fermentation	29.7	78.3

Assess the potential of ethanol as an alternative fuel, making use of data from the table.

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Chemistry

Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 26 (4 marks)

Discuss the benefits and problems associated with the use of ONE radioactive isotope in industry. **4**

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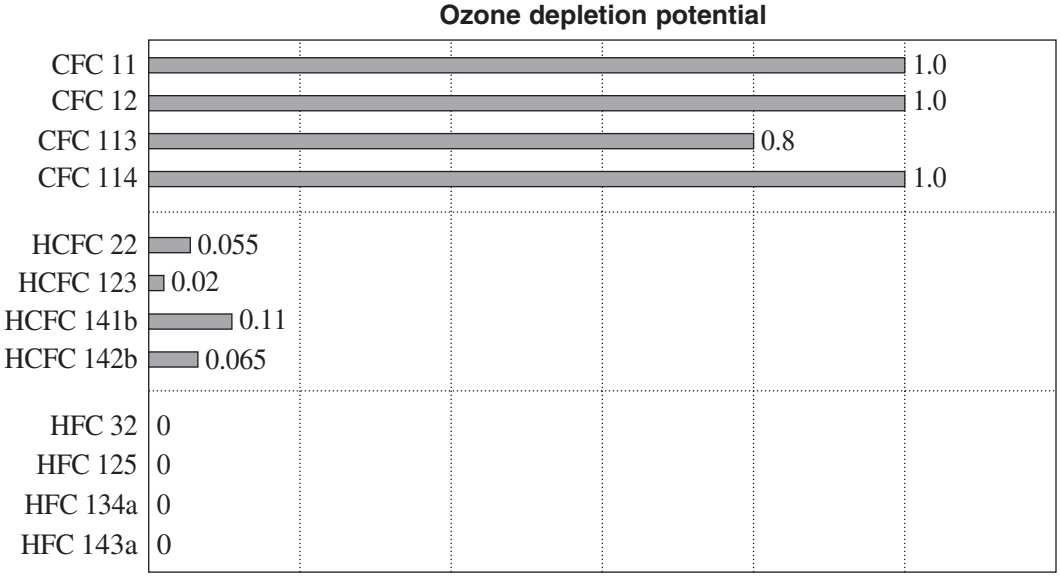
Marks

Question 27 (7 marks)

The table shows ozone depletion potential (ODP) for different compounds. **7**



http://www.princeton.edu/nchm333/2002/spring/ozone/alternatives_substitutes.htm

Discuss the problems associated with the use of CFCs, and assess the suitability of alternative chemicals as replacements, using data in the table.

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Question 27 continues on page 27

Question 27 (continued)

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End of Question 27

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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.

		Pages
Question 28	Industrial Chemistry	30–31
Question 29	Shipwrecks, Corrosion and Conservation	32–33
Question 30	The Biochemistry of Movement	34–35
Question 31	The Chemistry of Art	36
Question 32	Forensic Chemistry	37–38

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) (i) Identify a safety precaution used when diluting concentrated sulfuric acid. **1**

(ii) Many of the steps in the Contact process for the manufacture of sulfuric acid are reversible equilibrium reactions. Identify ONE of these reactions and describe how the product yield can be maximised. **3**

(b) The table shows the structures of three different classes of detergents.

Type of detergent	*Structure*
Anionic	
Non-ionic	
Cationic	

Roland Smith, 2000, Conquering Chemistry, 3rd edition (C) McGraw - Hill Australia Pty Ltd.

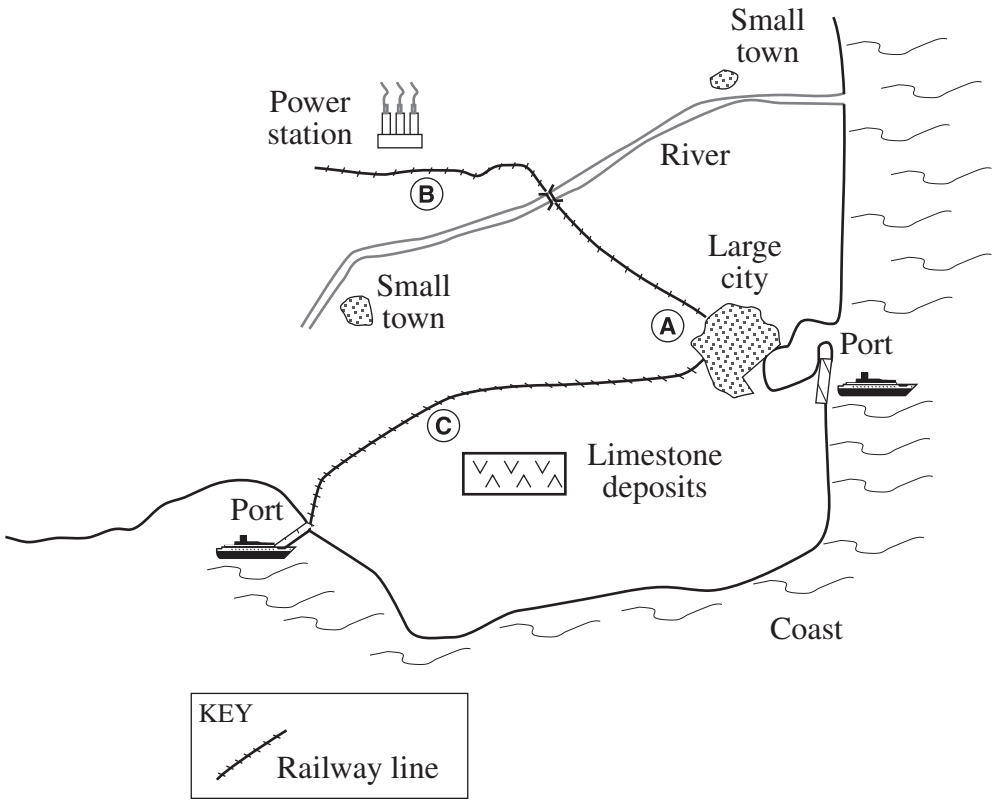
(i) Account for the cleaning action of anionic detergents. **2**

(ii) Assess the environmental impacts of the different classes of detergents. **4**

Question 28 continues on page 31

Question 28 (continued)

(c) Chemco Pty Ltd wishes to build two new industrial plants. One will be used for the production of sodium carbonate and the other for production of sodium hydroxide. The map shows three sites, labelled **A**, **B** and **C**, being considered for the location of the industrial plants. **7**



Assess the suitability of the three sites for locating industrial plants to produce each compound.

(d) During your practical work you performed a first-hand investigation to gather information and describe the properties of a named emulsion, and you related these properties to its uses.

(i) Define the term *emulsion*. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) Explain how the industrial method of producing soap differs from that used in school laboratories. **4**

End of Question 28

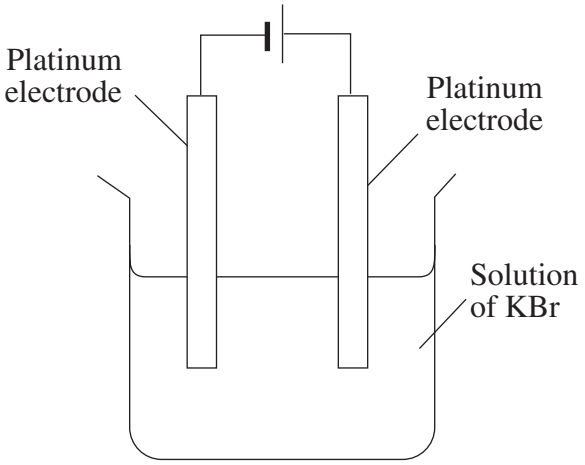
Marks

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

(a) (i) Identify ONE origin of minerals in oceans. **1**

(ii) Explain the damage that occurs when drying wooden artefacts that have been removed from long-submerged wrecks. **3**

(b) The diagram shows an electrolytic cell.



(i) Write half-equations for the main reactions occurring at the cathode and anode. **2**

(ii) Analyse the impact of the work of Faraday on our understanding of electrolysis. **4**

(c) Assess how increasing knowledge of metals and alloys has resulted in materials other than timber being used to construct ships. **7**

Question 29 continues on page 33

Marks

Question 29 (continued)

(d) During your practical work you performed a first-hand investigation to compare and describe the rates of corrosion of materials at different oxygen concentrations.

(i) Define the term *corrosion*. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) The diagram shows the locations of two identical steel ships that were wrecked at the same time near a tropical island. **4**

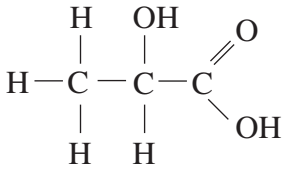
Explain how differences in oxygen concentration and temperature experienced by the two wrecks have resulted in different levels of corrosion.

End of Question 29

Marks

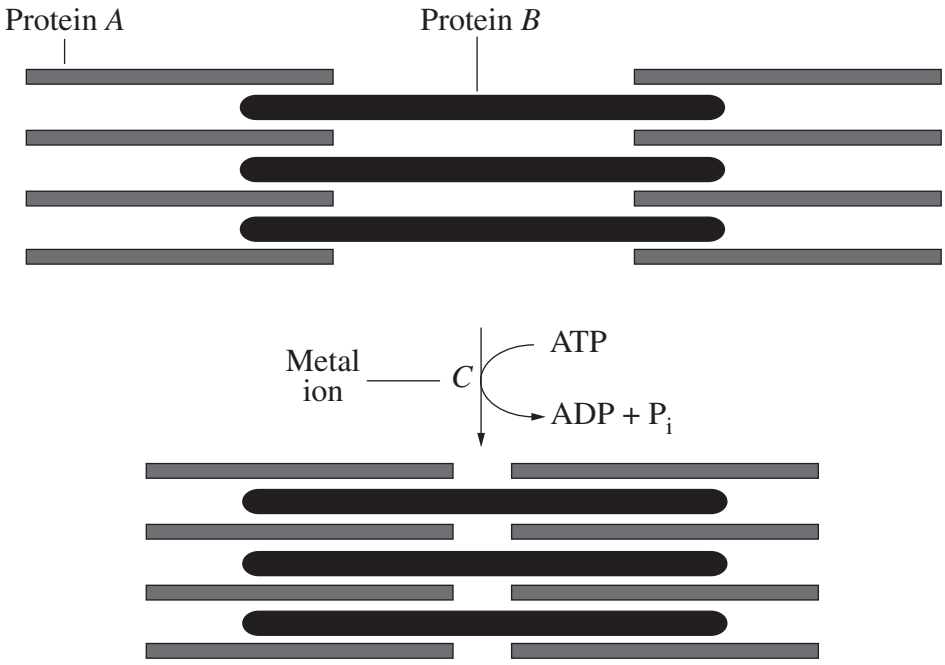
Question 30 — The Biochemistry of Movement (25 marks)

(a) (i) Identify the following molecule: **1**



(ii) Compare the formation of this molecule by anaerobic respiration with the process of fermentation. **3**

(b) The diagram illustrates schematically the current model of muscle contraction.



(i) Identify protein *A*, protein *B*, and metal ion *C*. **2**

(ii) Explain why different energy sources are used in sprinting and light exercise. **4**

Question 30 continues on page 35

Marks

Question 30 (continued)

(c) Assess the importance of oxidative phosphorylation as an energy source, referring to the roles of cytochromes and oxygen. **7**

(d) During your practical work you performed a first-hand investigation on the effect of pH on the reaction of an enzyme.

(i) Define the term *enzyme*. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) Explain the possible effects of varying pH on the primary, secondary and tertiary structures of enzymes. **4**

End of Question 30

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) The formulae of three coordination complexes containing chromium(III) are shown below.

$$\left[Cr\left(H_2O\right)_6\right]^{3+}$$

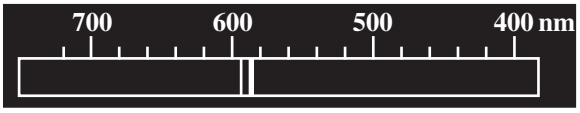
$$\left[Cr\left(H_2O\right)_5Cl\right]^{2+}$$

$$\left[Cr\left(H_2O\right)_4Cl_2\right]^{+}$$

(i) What is the electron configuration of chromium metal in the ground state? **1**

(ii) Draw a Lewis structure of ONE of these coordination complexes, and explain the bonding in this molecule. **3**

(b) The diagram shows the emission spectrum of sodium seen through a spectroscope.



(i) Draw an energy level diagram to represent the origin of these spectral lines. **2**

(ii) Explain how the Bohr model of the atom was developed using the emission spectrum of hydrogen, and outline its limitations. **4**

(c) Assess the potential health risks associated with chemicals found in cosmetics that were used in an ancient culture. **7**

(d) During your practical work you performed a first-hand investigation to observe the colour changes of a named transition element as it changed in oxidation state.

(i) Define the term *transition element*. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) Explain why transition elements may have more than one oxidation state. **4**

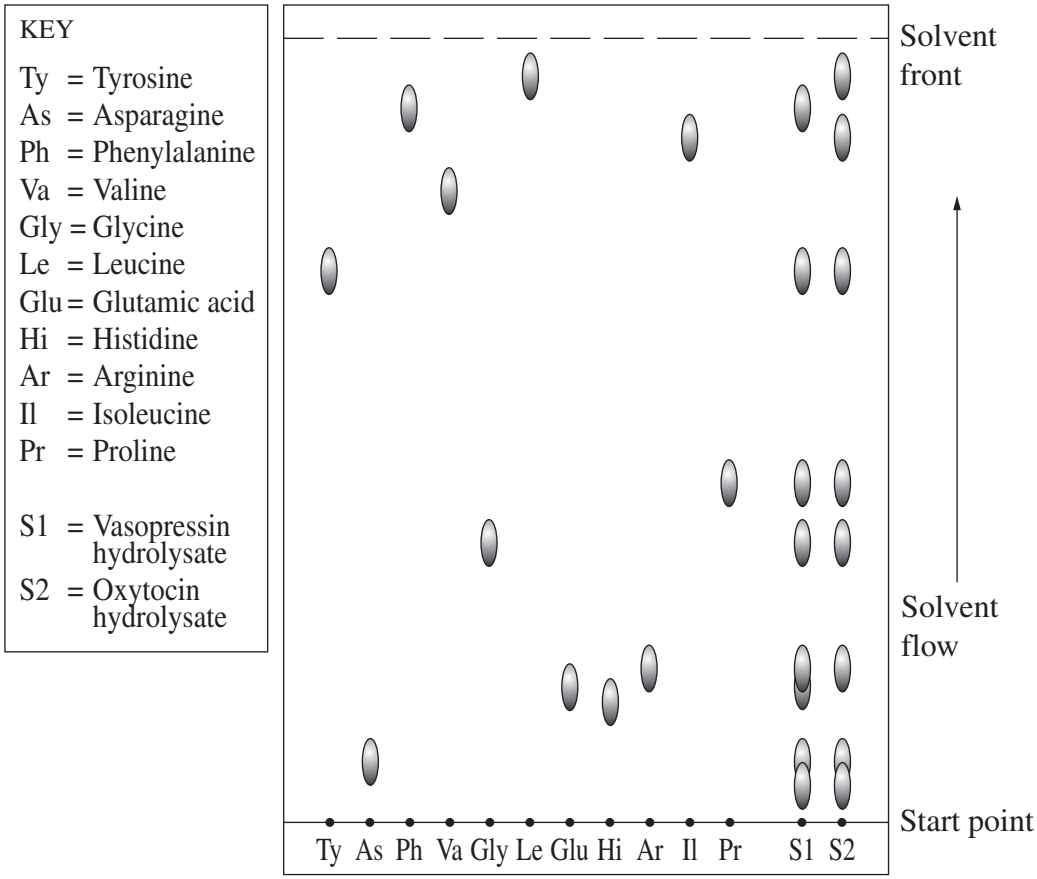
Marks

Question 32 — Forensic Chemistry (25 marks)

(a) (i) Identify the technique used to separate amino acids on the basis of differences in their charge. **1**

(ii) Explain how a mass spectrometer operates, and identify its usefulness for forensic science. **3**

(b) Oxytocin and vasopressin are small proteins consisting of nine amino acids. A forensic scientist decided to determine the amino acid composition of both proteins using paper chromatography. Samples of both proteins were first hydrolysed into their constituent amino acids using a mixture of enzymes. The resulting protein hydrolysates were spotted onto a sheet of filter paper together with eleven reference amino acids. After the filter paper had been placed in a suitable solvent and developed, the chromatogram below was obtained.



(i) Contrast the amino acid composition of both proteins after analysing the chromatogram. **2**

(ii) Explain how variations in the composition and structure of proteins affect their biological functions. **4**

Question 32 continues on page 38

Marks

Question 32 (continued)

(c) Assess the usefulness of distinguishing tests for carbohydrates and metal ions used in the school laboratory, compared with technology used by forensic chemists in laboratories, for the same purposes. **7**

(d) During your practical work you performed a first-hand investigation to identify the range of solvents that may be used for chromatography to separate and identify mixtures.

(i) Define the term *chromatography*. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) Describe precautions used to prevent contamination of forensic samples, and explain why they are needed. **4**

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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

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

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

KEY

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

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.