BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2016 HIGHER SCHOOL CERTIFICATE EXAMINATION

IMPORTANT:
This resource was developed to support a previous version of the syllabus. It may contain content that differs from the current syllabus.

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black 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

Total marks – 100

Section I Pages 2–27

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 21–30
- Allow about 1 hour and 40 minutes for this part

Section II Pages 29–40

25 marks

- Attempt ONE question from Questions 31–35
- Allow about 45 minutes for this section

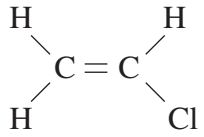
Section I
75 marks

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 What is the name of this compound?



(A) Styrene

(B) Ethylene

(C) Chloroethane

(D) Vinyl chloride

2 Which of the following metal ions would NOT cause heavy metal pollution if released in high concentrations?

(A) Copper

(B) Lead

(C) Mercury

(D) Sodium

3 What is the molecular formula of pentanoic acid?

(A) C_5H_9O

(B) $C_5H_{10}O$

(C) $C_5H_{10}O_2$

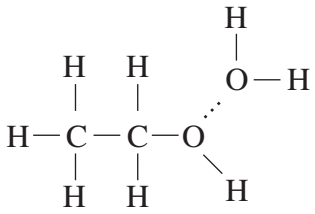
(D) $C_5H_{11}O_2$

4 Which row of the table correctly identifies an application of polystyrene and the reason for its suitability for that application?

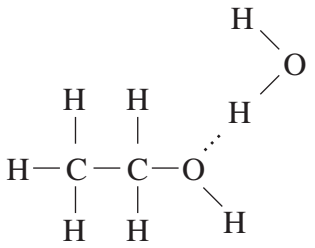
	Application	*Reason for suitability*
(A)	Shopping bags	Rigidity
(B)	Shopping bags	Flexibility
(C)	Screwdriver handles	Rigidity
(D)	Screwdriver handles	Flexibility

5 Which of the following diagrams best represents the bonding between molecules of water and ethanol?

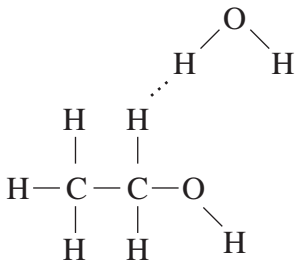
(A)



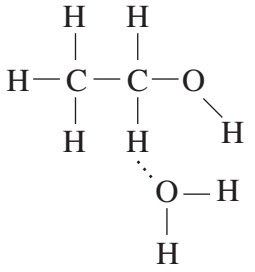
(B)



(C)



(D)



6 Which combination of equimolar solutions would produce the most basic mixture?

(A) Acetic acid and barium hydroxide

(B) Acetic acid and sodium carbonate

(C) Sulfuric acid and barium hydroxide

(D) Sulfuric acid and sodium carbonate

7 Which indicator in the table would be best for distinguishing between lemon juice (pH = 2.3) and potato juice (pH = 5.8)?

	Indicator	*Colour at different pH*	
(A)	Crystal violet	0.2 – yellow	1.8 – blue
(B)	Methyl orange	3.2 – red	4.4 – yellow
(C)	Bromothymol blue	6.0 – yellow	7.6 – blue
(D)	Phenolphthalein	8.2 – colourless	10.0 – pink

8 The following procedure was used to test water hardness.

- 5.0 mL of hard water was placed in a test tube.
- 0.1 mL of liquid soap was added to the test tube.
- The sample was shaken for 30 seconds.
- The height of bubbles was measured.

What would be a suitable control to use with this procedure?

(A) Not adding any soap to the test tube

(B) Not placing any water in the test tube

(C) Using a second sample of the hard water

(D) Replacing the hard water with distilled water

9 Curium is produced according to this equation.

$$^{239}_{94}\text{Pu} + X \longrightarrow {}^{242}_{96}\text{Cm} + {}^{1}_{0}\text{n}$$

What is X in the equation?

(A) A proton

(B) A neutron

(C) A beta particle

(D) An alpha particle

10 Which of the following is the conjugate base of the $H_2PO_4^-$ ion?

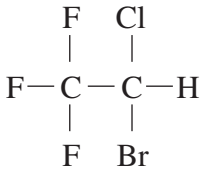
(A) H_3PO_4

(B) H_3PO_3

(C) HPO_4^{2-}

(D) HPO_3^{2-}

11 What is the IUPAC name of the following compound?



(A) 1-bromo-1-chloro-2,2,2-trifluoroethane

(B) 1-chloro-1-bromo-2,2,2-trifluoroethane

(C) 2-chloro-2-bromo-1,1,1-trifluoroethane

(D) 2-bromo-2-chloro-1,1,1-trifluoroethane

12 Which of the following could be added to 100 mL of 0.01 mol L^{-1} hydrochloric acid solution to change its pH to 4?

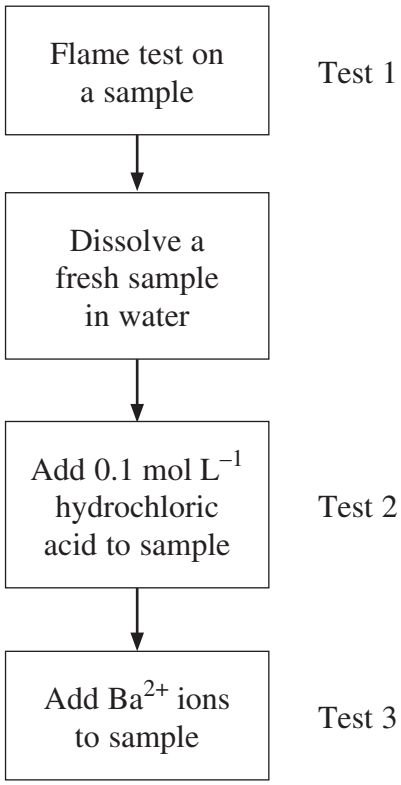
(A) 900 mL of water

(B) 900 mL of 0.01 mol L^{-1} hydrochloric acid

(C) 9900 mL of water

(D) 9900 mL of 0.01 mol L^{-1} hydrochloric acid

13 The flow chart shows the steps used to identify a sample of a substance.



If the substance is sodium sulfate, what should have been observed in Tests 1, 2 and 3?

	Test 1	*Test 2*	*Test 3*
(A)	Bright orange flame	No bubbles	White precipitate formed
(B)	Bright orange flame	Bubbles	No precipitate formed
(C)	Blue-green flame	No bubbles	No precipitate formed
(D)	Blue-green flame	Bubbles	White precipitate formed

14 Consider the following endothermic reaction taking place in a closed vessel.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

Which of the following actions would cause more N_2O_4 to be produced?

(A) Adding a catalyst

(B) Decreasing the volume

(C) Decreasing the pressure

(D) Increasing the temperature

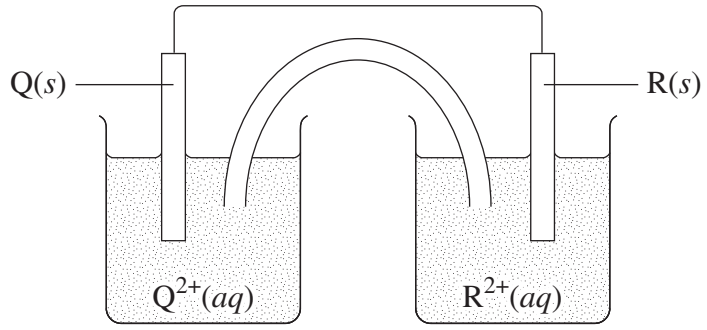
15 The table lists some properties of the straight-chained carbon compounds *W*, *X*, *Y* and *Z*.

Compound	*Reactivity in bromine water*	*Solubility in water*
W	Rapidly decolourises	Insoluble
X	Unreactive	Insoluble
Y	Unreactive	Soluble
Z	Unreactive	Partly soluble

Which row of the following table best identifies the compounds *W*, *X*, *Y* and *Z*?

	W	*X*	*Y*	*Z*
(A)	C_3H_6	C_3H_8	CH_3OH	C_4H_9OH
(B)	C_3H_8	C_3H_6	CH_3OH	C_4H_9OH
(C)	C_3H_6	C_3H_8	C_4H_9OH	CH_3OH
(D)	C_3H_8	C_3H_6	C_4H_9OH	CH_3OH

16 An electrochemical cell has the following structure.



This particular cell can be represented as:

$$Q \mid Q^{2+} \parallel R^{2+} \mid R$$

Which of the following cells would produce the highest cell potential at standard conditions?

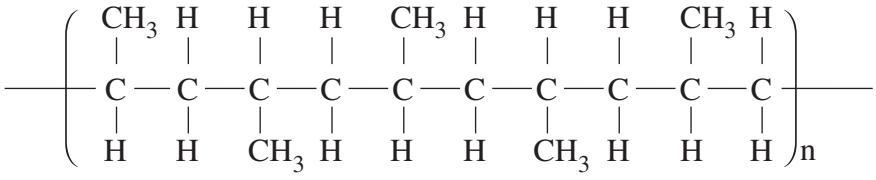
(A) $Mg \mid Mg^{2+} \parallel Fe^{2+} \mid Fe$

(B) $Al \mid Al^{3+} \parallel Cu^{2+} \mid Cu$

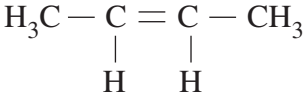
(C) $Zn \mid Zn^{2+} \parallel Pb^{2+} \mid Pb$

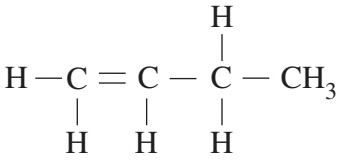
(D) $Ni \mid Ni^{2+} \parallel Ag^{+} \mid Ag$

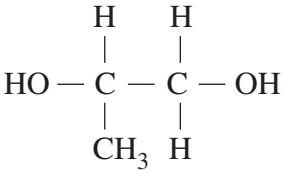
17 A polymer has the following structure.

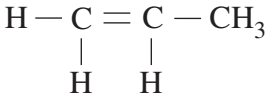


Which of the following represents the monomer from which this polymer can be produced?

(A) 

(B) 

(C) 

(D) 

18 40 mL of 0.10 mol L^{-1} NaOH is mixed with 60 mL of 0.10 mol L^{-1} HCl.

What is the pH of the resulting solution?

(A) 7.0

(B) 1.7

(C) 1.4

(D) 1.2

19 Excess barium nitrate solution is added to 200 mL of 0.200 mol L^{-1} sodium sulfate.

What is the mass of the solid formed?

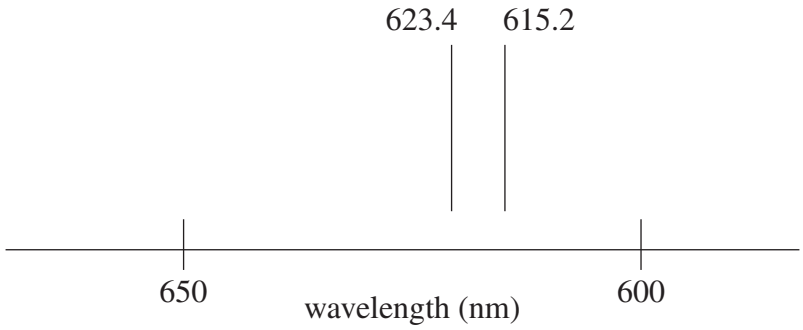
(A) 4.65 g

(B) 8.69 g

(C) 9.33 g

(D) 31.5 g

20 A section of the emission spectrum of a mercury lamp is shown.



Light at 623.4 nm and 615.2 nm from the mercury lamp was passed through a sample of water containing mercury, and the intensities were then measured by a detector.

I (x nm) = Intensity of light at a wavelength of x nm from the lamp
I_d (x nm) = Intensity of light at a wavelength of x nm at the detector

Which of the following pairs of intensities can be used in the determination of the amount of mercury in the water sample using atomic absorption spectroscopy (AAS)?

(A) I (615.2 nm) and I_d (615.2 nm)

(B) I (615.2 nm) and I_d (623.4 nm)

(C) I (615.2 nm) and I (623.4 nm)

(D) I_d (615.2 nm) and I_d (623.4 nm)

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Chemistry

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–30
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.

Extra writing space is provided on pages 25–27. If you use this space, clearly indicate which question you are answering.

Write your Centre Number and Student Number at the top of this page.

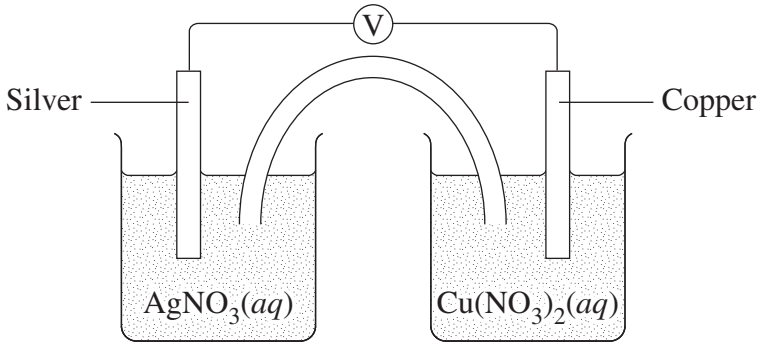
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Please turn over

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Question 21 (5 marks)

A student set up the following galvanic cell.



(a) On the diagram clearly indicate the direction of electron flow. **1**

(b) Complete the following table for this galvanic cell. **4**

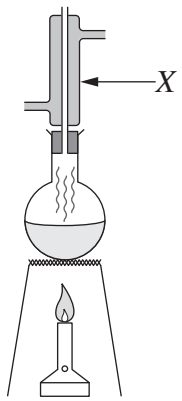
Anode half equation	
Cathode half equation	
Overall cell equation	
Overall cell potential	

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Question 22 (5 marks)

This apparatus was set up to produce methyl butanoate.



(a) Identify a safety issue in this experiment. **1**

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(b) Using structural formulae, write the equation for the production of methyl butanoate. **2**

(c) Justify the use of apparatus *X* in this experiment. **2**

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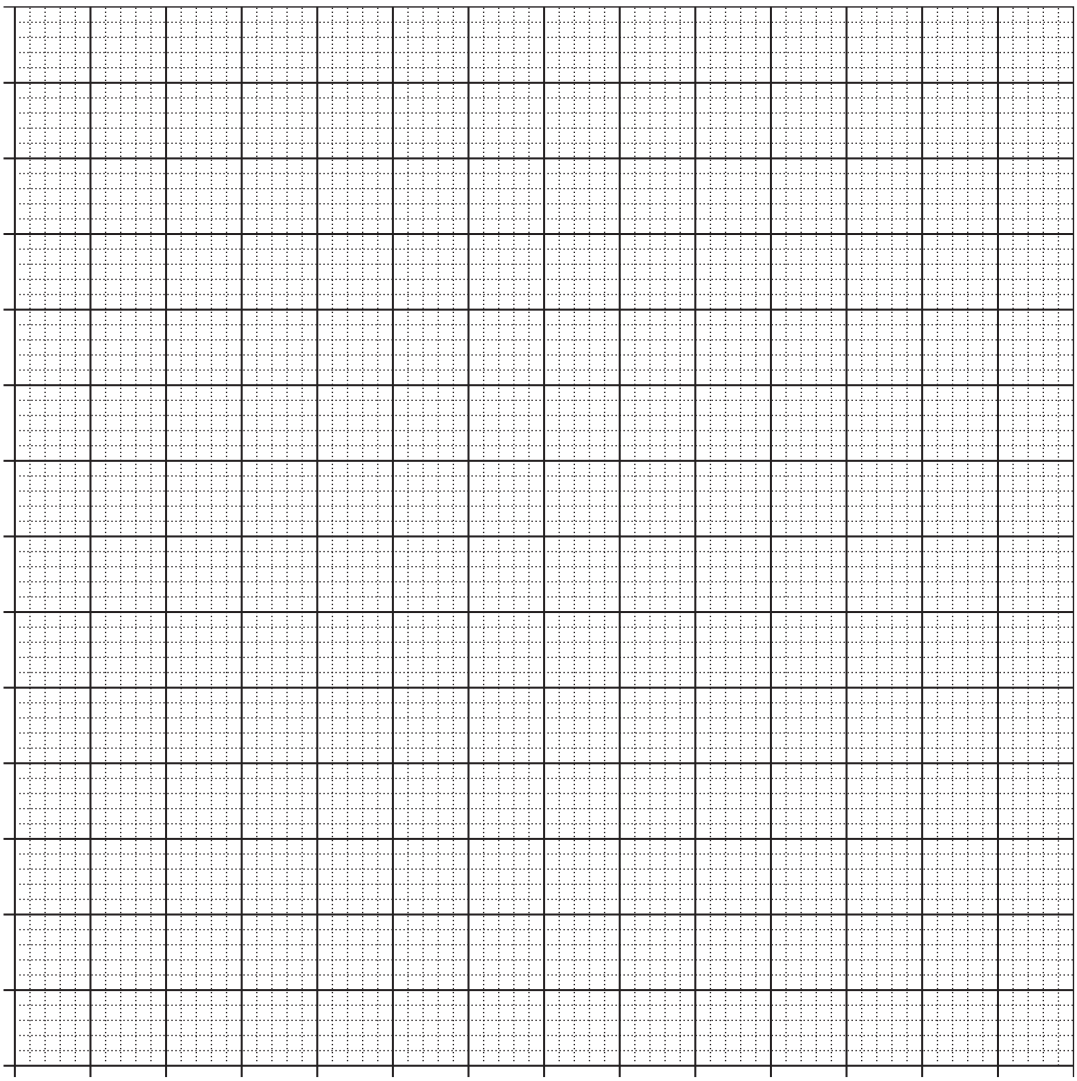
Question 23 (6 marks)

A spirit burner containing ethanol was used to heat water in a conical flask for three minutes to measure the molar heat of combustion of ethanol.

The results from the investigation are shown.

Time (min)	0	0.5	1.5	2.0	2.5	3.0	3.5	4.5	5.0
Temperature of water (°C)	18.5	20.5	25.0	27.0	29.5	31.0	30.5	28.5	27.5

(a) On the grid, draw a line graph to represent the data contained in the table. **3**



Question 23 continues on page 17

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Question 23 (continued)

(b) The following values were also recorded during the investigation: **3**

Initial mass of spirit burner = 236.14 g

Final mass of spirit burner = 235.56 g

Calculated experimental molar heat of combustion of ethanol = –827 kJ mol^{-1}.

Using information from the previous page and the above values, determine the mass of water that was in the conical flask.

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End of Question 23

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Question 24 (7 marks)

(a) Explain how microscopic membrane filters are used to purify contaminated water. Use a labelled diagram to support your answer. **4**

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(b) Explain why dissolved oxygen levels can be used to measure the extent of eutrophication. **3**

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Question 25 (4 marks)

An unattended car is stationary with its engine running in a closed workshop. The workshop is 5.0 m × 5.0 m × 4.0 m and its volume is 1.0×10^5 L. The engine of the car is producing carbon monoxide in an incomplete combustion according to the following chemical equation: **4**

$$C_8H_{18}(l) + \tfrac{17}{2}O_2(g) \rightarrow 8CO(g) + 9H_2O(l)$$

Exposure to carbon monoxide at levels greater than 0.100 g L^{-1} of air can be dangerous to human health.

6.0 kg of octane was combusted by the car in this workshop.

Using the equation provided, determine if the level of carbon monoxide produced in the workshop would be dangerous to human health. Support your answer with relevant calculations.

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Question 26 (6 marks)

(a) Explain why cellulose is classified as a condensation polymer. **2**

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(b) Justify the need for research into biopolymers. **4**

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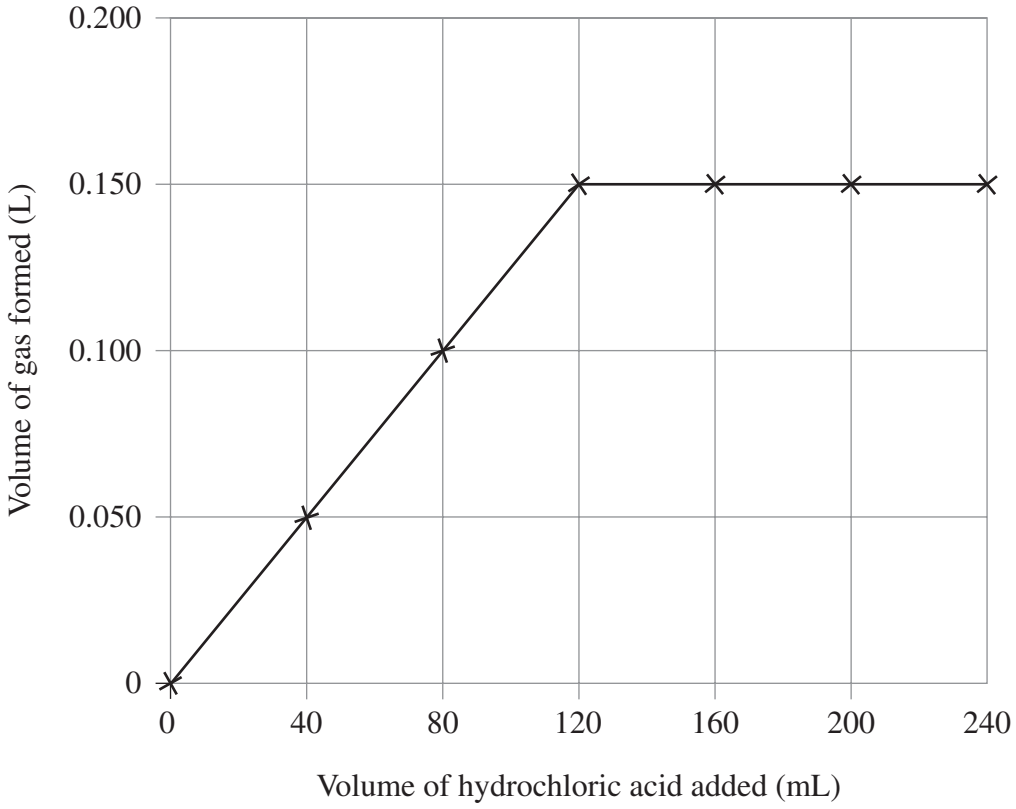
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Question 27 (4 marks)

The volume of gas formed at 25°C and 100 kPa as hydrochloric acid was added to a pure sample of aluminium is shown in the graph. **4**



Calculate the original mass of the aluminium sample used in the reaction.

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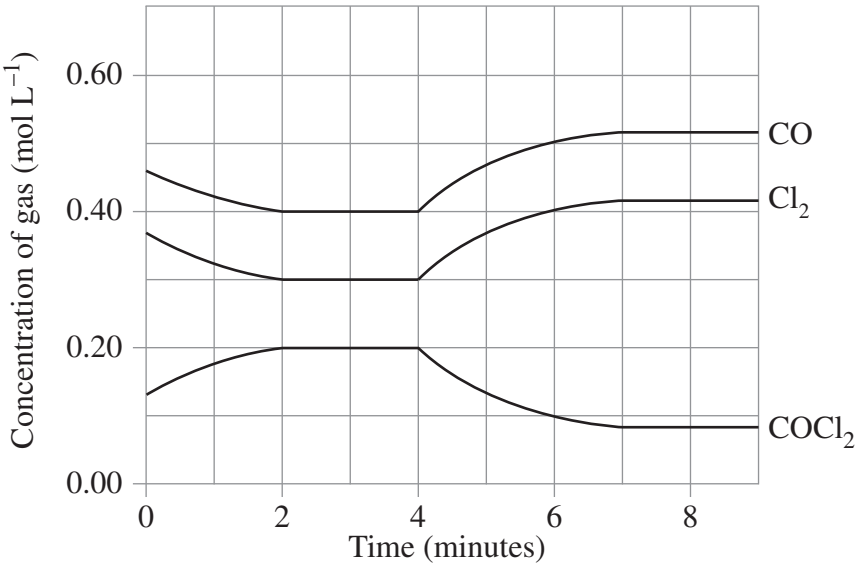
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Question 28 (5 marks)

A mixture of carbon monoxide, chlorine and phosgene ($COCl_2$) gases was placed in a closed container. The concentrations of the gases were monitored over time.



(a) At what time does the system first reach equilibrium? Justify your answer. **2**

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(b) At four minutes, the temperature of the container was increased. **3**

Explain, with reference to the graph, whether the decomposition of $COCl_2$ into CO and Cl_2 is exothermic or endothermic.

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Question 29 (6 marks)

A solution of hydrochloric acid was standardised by titration against a sodium carbonate solution using the following procedure.

- All glassware was rinsed correctly to remove possible contaminants.
- Hydrochloric acid was placed in the burette.
- 25.0 mL of sodium carbonate solution was pipetted into the conical flask.

The titration was performed and the hydrochloric acid was found to be 0.200 mol L^{-1}.

(a) Identify the substance used to rinse the conical flask and justify your answer. **2**

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(b) Seashells contain a mixture of carbonate compounds. The standardised hydrochloric acid was used to determine the percentage by mass of carbonate in a seashell using the following procedure. **4**

- A 0.145 g sample of the seashell was placed in a conical flask.
- 50.0 mL of the standardised hydrochloric acid was added to the conical flask.
- At the completion of the reaction, the mixture in the conical flask was titrated with 0.250 mol L^{-1} sodium hydroxide.

The volume of sodium hydroxide used in the titration was 29.5 mL.

Calculate the percentage by mass of carbonate in the sample of the seashell.

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Question 30 (7 marks)

The use of CFCs has caused ozone depletion in the stratosphere. **7**

Explain the steps that have been taken to reduce this problem. Include relevant chemical equations in your answer.

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 31–35
Allow about 45 minutes for this section

Answer parts (a)–(d) of one question in the Section II Writing Booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Pages

Question 31 Industrial Chemistry 30–31

Question 32 Shipwrecks, Corrosion and Conservation 32–33

Question 33 The Biochemistry of Movement 34–35

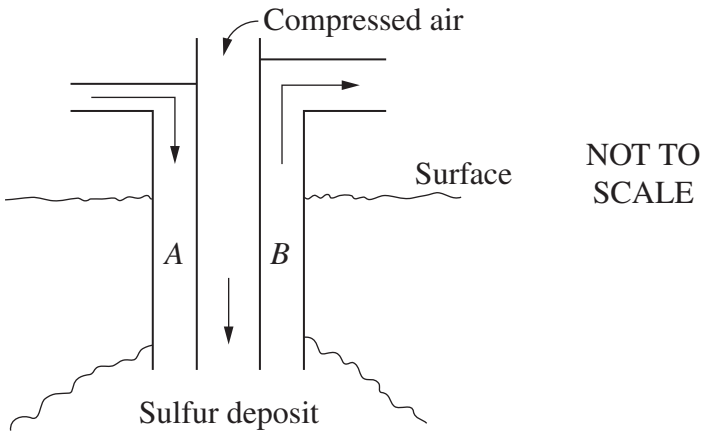
Question 34 The Chemistry of Art 36–37

Question 35 Forensic Chemistry 38–40

Question 31 — Industrial Chemistry (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) The diagram shows a method used to extract sulfur from an underground sulfur deposit.



(i) Identify the substances travelling through pipes *A* and *B*. **2**

(ii) Explain how the properties of sulfur allow it to be extracted using this method. **3**

(b) A first-hand investigation to electrolyse a solution of sodium chloride is to be performed.

(i) Outline a procedure that is suitable for carrying out this investigation in a school laboratory. In your answer, address a safety issue. **3**

(ii) Describe how one of the products of the electrolysis of the sodium chloride solution can be identified. In your answer, refer to the chemistry occurring at each of the electrodes. **4**

Question 31 continues on page 31

Question 31 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) (i) Methane and water vapour react to form carbon monoxide and hydrogen in a closed container as shown. **3**

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206 \text{ kJ}$$

Compare the impact on the equilibrium system of a decrease in volume of the container to the impact of a decrease in temperature. Refer to the equilibrium constant in your answer.

(ii) Solid ammonium hydrogen sulfide (NH_4HS) decomposes to form ammonia gas and hydrogen sulfide gas (H_2S). **4**

2.00 moles of ammonium hydrogen sulfide were placed in a sealed 3.00 L container and the system was allowed to reach equilibrium. At equilibrium, there were 0.0328 moles of ammonia gas.

Calculate the equilibrium constant for this reaction.

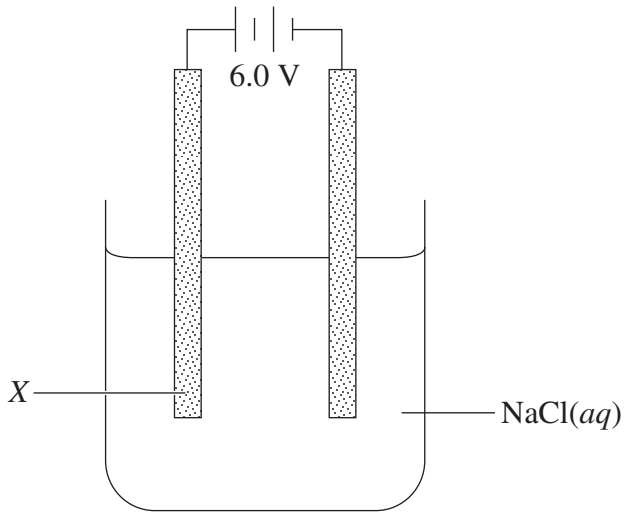
(d) Compare the process of saponification in a school laboratory with the industrial preparation of soap and justify any differences in the methods used. Include a relevant chemical equation in your answer. **6**

End of Question 31

Question 32 — Shipwrecks, Corrosion and Conservation (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) The diagram shows an electrochemical cell with graphite electrodes.



(i) Identify the type of electrochemical cell shown in the diagram, giving a reason for your answer. **2**

(ii) Describe a chemical process that could occur at the electrode labelled *X* in the electrochemical cell in terms of electron transfer. Include a relevant chemical equation in your answer. **3**

(b) A first-hand investigation to compare the rate of corrosion of materials at different temperatures is to be performed.

(i) Describe a procedure that can be used to carry out this investigation safely and reliably. **3**

(ii) Explain how the results of this investigation AND one other factor can be used to predict the rate of corrosion of a wreck at great depth in the ocean. **4**

Question 32 continues on page 33

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) (i) Using an example, explain how *passivating metals* resist corrosion. **3**

(ii) Using an example, explain how a sacrificial electrode can prevent corrosion of an iron ocean-going vessel. **4**

(d) Iron cannons have been found in a wreck on a coral reef. It is estimated that the wreck occurred about 250 years ago. **6**

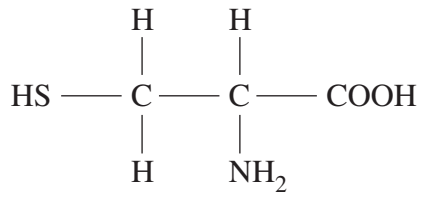
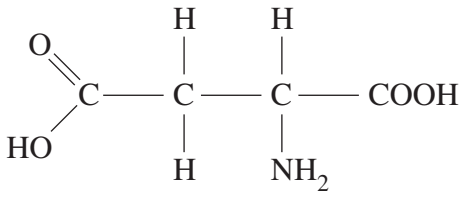
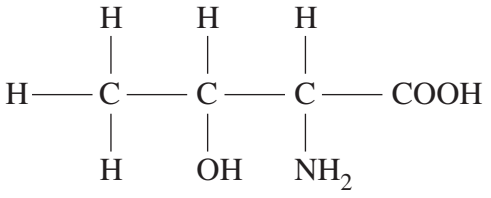
Explain the processes involved in restoring the cannons after they have been salvaged from the wreck.

End of Question 32

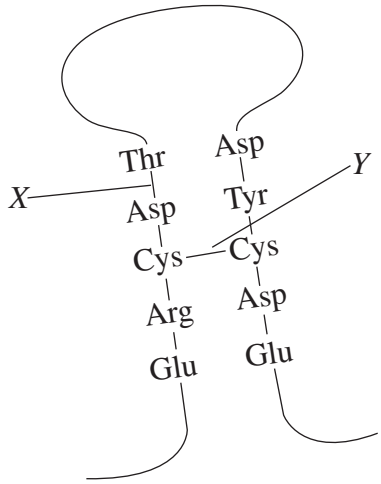
Question 33 — The Biochemistry of Movement (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) The table shows the formulae of some amino acids.

Cys	
Asp	
Thr	

The diagram shows part of the amino acid chain in the enzyme ribonuclease.



(i) Name the TWO types of covalent bond labelled *X* and *Y* on the diagram. **2**

(ii) Explain why ribonuclease loses its enzyme activity when it is heated to 65°C. **3**

Question 33 continues on page 35

(b) A first-hand investigation to compare the structures of glycogen and glucose is to be performed.

(i) Describe the benefits of using diagrams or models in this investigation. **3**

(ii) Describe the processes of bond formation between glucose molecules that result in the structure of the glycogen polymer. **4**

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) Aerobic respiration is the main metabolic pathway used in long distance running. This metabolic pathway uses fuels from a variety of sources such as glucose and fats.

(i) The aerobic respiration of glucose releases 2800 kJ mol^{-1}. A long distance runner uses energy derived from glucose at 55 kJ per minute. **3**

Calculate the mass of glucose this athlete would use while running for 4.0 hours.

(ii) Describe how fats are used as an energy source during exercise. **4**

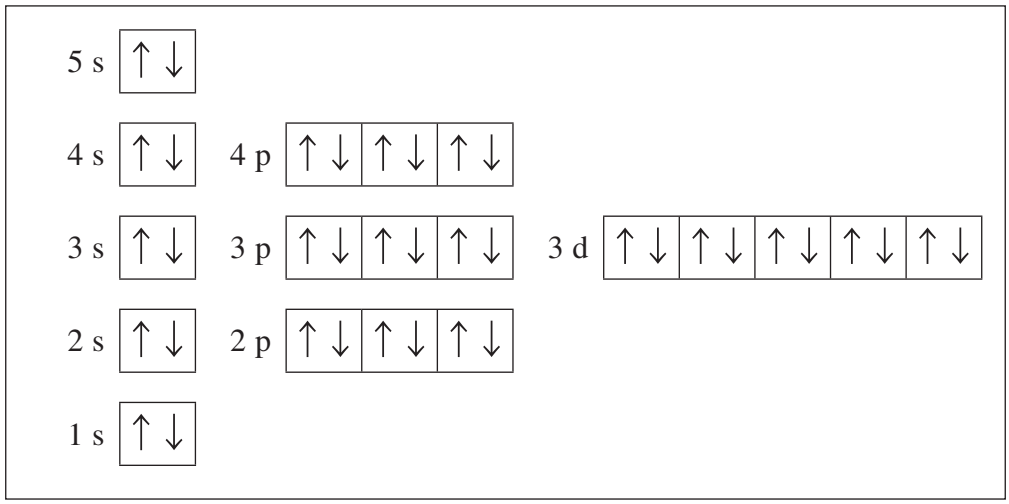
(d) Explain why the type of muscle cell required for sprinting is different to the type required for gentle exercise. In your answer, refer to the appearance and metabolism of muscle cells. **6**

End of Question 33

Question 34 — The Chemistry of Art (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) The electronic configuration of an element is shown.



(i) Identify the name and valency of this element. **2**

(ii) Explain why ions of this element produce a characteristic flame colour when heated strongly. **3**

(b) (i) A first-hand investigation to observe the colour changes of a transition element as it changes its oxidation state is to be performed. **3**

Name a chemical used in this investigation and explain how ONE safety issue associated with this chemical can be addressed.

(ii) Using iron as an example, explain why transition metals may have more than one oxidation state. **4**

Question 34 continues on page 37

Question 34 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) (i) Using examples of their use, explain why pigments need to be insoluble. **3**

(ii) Explain how infra-red spectroscopy is used in the analysis and identification of chemicals in pigments. **4**

(d) Explain how the formation of complex ions of transition metals can produce a wide range of coloured compounds. In your answer, make reference to a specific example. **6**

End of Question 34

Question 35 — Forensic Chemistry (25 marks)

Answer parts (a) and (b) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) The photo shows a shoe print in soil obtained at a crime scene. **2**



Describe how chemical analysis of material on the shoe that made this print could be used to link a suspect to the crime scene.

(ii) Describe ways of collecting samples from a crime scene that improve the accuracy of evidence presented in court. **3**

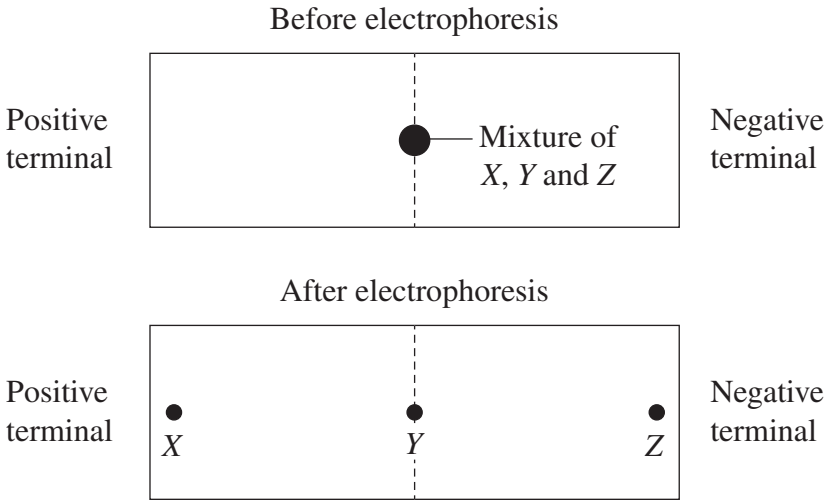
Question 35 continues on page 39

Question 35 (continued)

(b) (i) A first-hand investigation to separate a mixture using electrophoresis is to be performed in a school laboratory. **3**

Describe a procedure that is suitable for use in this investigation. In your answer, address a safety issue.

(ii) Electrophoresis was performed on a mixture of three amino acids, *X*, *Y* and *Z,* at a pH of 6.0. **4**



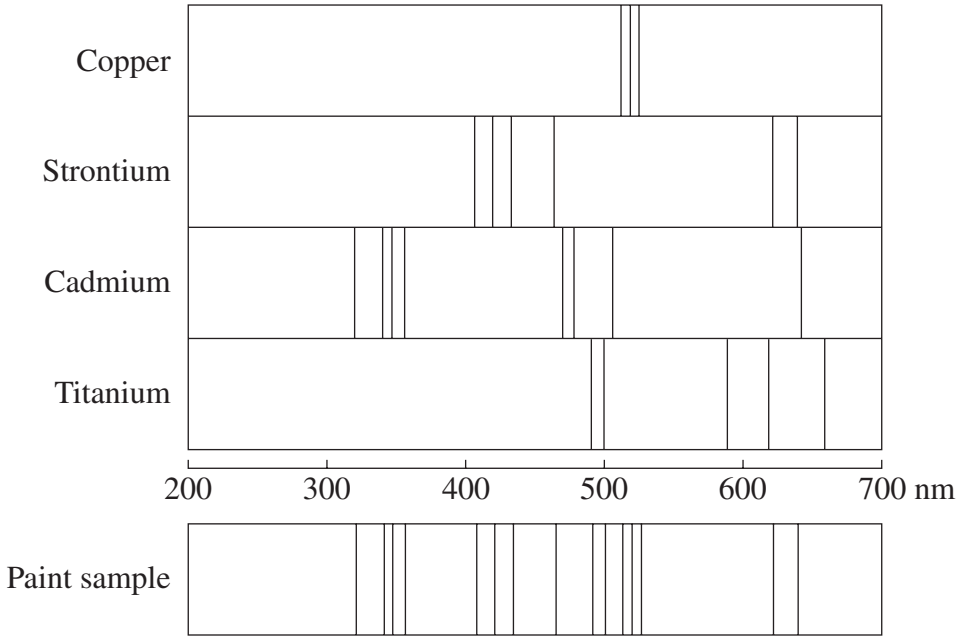
Explain how electrophoresis has separated the amino acids *X*, *Y* and *Z*.

Question 35 continues on page 40

Question 35 (continued)

Answer parts (c) and (d) of the question on pages 5–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(c) The diagrams below show schematic representations of atomic emission spectra from a range of metals and an unknown mixture from a paint sample.



(i) Identify TWO of the metal ions present in the paint sample and justify your answer. **3**

(ii) Describe how atomic emission spectra are produced and used in forensic analysis. **4**

(d) Explain how technology allows forensic scientists to use the features of DNA to improve the accuracy of evidence presented in criminal cases. **6**

End of paper

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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	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 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 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Uut Ununtrium	114 Fl Flerovium	115 Uup Ununpentium	116 Lv Livermorium	117 Uus Ununseptium	118 Uuo Ununoctium

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (January 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.