BOARD OF STUDIES
NEW SOUTH WALES

2005

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, 15, 17, and 21

Total marks – 100

Section I Pages 2–24

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks

- Attempt Questions 1–15
- Allow about 30 minutes for this part

Part B – 60 marks

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

Section II Pages 25–36

25 marks

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

Section I
75 marks

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

Use the multiple-choice answer sheet.

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

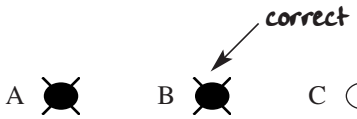
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

1 Which of the following conditions would produce a radioactive isotope?

(A) Too many atoms in the sample provided

(B) Too many protons and neutrons in the atom

(C) Too many electrons in the outer shell of the atom

(D) Too many electrons for the number of neutrons in the atom

2 Which of the following makes cellulose a potential raw material for the petrochemical industry?

(A) It is available in many parts of the world.

(B) It is light in weight and easy to transport.

(C) It is an organic polymer based on carbon.

(D) It is a polymer that undergoes combustion.

3 The heat of combustion of butan-1-ol is 2676 kJ mol^{-1}.

What is the value of the heat of combustion in kJ g^{-1}?

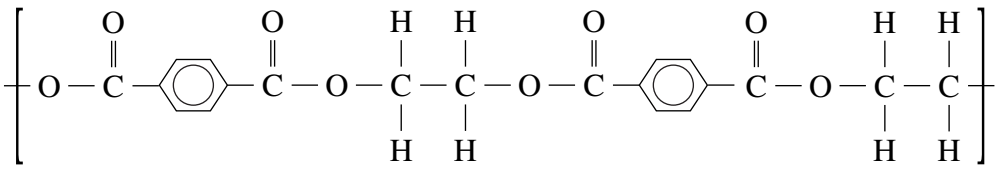
(A) 30.41

(B) 36.10

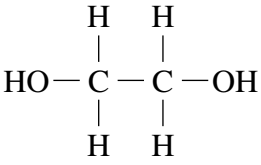
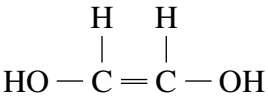
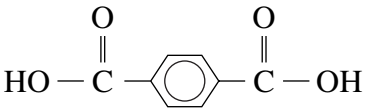
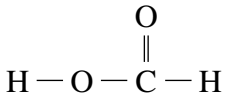
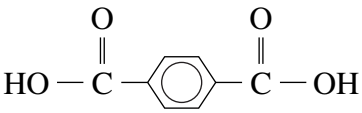
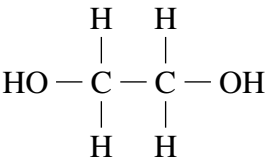
(C) 44.60

(D) 47.79

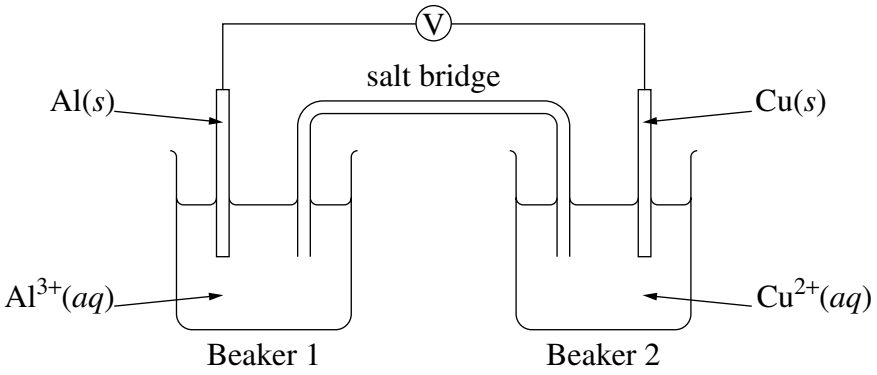
4 Terylene (polyester) is a condensation polymer. Part of the structure of the polymer is shown.



What are the two monomers that form this polymer?

	Monomer 1	*Monomer 2*
(A)		
(B)		
(C)		
(D)		

5 An electrochemical cell is set up as shown in the diagram.



What are two observations for this electrochemical cell?

	Observation 1	*Observation 2*
(A)	A reading was shown on the voltmeter	In Beaker 2 the solution became a darker blue
(B)	In Beaker 2 the blue solution faded	A reddish precipitate formed on the copper electrode
(C)	A grey precipitate formed on the aluminium electrode	In Beaker 2 the solution became a darker blue
(D)	Electrons moved through the voltmeter	A reddish precipitate formed on the copper electrode

6 Which of the following is a common use for ethyl pentanoate?

(A) Flavouring

(B) Fuel

(C) Indicator

(D) Solvent

7 A series of observations was made about a first-hand investigation.

- A cup of carbonated soft drink was poured from a newly-opened, chilled bottle.
- A lot of bubbles were observed in the cup.
- The cup was then left on the kitchen bench for several hours.
- After this time, it was observed that there were no bubbles visible in the cup.

Why were there no bubbles visible in the cup after several hours?

(A) The bubbles of carbon dioxide had dissolved into the soft drink.

(B) The carbon dioxide had been neutralised by the water in the soft drink.

(C) Carbon dioxide is less soluble at higher temperatures and lower pressures.

(D) Carbon dioxide is more soluble at higher temperatures and lower pressures.

8 What would be the pH of a 0.1 mol L^{-1} solution of sulfuric acid?

(A) Less than 1.0

(B) Exactly 1.0

(C) Between 1.0 and 7.0

(D) Greater than 7.0

9 Which of the following pairs would form a buffer solution?

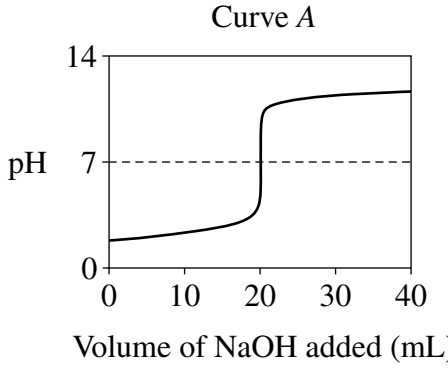
(A) $HCl(aq)$ / $Cl^{-}(aq)$

(B) $H_2PO_4^{-}(aq)$ / $PO_4^{3-}(aq)$

(C) $H_2SO_4(aq)$ / $HSO_4^{-}(aq)$

(D) $CH_3COOH(aq)$ / $CH_3COO^{-}(aq)$

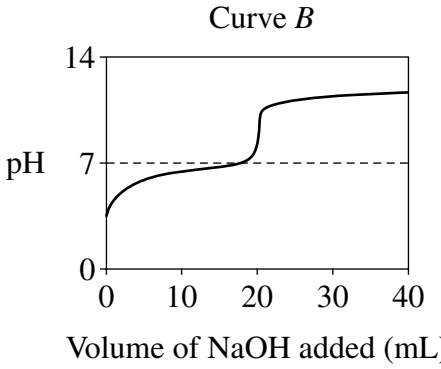
10 A titration was conducted by adding NaOH from a teflon-coated burette to HCl in a conical flask. The pH in the flask was recorded during the titration and Curve *A* was produced.



The table shows appropriate indicators used to identify the equivalence point in titrations. For NaOH and HCl the appropriate indicator is bromothymol blue.

Indicator	*Acidic colour*	*Range of colour change*	*Basic colour*
Methyl orange	red	3.1 – 4.4	yellow
Methyl red	red	4.4 – 6.2	yellow
Bromothymol blue	yellow	6.0 – 7.6	blue
Cresolphthalein	colourless	8.1 – 9.7	red
Alizarin yellow	yellow	10.1 – 12.0	red

A second titration was conducted by adding NaOH to a different acid. The pH in the flask was recorded during the titration and Curve *B* was produced.



What is the appropriate indicator for Curve *B* using the table?

(A) Methyl orange

(B) Methyl red

(C) Cresolphthalein

(D) Alizarin yellow

11 Which of the following substances is best analysed by atomic absorption spectroscopy (AAS)?

(A) Calcium

(B) Iodine

(C) Nitrogen

(D) Silicon

12 A student performed a sampling technique as part of a first-hand investigation on water quality and repeated the sampling technique several times.

What aspect of the experiment was improved by repeating the procedure?

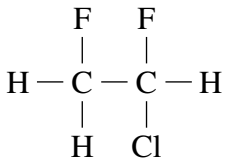
(A) Accuracy

(B) Reliability

(C) Safety

(D) Validity

13 What is the name of the following compound?



(A) 1,2-difluoro-1-chloroethane

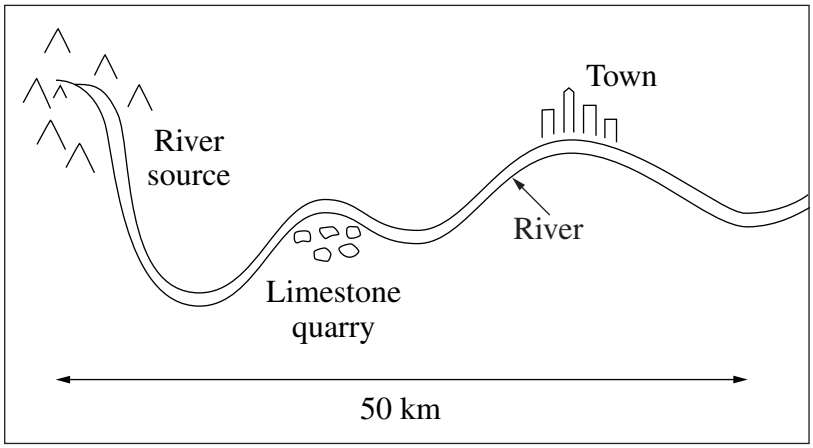
(B) 1,2-difluoro-2-chloroethane

(C) 1-chloro-1,2-difluoroethane

(D) 2-chloro-1,2-difluoroethane

14 Water quality analyses were performed at different sites on a river shown on the map.

Map



The table shows the results of the tests performed at the different sites.

	Results of tests performed		
Site	*Dissolved oxygen* (ppm)	*Biochemical oxygen demand* (ppm)	*pH*
1	3	145	5.2
2	10	2	6.9
3	7	12	7.4

Where was each set of tests performed?

	River source	*Limestone quarry*	*Town*
(A)	Site 2	Site 1	Site 3
(B)	Site 1	Site 2	Site 3
(C)	Site 1	Site 3	Site 2
(D)	Site 2	Site 3	Site 1

15 The Winkler method is used to determine the amount of dissolved oxygen in a sample. In this procedure, oxygen reacts with Mn^{2+} under alkaline conditions to produce a precipitate of $MnO(OH)_2$.

$$2Mn^{2+}(aq) + O_2(aq) + 4OH^-(aq) \rightarrow 2MnO(OH)_2(s)$$

The precipitate is then dissolved in acid and reacted with iodide, forming iodine and Mn^{2+}.

$$MnO(OH)_2(s) + 2I^-(aq) + 4H^+(aq) \rightarrow I_2(aq) + Mn^{2+}(aq) + 3H_2O(aq)$$

Finally, the amount of iodine produced is determined by reaction with thiosulfate.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

When a sample of water was analysed using the Winkler method, a total of 0.60 mol of thiosulfate was used in the reaction.

How many moles of oxygen were present in the original sample?

(A) 0.15

(B) 0.30

(C) 0.60

(D) 1.20

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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)

During your practical work you performed a first-hand investigation to distinguish between an alkene and the corresponding alkane.

(a) Name the alkene used in your investigation. **1**

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(b) Identify a potential hazard in your investigation, and outline how you addressed this hazard. **2**

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(c) Outline the procedure you used for your first-hand investigation. **2**

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Marks

Question 17 (3 marks)

The heat of combustion of ethanol is 1367 kJ mol^{-1}. In a first-hand investigation to determine the heat of combustion of ethanol, the experimental value determined differed from the theoretical value.

(a) Identify a reason for this difference. **1**

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(b) Calculate the theoretical mass of ethanol required to heat 200 mL of water from 21.0°C to 45.0°C. **2**

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Question 18 (4 marks)

Assess the impact of the recent development of a named biopolymer on society and the environment. **4**

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Centre Number

Section I – Part B (continued)

Student Number

Marks

Question 19 (4 marks)

You have studied one of the cells shown below.

Cell *X*

Cell *Y*

Choose ONE of the cells and answer parts (a) and (b).

(a) State ONE environmental impact associated with the cell you have chosen. **1**

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(b) Describe the chemistry of the cell you have chosen. **3**

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Marks

Question 20 (7 marks)

The flow chart shows a series of steps involved in the production of ethyl butanoate. **7**

glucose → mixture containing ethanol → pure ethanol → ethyl butanoate

Describe the chemistry and procedure involved in each of these steps, using diagrams where appropriate.

Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 21 (5 marks)

Analyse how knowledge of the composition and properties of acids has led to changes in the definition of acids. **5**

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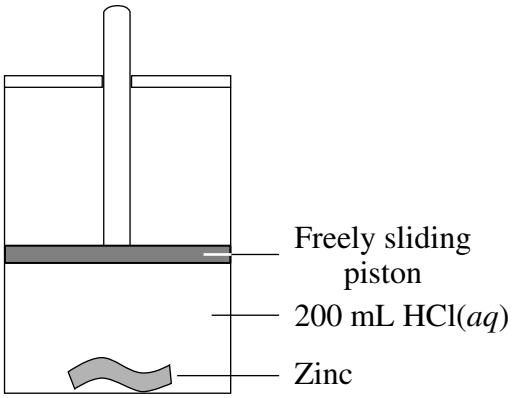
Marks

Question 22 (7 marks)

A student carried out a first-hand investigation to identify the relationship between the mass of a metal used in a reaction, and the volume of gas produced. The first-hand investigation was carried out at 25°C, and 100 kPa. In each experiment, 200 mL of hydrochloric acid was added to some zinc, and the volume of gas produced was recorded. The diagram shows the equipment used, and the table contains the student's results.

Mass of zinc (g)	*Volume of gas collected at 25°C and 100 kPa* (mL)
0.12	45
0.33	125
0.56	115
0.83	315
0.96	365
1.22	380
1.64	380
1.93	380



(a) Graph the results from these experiments. **3**

Question 22 continues on page 19

Marks

Question 22 (continued)

(b) Predict the volume of gas that would be produced in this experiment if 3.00 g of zinc had been used. Justify your answer. **2**

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(c) Calculate the theoretical volume of gas produced at 25°C and 100 kPa by the reaction of 0.56 g of zinc with the 200 mL of hydrochloric acid. **2**

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Question 23 (2 marks)

(a) What causes incomplete combustion? **1**

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(b) Write a balanced equation for the incomplete combustion of methane. **1**

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Marks

Question 24 (5 marks)

An antacid tablet is known to contain calcium carbonate ($CaCO_3$). To determine the mass of calcium carbonate in the tablet, the following procedure was used.

- The tablet was crushed and then placed in a beaker.
- A pipette was used to add 25.0 mL of 0.600 mol L^{-1} hydrochloric acid to the crushed tablet in the beaker.
- Once the reaction between the calcium carbonate and hydrochloric acid had stopped, phenolphthalein indicator was added to the reaction mixture.
- A teflon-coated burette was then used to add 0.100 mol L^{-1} sodium hydroxide to the beaker to neutralise the excess hydrochloric acid.
- The phenolphthalein changed from colourless to pink after 14.2 mL of the sodium hydroxide solution had been added.

(a) Write a balanced chemical equation for the reaction that occurred between the calcium carbonate in the tablet and the hydrochloric acid. **1**

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(b) How many moles of hydrochloric acid were added to the tablet? **1**

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(c) Calculate the mass of calcium carbonate in the original antacid tablet. **3**

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 25 (6 marks)

A student collected a 500 mL sample of water from a local creek for analysis. It was filtered and the filtrate evaporated to dryness. The following data were collected.

Mass of filter paper	0.16 g
Mass of filter paper and solid	0.19 g
Mass of evaporating basin	45.33 g
Mass of basin and solid remaining	45.59 g

(a) Calculate the percentage of total dissolved solids in the creek sample. **2**

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(b) It is suspected that lead has contaminated the creek. Describe a chemical test that could be carried out on the water sample to determine the presence of lead. **2**

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(c) The concentrations of ions in substances used by society need to be monitored. Justify this statement with reference to ONE ion you have studied. **2**

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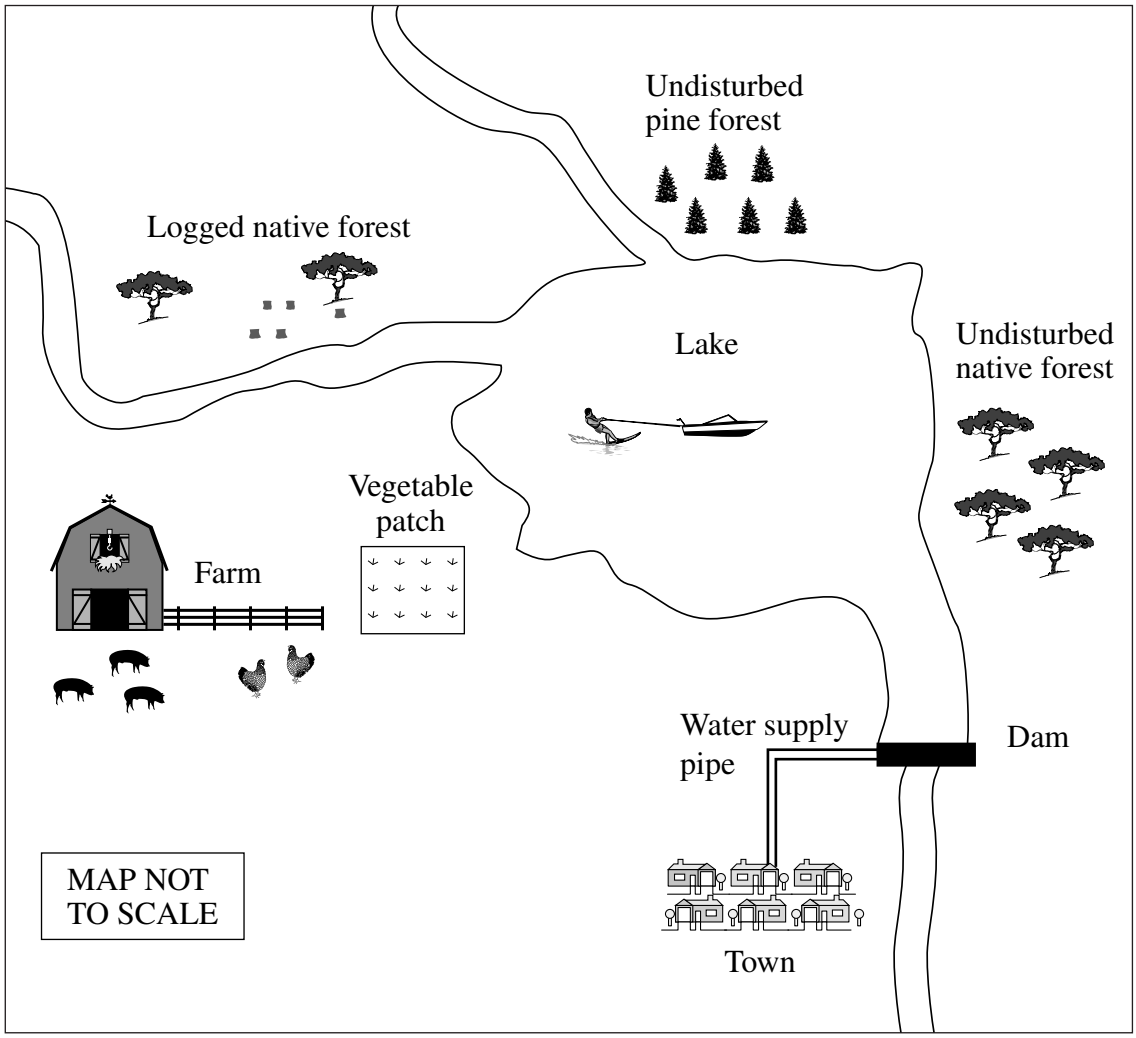
Question 26 (7 marks)

The map shows the catchment for a town water supply.



Question 26 continues on page 23

Marks

Question 26 (continued)

Describe TWO possible sources of contamination in this catchment, and assess methods that could be used for purifying the water before it reaches the town. **7**

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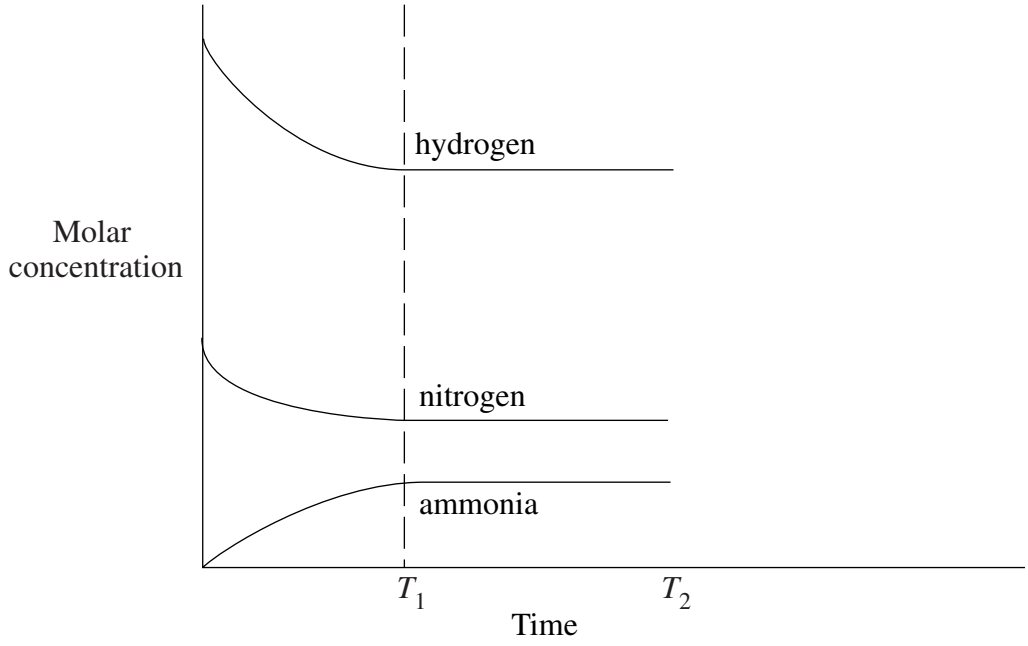
End of Question 26

Marks

Question 27 (5 marks)

The graph shows the variation in concentrations of reactants and product with time for the Haber process.



(a) State why the concentrations of reactants and product do not change between T_1 and T_2. **1**

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(b) At time T_2 the volume of the reaction vessel was reduced.

(i) Sketch on the graph how the concentrations of reactants and product would change after the volume was reduced. **2**

(ii) Explain the changes shown on your graph. **2**

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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.

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) Sulfuric acid is an important industrial chemical. One of the intermediate products in the synthesis of sulfuric acid is $H_2S_2O_7$.

(i) What is the name of $H_2S_2O_7$? **1**

(ii) With reference to the properties of sulfuric acid, describe safety precautions necessary for its transport. **3**

(b) Nitrogen dioxide forms an equilibrium mixture with dinitrogen tetraoxide as shown.

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

At 100°C, K for this reaction is 2.08.

At 25°C, a 1.00 L vessel initially contained 0.132 mol of $NO_2(g)$. Once equilibrium had been established, there was 0.0400 mol of $N_2O_4(g)$ in the vessel.

(i) Explain the effects of the addition of a catalyst and an increase in pressure on the yield of N_2O_4 in this reaction when carried out at 25°C. **2**

(ii) Calculate the equilibrium constant for this reaction at 25°C, and account for any difference from the K value at 100°C. **4**

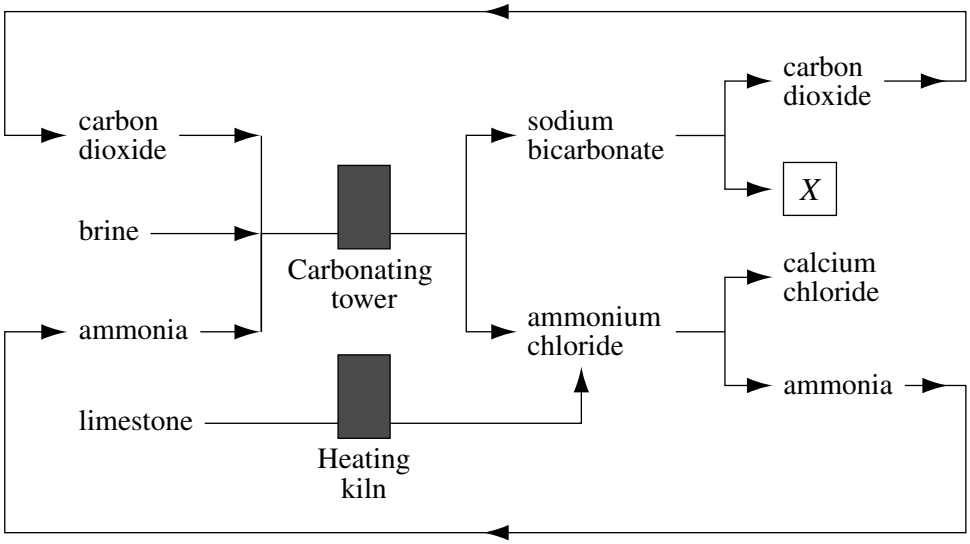
(c) Advances in chemistry have impacted on the development of technologies. **7**

Discuss this statement by analysing changes that have occurred in industrial methods for the production of sodium hydroxide.

Question 28 continues on page 27

Question 28 (continued)

(d) The diagram summarises the Solvay process.



(i) Identify compound *X*. **1**

(ii) During the Solvay process, ammonia is recovered. **2**

Outline the chemistry involved in the recovery of ammonia, and suggest a reason why this recovery is desirable.

(iii) Identify possible environmental issues that may arise from the Solvay process, and evaluate methods of dealing with those environmental issues. **5**

End of Question 28

Marks

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

(a) (i) Reactive metals such as aluminium and zinc form a strongly adhering oxide coating as a result of the reaction with oxygen. **1**

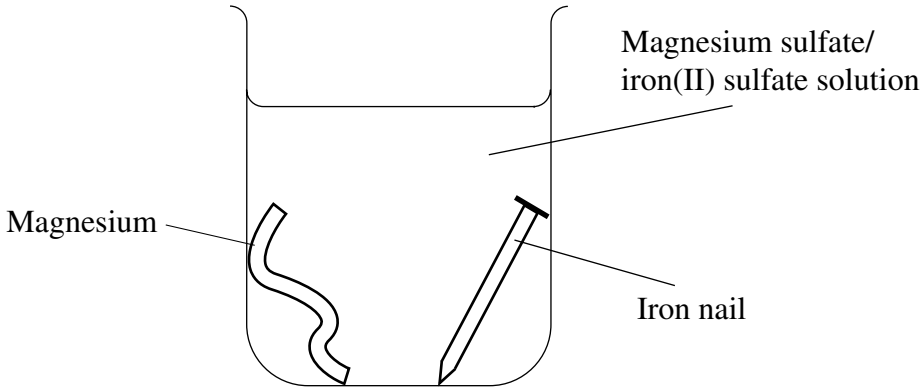
What name is given to these metals?

(ii) The hulls of modern ships contain steels that have lower levels of carbon and sulfur than was used in the past. **3**

Compare the properties and uses of TWO types of steel that you have studied.

(b) (i) Outline ONE factor that influences the rate of corrosion of iron in deep-water wrecks. **2**

(ii) A student set up a laboratory experiment in which a beaker contained a strip of magnesium, an iron nail, and a solution of iron(II) sulfate and magnesium sulfate. This was left for several days. **4**



Describe what would happen in this experiment. Include relevant chemical equations in your answer.

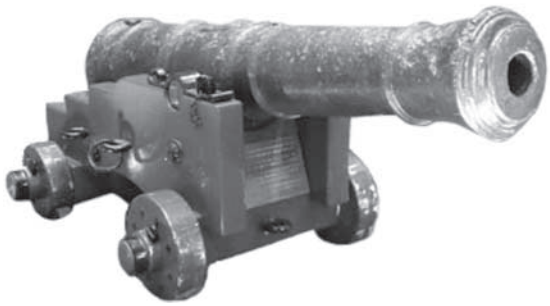
Question 29 continues on page 29

Question 29 (continued)

(c) Advances in chemistry have impacted on the development of technologies. **7**

Discuss this statement by analysing current methods of corrosion protection for ships.

(d) An iron cannon was recovered from a wreck on the Great Barrier Reef.



Reproduced with the permission of the Museum of New Zealand Te Papa Tonarewa

The process used to restore the cannon was as follows:

Step 1: The cannon was placed in dilute sodium hydroxide for several weeks. During this period, the solution was replaced by fresh dilute sodium hydroxide solution at regular intervals.

Step 2: Coral that had grown on the cannon was carefully chipped away.

Step 3: Electrolysis was performed on the cannon.

Step 4: The restored cannon was then coated in wax.

(i) Why was the restored cannon coated in wax? **1**

(ii) Explain the purpose of Step 1 in the restoration of the iron cannon. **2**

(iii) Describe and justify the procedure for Step 3. Include relevant chemical equations in your answer. **5**

End of Question 29

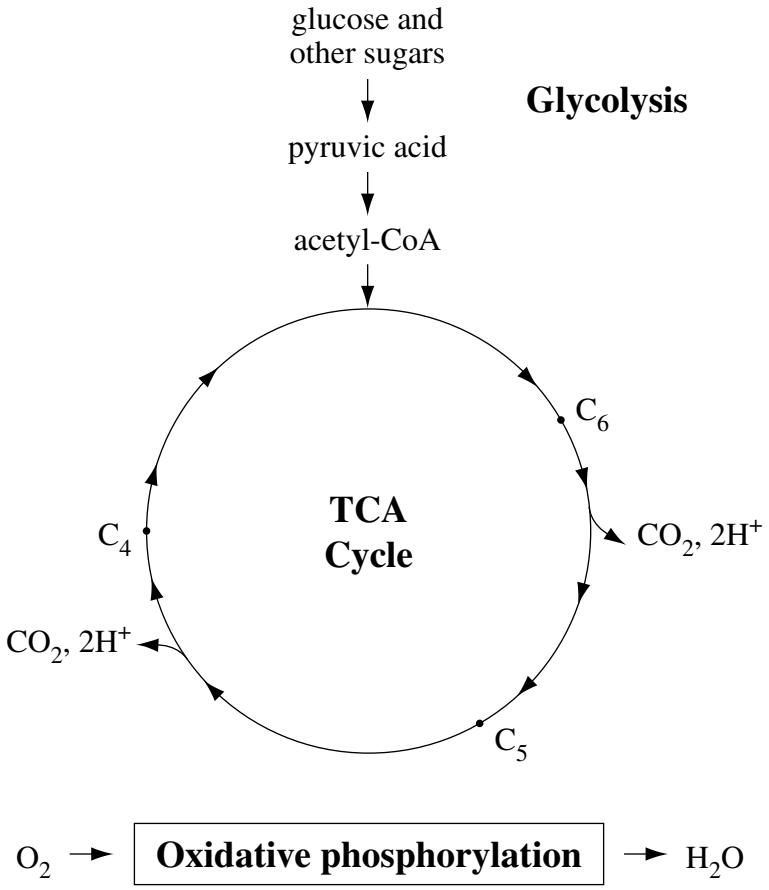
Marks

Question 30 — The Biochemistry of Movement (25 marks)

(a) (i) Draw the structure of glycerol. **1**

(ii) Explain the viscosity of glycerol and its solubility in water. **3**

(b) The diagram below summarises some of the steps involved in respiration.



(i) Compare the energy output from glycolysis with the total energy output from respiration. **2**

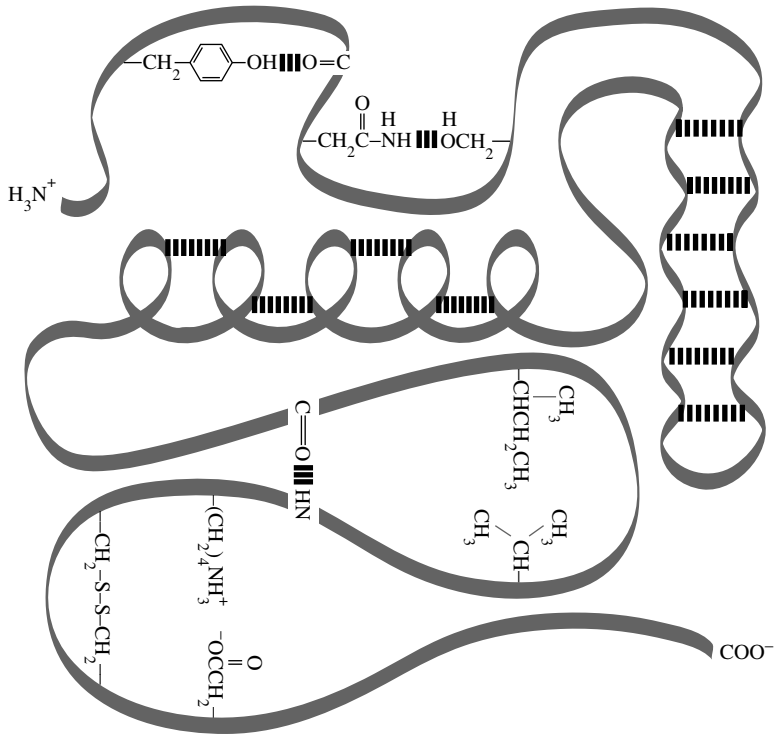
(ii) Explain the role of oxidation and reduction in respiration. **4**

Question 30 continues on page 31

Marks

Question 30 (continued)

(c) A diagram illustrating the structure of a protein is shown.



Describe how chemical features affect the structure and shape of proteins, and assess the importance of shape in the current model of enzyme function. **7**

Question 30 continues on page 32

Question 30 (continued)

(d) An athletics coach persuaded his runners to drink one of two sports drinks immediately before a race to boost performance. The composition of the two drinks is shown in the table. The coach believes that the sports drinks will give the runners extra energy during both a sprint race and a marathon.

Name of sports drink	*Carbohydrate content (%)*	*Carbohydrate composition*	*Sodium* (mg per 500 mL)
Athletaid	6	sucrose glucose fructose	225
Energade	8	fructose maltodextrin*	130

*Maltodextrin is a polymer composed of many glucose molecules bonded together.

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

(ii) Describe the chemical process involved when humans store carbohydrates for later use. **2**

(iii) Use data in the table to assess the hypothesis made by the coach. **5**

End of Question 30

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) A solution of iron(II) sulfate is mixed with a solution of potassium permanganate under acidic conditions, resulting in a colour change.

(i) What is the observed colour change? **1**

(ii) Account for the colour change in terms of oxidation states. Include relevant half-equations in your answer. **3**

(b) The table provides examples of the colours shown by transition metal complexes.

Metal ion	*Ligand*	*Colour of complex*
Cu^{2+}	H_2O	light blue
Cu^{2+}	NH_3	dark blue
Cr^{3+}	H_2O	green
Cr^{2+}	H_2O	violet

(i) Account for the differences in colours shown by these transition metal complexes. **2**

(ii) Assess the importance of minerals as pigments to TWO ancient cultures. **4**

(c) Describe the methodology and use of laser microspectral analysis, and assess the impact of advances in the understanding of emission spectra on the development of technologies. **7**

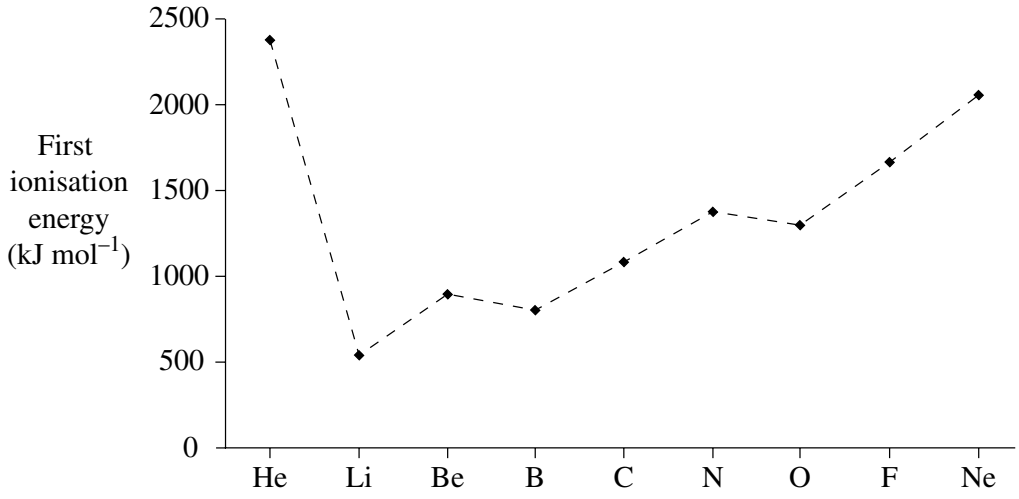
Question 31 continues on page 34

Question 31 (continued)

(d) (i) Define the Pauli exclusion principle. **1**

(ii) Distinguish between first ionisation energy and electronegativity. **2**

(iii) The graph shows the first ionisation energies for the elements helium to neon. **5**



Analyse the relationship between first ionisation energy and electron configuration, using data from the graph.

End of Question 31

Marks

Question 32 — Forensic Chemistry (25 marks)

(a) The diagram shows the emission spectra of three elements and an unknown mixture.

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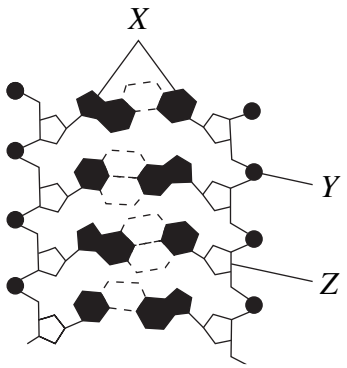
(i) Name TWO elements present in the unknown mixture. **1**

(ii) Describe how emission spectra assist in the identification of elements in a mixture. **3**

(b) The diagram illustrates the structure of DNA.



(i) Identify the components labelled *X, Y* and *Z*. **1**

(ii) Explain how the analysis of DNA allows for identification of relationships between people. **2**

(iii) Discuss the ethics of maintaining data banks of DNA. **3**

Question 32 continues on page 36

Question 32 (continued)

(c) Describe the structure and composition of proteins, and assess the potential of electrophoresis as a method for their analysis. **7**

(d) (i) What type of carbohydrate is sucrose? **1**

(ii) Describe a chemical test that can be used to distinguish glucose from starch. **2**

(iii) A scientist wanted to develop a method of separation for a mixture of six carbohydrates using high performance liquid chromatography. The diagram shows the chromatograms obtained for the mixture using two different solvents as the mobile phase. **5**

Describe high performance liquid chromatography, and assess the effectiveness of the different solvents used by the scientist for separating the mixture of carbohydrates.

End of paper

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

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.