

Student Number	
Mark / 68	

Chemistry

Preliminary Course
Final Examination • 2002

General Instructions

- Reading time – 5 minutes
- Working time – 2 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 Student Number at the top of this page

Total Marks – 68

Part A – 11 marks

- Attempt Questions 1 – 11
- Allow about 20 minutes for this part

Part B – 57 marks

- Attempt Questions 12 – 23
- Allow about 100 minutes for this part

Part A – 11 marks
Attempt Questions 1–11
Allow about 20 minutes for this part

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.

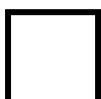
A B C D

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
 correct
 ↙

Answer Box for Questions 1–11

1	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
2	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
3	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
4	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
5	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
6	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
7	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
8	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
9	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
10	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>
11	A <input type="radio"/>	B <input type="radio"/>	C <input type="radio"/>	D <input type="radio"/>



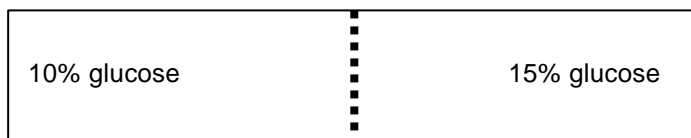
Mark your answers for Questions 1 – 11 in the Answer Box on page 1.

- 1 What is the change in mass of 1.00 gram samples of Li and Ca metals when they react with an excess of oxygen (O_2)?

CHANGE IN MASS (g)	
Li	Ca
(A) 1.000	1.000
(B) 2.153	1.399
(C) 1.153	0.399
(D) 0.576	0.799

- 2 Which of the following statements relates to a detrimental effect of thermal pollution in waterways?
- (A) Fish populations will increase to disproportionate levels in higher water temperature.
(B) Increased water temperature will lead to less dissolved oxygen causing stress to aquatic organisms.
(C) Metabolic rates in fish are decreased.
(D) Higher water temperature results in the increased precipitation of heavy metals.
- 3 Which of the following ranks of coal has the highest carbon content?
- (A) anthracite
(B) bituminous coal
(C) brown coal
(D) lignite
- 4 What is the mass of 2 moles of oxygen atoms?
- (A) 8.0 grams
(B) 16 grams
(C) 32 grams
(D) 64 grams

- 5 The diagram shows a two section compartment filled with aqueous glucose solutions separated by a semi-permeable membrane.



Which statement describes what will happen with time?

- (A) Glucose molecules will move into the right side by diffusion.
 (B) Water molecules will move into the left side by diffusion.
 (C) Glucose molecules will move into the left side by osmosis.
 (D) Water molecules will move into the right side by osmosis.

- 6 Water, hydrogen sulfide and ammonia are compounds of O, S and N with hydrogen. Which of the following are correct Lewis electron dot structures, where X = N, O or S?

	WATER	HYDROGEN SULFIDE	AMMONIA
(A)	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$
(B)	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \end{array}$	$\begin{array}{c} \text{H} \\ \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$	$\begin{array}{c} \text{H} : \text{X} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$
(C)	$\text{H} : \text{X} : \text{H}$	$\text{H} : \text{X} : \text{H}$	$\begin{array}{c} \text{H} : \text{X} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$
(D)	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \end{array}$	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{X} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$

7 What is the whole number mass ratio of metal to non-metal (metal:non-metal) in barium chloride?

- (A) 1:2
- (B) 2:1
- (C) 1:1
- (D) 4:1

8 Which of the following binary compounds would have the greatest solubility in water?

- (A) CH₄
- (B) CO₂
- (C) HCl
- (D) HF

9 Which of the following equations shows the precipitation of copper(I) chloride?

- (A) $\text{Cu}_{(s)} + \frac{1}{2} \text{Cl}_{2(g)} \rightarrow \text{CuCl}_{(s)}$
- (B) $\text{Cu}_{(s)} + \text{Cl}^{-}_{(aq)} \rightarrow \text{CuCl}_{(s)}$
- (C) $\text{Cu}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)} \rightarrow \text{CuCl}_{(s)}$
- (D) $\text{Cu}^{+}_{(aq)} + \frac{1}{2} \text{Cl}_{2(g)} \rightarrow \text{CuCl}_{(s)}$

10 0.10 mole of aluminium chromate, Al₂(CrO₄)₃, is dissolved in sufficient water to make 500 mL of solution. What are the concentrations of the resultant ions formed?

CONCENTRATION (mol L ⁻¹)	
Al ³⁺	CrO ₄ ²⁻
(A) 0.050	0.033
(B) 0.10	0.10
(C) 0.20	0.20
(D) 0.40	0.60

11 Which of the following is the second hydrocarbon compound in the alkyne homologous series?

- (A) butyne
- (B) ethyne
- (C) hexyne
- (D) propyne

Part B – 57 marks
Attempt Questions 12 – 23
Allow about 100 minutes for this part

Show all relevant working in questions involving calculations.

Question 12 (4 marks)

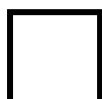
The table lists the boiling points for the first eight members of the homologous series of alkanes.

FORMULA	BOILING POINT (K)
CH ₄	112
C ₂ H ₆	184
C ₃ H ₈	231
C ₄ H ₁₀	273
C ₅ H ₁₂	309
C ₆ H ₁₄	342
C ₇ H ₁₆	371
C ₈ H ₁₈	399

(a) Define the term, homologous series. **(1 mark)**

(b) Explain the trend in boiling point for the alkanes. **(1 mark)**

(c) List two hazards of working with hydrocarbons and the precautions taken to avoid these dangers. **(2 marks)**



Question 13 (6 marks)

- (a) Compare one use of each carbon allotrope and relate this use to a physical property. **(4 marks)**

ALLOTROPE	USE	PHYSICAL PROPERTY
graphite		
diamond		

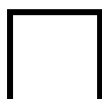
- (b) Carbon exists in several allotropes and several isotopes. Differentiate between the terms, allotrope and isotope. **(2 marks)**

Question 14 (3 marks)

A student experimentally determined the molar heat of solution of calcium chloride using a calorimeter.

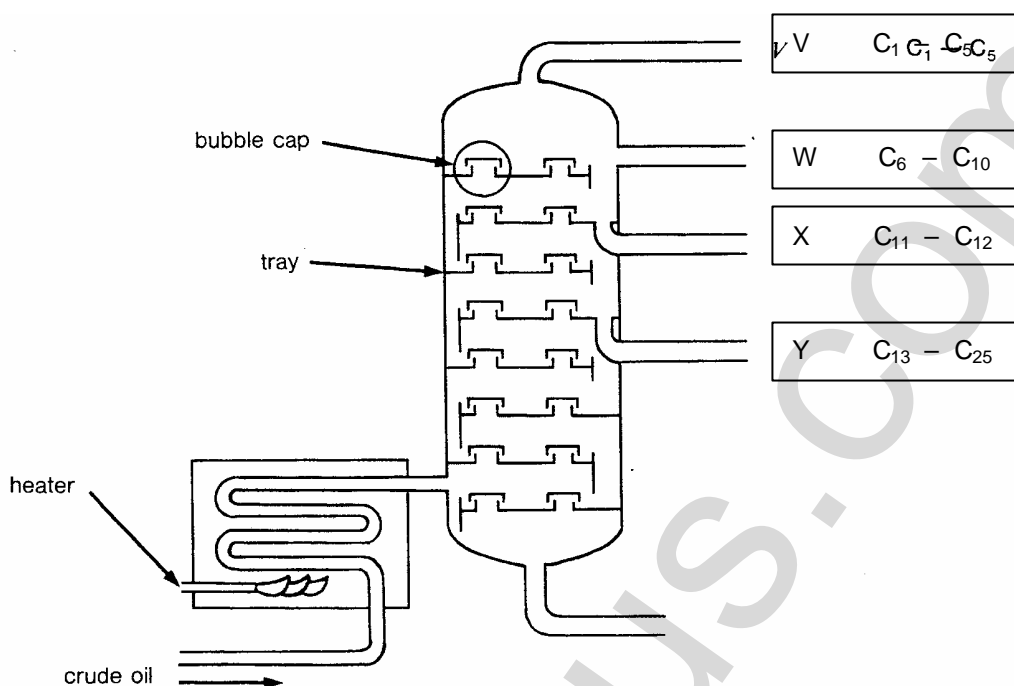
- (a) The student used the specific heat of water in the calculation of the result. Define the term, specific heat. **(1 mark)**

- (b) The student found that when 5.3 grams of calcium chloride dissolved in 250 g of water the temperature rose by 3.4 C° in the calorimeter. Calculate the molar heat of solution from this data. **(2 marks)**



Question 15 (7 marks)

The diagram shows a fractionating tower which is used in the processing of crude oil. Hydrocarbon fractions are removed from outlets on the right hand side of the tower. The approximate numbers of carbon atoms in molecules from each fraction are indicated.



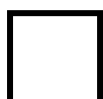
(a) From which fraction, (V, W, or X) is petrol made? **(1 mark)**

(b) Why is it incorrect to write a chemical formula for petrol? **(1 mark)**

(c) Identify one use for the fraction obtained at Y. **(1 mark)**

(d) Identify the physical property of hydrocarbons which allows them to be separated by the fractionating tower. **(1 mark)**

Question 15 continues on page 8



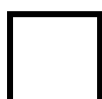
Question 15 (continued)

- (e) Describe the geological processes resulting in a crude oil accumulation and the method by which it is extracted from the earth. Use a diagram to illustrate your answer. **(3 marks)**

Question 16 (3 marks)

The table shows the boiling points of water, ammonia and hydrogen sulfide. Explain the differences in the relative boiling points of each of these substances.

water	ammonia	hydrogen sulfide
100° C	- 33° C	- 62° C



Question 17 (6 marks)

Explain the implications of the following properties of water for plants and animals.

- (a) The low density of ice. **(2 marks)**

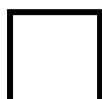
- (b) Adhesion and cohesion. **(2 marks)**

- (c) Surface tension. **(2 marks)**

Question 18 (3 marks)

- (a) What is the empirical formula of a compound of bismuth and chlorine, which is 66% (w/w) bismuth. **(2 marks)**

- (b) If a sample of this compound contained 2 g of bismuth, what would be the total mass of the sample? **(1 mark)**



Question 19 (4 marks)

A 10.0 g sample of impure zinc metal, heavily corroded with zinc hydroxide on its surface, was chemically analysed to determine the amount of zinc metal present. The sample was 'dissolved' in excess 1.00 mol L⁻¹ hydrochloric acid solution and 3.05 L of hydrogen gas was produced at 25°C and 101.3 kPa.

- (a) Write a balanced chemical equation for the reaction producing hydrogen gas. **(1 mark)**

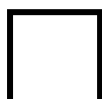
- (b) How many moles of zinc metal reacted to produce the hydrogen gas? **(1 mark)**

- (c) Calculate the mass percentage of zinc metal in the original sample. **(1 mark)**

- (d) Calculate the volume of acid which reacted with the whole sample. **(1 mark)**

Question 20 (2 marks)

Briefly describe an experiment to identify the effect of mass of added salt to a fixed mass of water on the boiling point of water.



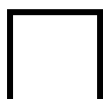
Question 21 (5 marks)

- (a) A chemist requires an accurately prepared solution of barium chloride.

Solution specifications	
volume	500.0 mL
concentration	0.250 mol L ⁻¹
solute	barium chloride-2-water
warning	toxic

Describe the steps involved in the preparation of this solution.
Include calculations and mention any specialised apparatus used. (4 marks)

- (b) Convert the molarity of the barium chloride solution into a percentage concentration (w/w).
Assume the solution's density is 1.00 g mL⁻¹. (1 mark)



Question 22 (7 marks)

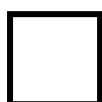
(a) Complete the table showing examples of bonding types and aqueous solubilities. (5 marks)

Bonding type	Common example	Aqueous solubility (in general)
metallic	zinc	insoluble
	cellulose	
covalent network		
	hydrogen chloride	
non-polar covalent		
	sodium sulfate	

(b) The dissolving of oxygen in water can be correctly represented as... $O_2(g) \rightleftharpoons O_2(aq)$

Identify two reasons why the dissolving of HCl in water cannot be represented as...





Question 23 (7 marks)

Use the solubility table to answer the questions which follow.

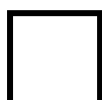
SOLUBILITY TABLE

ANION	+	CATION	→	COMPOUND
All		Group I metals		soluble
All		Ammonium, NH_4^+		soluble
Nitrate, NO_3^-		All		soluble
Acetate/ethanoate CH_3COO^-		All except Ag^+		soluble
Chloride, Cl^- Bromide, Br^- Iodide, I^-		Ag^+ , Pb^{2+} , Hg_2^{2+} , Cu^+		insoluble
		All others		soluble
Sulfate, SO_4^{2-}		Ca^{2+} , Sr^{2+} , Ba^{2+} , Pb^{2+} , Ag^+ , Hg_2^{2+}		insoluble
		All others		soluble
Sulfide, S^{2-}		Group I and II metals, NH_4^+		soluble
		All others		insoluble
Hydroxide, OH^-		Group I metals, NH_4^+ , Sr^{2+} , Ba^{2+}		soluble
		All others		insoluble
Carbonate, CO_3^{2-} Phosphate, PO_4^{3-} Sulfite, SO_3^{2-}		Group I metals, NH_4^+		soluble
		All others		insoluble

- (a) Complete the table indicating the solubility of the salts. Use **S for soluble** and **I for insoluble**.
(3 marks)

	CH_3COO^-	Cl^-	CO_3^{2-}	S^{2-}
Ag^+	I	I		
Ca^{2+}	S		I	
Hg_2^{2+}	S	I		

Question 23 continues on page 14



Question 23 (continued)

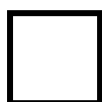
- (b) A solution of lead(II) nitrate is accidentally spilled into a pond. Identify a problem resulting from this spill. **(1 mark)**

- (c) The lead(II) nitrate can be chemically removed by precipitation. Identify a compound which will react with lead(II) nitrate and form a precipitate. **(1 mark)**

- (d) Write a balanced chemical equation for the precipitation reaction in (c). **(1 mark)**

- (e) Write the net ionic equation for the precipitation reaction in (c). **(1 mark)**

- End of Examination -



Chemistry

DATA SHEET

Avogadro's constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Volume of 1 mole ideal gas: at 101.3 kPa (1.00 atm) and	
at 273 K (0°C)	22.41 L
at 298 K (25°C)	24.47 L
Ionisation constant for water at 298 K (25°C), K_w	1.0×10^{-14}
Specific heat capacity of water	$4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

Some useful formulae

$$\text{pH} = -\log_{10} [\text{H}^+]$$

$$\Delta H = -m C \Delta T$$

Some standard potentials

$\text{K}^+ + \text{e}^-$	\rightleftharpoons	K(s)	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ba(s)	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ca(s)	-2.87 V
$\text{Na}^+ + \text{e}^-$	\rightleftharpoons	Na(s)	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	\rightleftharpoons	Mg(s)	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	\rightleftharpoons	Al(s)	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Mn(s)	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_2(\text{g}) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Zn(s)	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	\rightleftharpoons	Fe(s)	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ni(s)	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Sn(s)	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	\rightleftharpoons	Pb(s)	-0.13 V
$\text{H}^+ + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_2(\text{g})$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	$\text{SO}_2(\text{aq}) + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	\rightleftharpoons	Cu(s)	0.34 V
$\frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O} + 2\text{e}^-$	\rightleftharpoons	2OH^-	0.40 V
$\text{Cu}^+ + \text{e}^-$	\rightleftharpoons	Cu(s)	0.52 V
$\frac{1}{2}\text{I}_2(\text{s}) + \text{e}^-$	\rightleftharpoons	I^-	0.54 V
$\frac{1}{2}\text{I}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	I^-	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	\rightleftharpoons	Fe^{2+}	0.77 V
$\text{Ag}^+ + \text{e}^-$	\rightleftharpoons	Ag(s)	0.80 V
$\frac{1}{2}\text{Br}_2(\text{l}) + \text{e}^-$	\rightleftharpoons	Br^-	1.08 V
$\frac{1}{2}\text{Br}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	Br^-	1.10 V
$\frac{1}{2}\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	H_2O	1.23 V
$\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^-$	\rightleftharpoons	Cl^-	1.36 V
$\frac{1}{2}\text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	\rightleftharpoons	$\text{Cr}^{3+} + \frac{7}{2}\text{H}_2\text{O}$	1.36 V
$\frac{1}{2}\text{Cl}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	Cl^-	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	\rightleftharpoons	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2}\text{F}_2(\text{g}) + \text{e}^-$	\rightleftharpoons	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (4th 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	Atomic Weight	Name of element	Atomic Number	Symbol of element	Atomic Weight	Name of element
1 H 1.008 Hydrogen				79 Au 197.0 Gold			
2 He 4.003 Helium							
3 Li 6.941 Lithium				5 B 10.81 Boron			
4 Be 9.012 Beryllium				6 C 12.01 Carbon			
11 Na 22.99 Sodium				7 N 14.01 Nitrogen			
12 Mg 24.31 Magnesium				8 O 16.00 Oxygen			
19 K 39.10 Potassium				9 F 19.00 Fluorine			
20 Ca 40.08 Calcium				10 Ne 20.18 Neon			
21 Sc 44.96 Scandium				13 Al 26.98 Aluminum			
22 Ti 47.87 Titanium				14 Si 28.09 Silicon			
23 V 50.94 Vanadium				15 P 30.97 Phosphorus			
24 Cr 52.00 Chromium				16 S 32.07 Sulfur			
25 Mn 54.94 Manganese				17 Cl 35.45 Chlorine			
26 Fe 55.85 Iron				18 Ar 39.95 Argon			
27 Co 58.93 Cobalt				31 Ga 69.72 Gallium			
28 Ni 58.69 Nickel				32 Ge 72.61 Germanium			
29 Cu 63.55 Copper				33 As 74.92 Arsenic			
30 Zn 65.39 Zinc				34 Se 78.96 Selenium			
39 Y 88.91 Yttrium				49 In 114.8 Indium			
40 Zr 91.22 Zirconium				50 Sn 118.7 Tin			
41 Nb 92.91 Niobium				51 Sb 121.8 Antimony			
42 Mo 95.94 Molybdenum				52 Te 127.6 Tellurium			
43 Tc [98.91] Technetium				81 Tl 204.4 Thallium			
44 Ru 101.1 Ruthenium				82 Pb 207.2 Lead			
45 Rh 102.9 Rhodium				83 Bi 209.0 Bismuth			
46 Pd 106.4 Palladium				84 Po [210.0] Polonium			
47 Ag 107.9 Silver				85 At [210.0] Astatine			
48 Cd 112.4 Cadmium				86 Rn [222.0] Radon			
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 — Ununium							
111 Uuu — Unununium							
112 Uub — Ununium							
113 — — Ununium							
114 Uuq — Ununium							
115 — — Ununium							
116 Uuh — Ununium							
117 — — Ununium							
118 Uuo — Ununium							

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
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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
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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 ²³⁷Np and ⁹⁹Tc.