**Answers and Marking Scheme**

# Chemistry

**The Chemical Earth and Metals Modules Test • 2004**

**General Instructions**

- Reading time – 5 minutes
- Working time – 55 minutes
- 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 and may be removed for convenience
- Write your Student Number at the top of this page

**Total Marks – 48**

**Part A – 12 marks**
- Attempt Questions 1 – 12
- Allow about 10 minutes for this part

**Part B – 36 marks**
- Attempt Questions 13 – 28
- Allow about 45 minutes for this part

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**Part A – 12 marks**
**Attempt Questions 1–12**
**Allow about 10 minutes for this part**

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

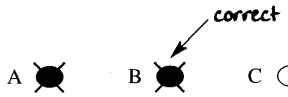
**Sample:** 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.




| Answer Box for Questions 1– 12 | | | | |
|---|---|---|---|---|
| 1 | A ○ | B ○ | C ◎ | D ○ |
| 2 | A ○ | B ◎ | C ○ | D ○ |
| 3 | A ◎ | B ○ | C ○ | D ○ |
| 4 | A ○ | B ○ | C ○ | D ◎ |
| 5 | A ◎ | B ○ | C ○ | D ○ |
| 6 | A ○ | B ○ | C ○ | D ◎ |
| 7 | A ○ | B ○ | C ◎ | D ○ |
| 8 | A ◎ | B ○ | C ○ | D ○ |
| 9 | A ○ | B ◎ | C ○ | D ○ |
| 10 | A ○ | B ◎ | C ○ | D ○ |
| 11 | A ○ | B ◎ | C ○ | D ○ |
| 12 | A ○ | B ○ | C ○ | D ◎ |

► ***Mark your answers for Questions 1 – 12 in the Answer Box on page 3.***

1 Which element is found uncombined in the biosphere?

(A) Carbon
(B) Hydrogen
(C) Oxygen
(D) Neon

2 Which of the following elements has the smallest first ionisation energy?

(A) Lithium
(B) Sodium
(C) Fluorine
(D) Chlorine

3 The properties of elements X, M, Z and T were investigated and the results tabled…

| Element | Malleability | Hardness | Electrical Conductivity (liquid state) |
|---|---|---|---|
| **X** | malleable | hard | high |
| **M** | brittle | soft | nil |
| **Z** | brittle | soft | high |
| **T** | brittle | hard | low |

Choose the correct classification of elements X, M, Z and T based on the data.

| | X | M | Z | T |
|---|---|---|---|---|
| (A) | metal | non–metal | carbon | semi–metal |
| (B) | non–metal | non–metal | carbon | metal |
| (C) | semi–metal | metal | carbon | semi–metal |
| (D) | metal | semi–metal | carbon | metal |

4 Which of these substances does not exist as a molecule?

(A) $C_6H_{12}O_6$
(B) $H_2$
(C) He
(D) NaCl

5 Which of these compounds has the highest melting point?

(A) LiH
(B) $SiH_4$
(C) $NH_3$
(D) HCl

6 Which of the following is an application of gravimetric analysis?

(A) Determining the melting point of a metal alloy.
(B) Determining the salinity of the Murray River by testing its electrical conductivity.
(C) Testing the flesh of tuna for the presence of mercury.
(D) Determining the mass percentage of iron in molasses.

7 Which statement is correct for element X located in period 4 and group 7?

(A) X is a solid that sublimes to a purple vapour.
(B) X covalently bonds with sodium to form NaX.
(C) X is a liquid at room temperature.
(D) X has a higher electronegativity than oxygen.

8 Which statement is correct for the recycling process for aluminium?

(A) The process involves a physical change.
(B) The process involves electrolysis.
(C) The process involves alloying.
(D) The process involves extraction.

9 Lithium and sodium have similar physical and chemical properties.
This is best explained by which of the following statements?

(A) They are both metals.
(B) They have the same outer shell electronic configuration.
(C) They have low relative atomic mass.
(D) They are in period 1 of the Periodic Table.

10 The melting points of four ionic salts are shown in the table…

| Ionic salt | Melting point (℃) |
|---|---|
| Sodium iodide | 660 |
| Silver nitrate | 209 |
| Rubidium bromide | 692 |
| Potassium sulfate | 1072 |

Which list gives the correct order of the strength of bonds between the indicated ions?

(A) $Ag^+ - NO_3^- > Rb^+ - Br^- > Na^+ - I^- > K^+ - SO_4^{2-}$
(B) $K^+ - SO_4^{2-} > Rb^+ - Br^- > Na^+ - I^- > Ag^+ - NO_3^-$
(C) $Ag^+ - NO_3^- > Na^+ - I^- > Rb^+ - Br^- > K^+ - SO_4^{2-}$
(D) $K^+ - SO_4^{2-} > Na^+ - I^- > Rb^+ - Br^- > Ag^+ - NO_3^-$

11 Which of these processes is used in the purification stage of producing pure, 99.96–99.99% copper?

(A) alloying
(B) electrolysis
(C) roasting
(D) smelting

12 The table shows the properties and uses of four metal alloys…

| Alloy | Properties | Uses |
|---|---|---|
| **W** | malleable | car bodies, pipes, nuts and bolts, roofing |
| **X** | hard and shock resistant | security safes, files, ball bearings |
| **Y** | resists corrosion, easily cast | ships' propellers, casting statues |
| **Z** | low melting point, adheres firmly to other metals when molten | joining metals together, applications in plumbing and electronics |

Which alloy best describes the properties and uses of solder?

(A) W
(B) X
(C) Y
(D) Z

**Part B – 36 marks**
**Attempt Questions 13 – 28**
**Allow about 45 minutes for this part**

► ***Show all relevant working in questions involving calculations.***

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**Question 13 (3 marks)**

(a) Complete the table showing the existence of compounds on the Earth… **(2 marks)**

| | Example of a compound found in the 'sphere |
|---|---|
| atmosphere | ***carbon dioxide*** |
| biosphere | ***glucose*** |
| hydrosphere | ***water*** |
| lithosphere | ***silicon dioxide*** |

(b) Explain why uncombined elements are rare. **(1 mark)**

***The vast majority of elements are chemically reactive. They chemically react with other elements to form stable compounds achieving noble gas configurations with lower energy.***

**Question 14 (2 marks)**

Name these compounds…

| | |
|---|---|
| $Fe_2S_3$ | ***iron(III) sulfide*** |
| $Fe(OH)_2$ | ***iron(II) hydroxide*** |
| $NO_2$ | ***nitrogen dioxide*** |
| $N_2O_4$ | ***dinitrogen tetroxide*** |

**Question 15 (2 marks)**

Chalcocite, a copper sulfide ore is converted into crude copper by a two–step process…

**STEP 1** – $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

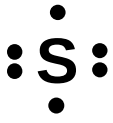
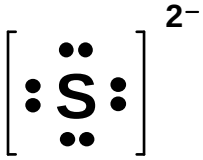
**STEP 2** – $2Cu_2O + C \rightarrow 4Cu + CO_2$

Balance each of the chemical equations. **(2 marks)**

**Question 16 (4 marks)**

Calcium reacts vigorously with sulfur producing calcium sulfide via an electron transfer reaction.

Complete the table detailing the process…

| | **Calcium atom** | **+** | **Sulfur atom** | **→** | **Calcium ion** | **+** | **Sulfide ion** |
|---|---|---|---|---|---|---|---|
| **Electronic configuration** | ***2–8–8–2*** | **+** | ***2–8–6*** | **→** | ***2–8–8*** | **+** | ***2–8–8*** |
| **Lewis electron dot structure** |  | **+** |  | **→** | $Ca^{2+}$ | **+** |  |

**Question 17 (2 marks)**

To separate the components of a mixture, differences in physical properties are used as the basis of the separation. Complete the table to illustrate this principle…

| Separation Process | Physical property which enables the separation to occur |
|---|---|
| distillation | ***boiling point*** |
| evaporation | ***boiling point*** |
| filtration | ***particle size*** ***solubility*** |
| sieving | ***particle size*** |

**Question 18 (2 marks)**

For a Prac test, a student is given the task of separating a sample of water collected at Bondi Beach into its three components (water, salt and sand) and determining the mass percentage of each.

A student records this data after filtration and evaporation…

| | |
|---|---|
| **Mass of original sample** | **226.73 g** |
| **Mass of filter paper** | **1.33 g** |
| **Mass of filter paper + dry sand** | **28.08 g** |
| **Mass of salt recovered after evaporation** | **9.66 g** |

Calculate the percentage mass of water in the original sample.

***Mass of sand = 28.08 g – 1.33 g = 26.75 g ( 1 mark )***

***Mass of water = 226.73 g (sample) – 26.75 g (sand) – 9.66 g (salt) = 190.32 g***

***Percentage water = 190.32 g ÷ 226.73 g = 83.94%***

**Question 19 (3 marks)**

Active metal, M, forms $M^{2+}$ when it reacts.
Write balanced formulae equations for the reactions of metal, M, with…

(i) oxygen
(ii) water
(iii) hydrochloric acid

(i) $2M_{(s)} + O_{2\,(g)} \rightarrow 2MO_{\,(s)}$

(ii) $M_{(s)} + 2H_2O_{\,(l)} \rightarrow M(OH)_{2\,(aq)} + H_{2\,(g)}$

(iii) $M_{(s)} + 2HCl_{\,(aq)} \rightarrow MCl_{2\,(aq)} + H_{2\,(g)}$

**Question 20 (2 marks)**

Explain why the formula for an ionic compound is an empirical formula.

***The empirical formula represents the simplest whole number ratio of atoms/ions of different elements in a compound. Ionic compounds are an infinite lattice/array of positive and negative ions and therefore the formula given to describe them is just the simplest ratio of ions in the array, i.e. the empirical formula.***

**Question 21 (2 marks)**

The reactions of metals with acids requires the transfer of electrons.

Write two half–equations to show the reaction between aluminium and sulfuric acid.

$Al_{\,(s)} \rightarrow Al^{3+} + 3e^-$

$2H^+ + 2e^- \rightarrow H_{2\,(g)}$

**Question 22 (1 mark)**

Identify **one** common element that exists as a covalent molecular structure and **one** common element that exists as a covalent network structure.

covalent molecule ***e.g. hydrogen or $H_2$***

covalent network ***e.g. carbon (diamond)***

**Question 23 (2 marks)**

Identify and explain the trend in the atomic radius from left to right across the Periodic Table.

***The atomic radii of elements decrease from left to right ( 1 mark ) across the Periodic Table, as the nuclear charge increases. The greater the nuclear charge, the more the electron shells are attracted to the nucleus and the radius decreases. ( 1 mark )***

**Question 24 (3 marks)**

The table shows the melting points of the chlorides of seven consecutive elements A – F in a period of the Periodic Table…

| **Element** | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| **Melting point of the element's chloride ( ℃ )** | 801 | 712 | 193 | – 68 | – 91 | – 80 |

(a) Identify an element (A – F) which could be a metal. ***A, B or C***

(b) Identify the type of bonding which exists in the chlorides of elements A and B. ***ionic***

(c) Compare the electrical conductivity of the chlorides, A – F in the liquid state.

***Chlorides A – C would be electrolytes.***
***Chlorides D – F would be non–electrolytes.***

**Question 25 (2 marks)**

Mendeleev's model of the Periodic Table in 1869 was a landmark in the history of Chemistry.

(a) Describe how Mendeleev used the properties of the known elements to develop his model for the Periodic Table. **(1 mark)**

***Mendeleev studied the patterns in the elemental data and organised chemically similar elements in columns (groups).***

***OR***

***Mendeleev realised that the properties of elements were a periodic function of their atomic weights.***

(b) Identify one chemical property of iodine which confirms that it is a halogen and should be placed in group 7. **(1 mark)**

***Iodine (atoms) react in a 1:1 ratio with group one elements to form ionic iodides.***

**Question 26 (2 marks)**

In the lab this semester, you decomposed copper(II) carbonate by strongly heating it.
Write a (a) word equation and (b) a balanced formulae equation for the decomposition reaction.
► *Assume the reactant is pure copper(II) carbonate.*

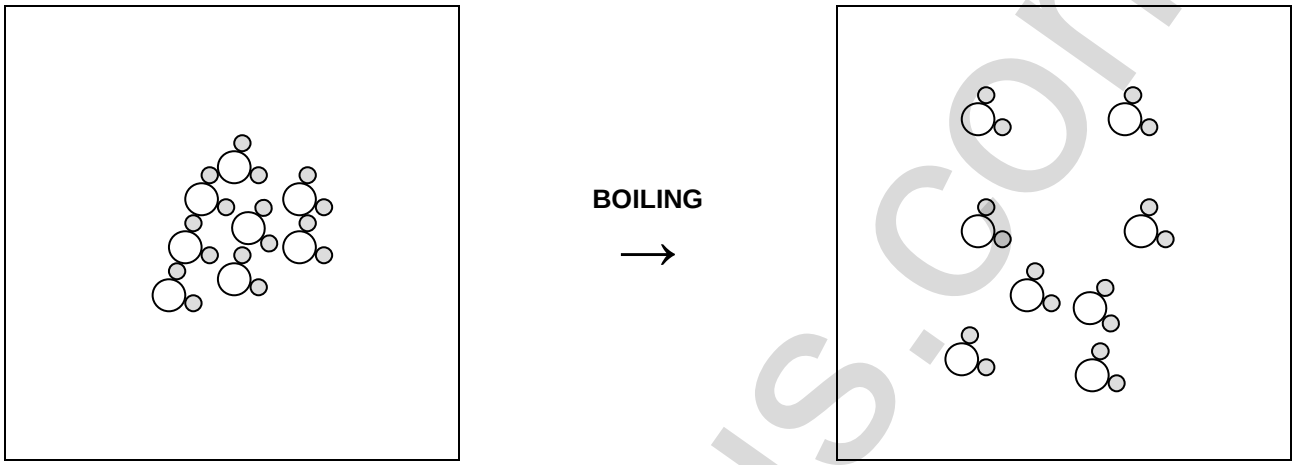
(a) ***copper(II) carbonate → copper(II) oxide + carbon dioxide***

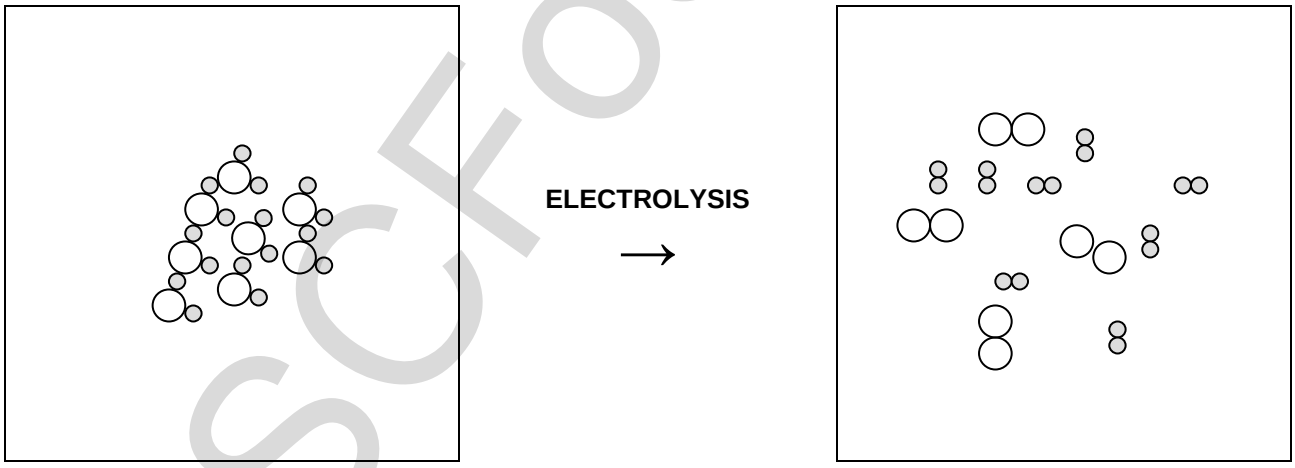
(b) $CuCO_{3\,(s)} \rightarrow CuO_{(s)} + CO_{2\,(g)}$

► ***Correct formulae including phase label required for 1 mark.***

**Question 27 (2 marks)**

The diagrams on the left show eight water molecules in the liquid state.
Complete the diagram boxes on the right, showing the arrangement of particles after all the water molecules have undergone the processes of boiling and electrolysis.




***1 mark each for boiling and electrolysis***
► ***Mass must be conserved in the transformation.***

**Question 28 (2 marks)**

(a) Identify one metal and one non–metal. **(1 mark)**

*metal* ***e.g. copper*** *non–metal* ***e.g. helium***

(b) Account for the use of ***either*** the metal ***or*** the non–metal you identified in terms of its ***physical properties***. **(1 mark)**

***Copper is used as electrical wire due to its good electrical conductivity and ductility.***

***OR***

***Helium is used as a filler for balloons because of its low density.***

## DATA SHEET

Avogadro constant, $N_A$ ..... $6.022 \times 10^{23}$ 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), $K_w$ ..... $1.0 \times 10^{-14}$

Specific heat capacity of water ..... $4.18 \times 10^3$ J kg$^{-1}$ K$^{-1}$

### Some useful formulae

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

### 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 $^{99}Tc$.