

Chemistry

Standard Grade and Intermediate 2

Data Booklet

1999 edition

Price: £0.20

Publication code: G0901

ISBN: 1 85969 259 1

Published by the Scottish Qualifications Authority

Hanover House, 24 Douglas Street, Glasgow G2 7NQ, and Ironmills Road, Dalkeith, Midlothian EH22 1LE

The information in this publication may be reproduced to support SQA qualifications. If it is reproduced for any other purpose then SQA should be clearly acknowledged as the source in the reproduction.

© Scottish Qualifications Authority 1999

Copies are available from the Sales Section at SQA, telephone 0141-242 2168

| Contents | <i>Page</i> |
|---|-------------|
| Electron Arrangements of Main Group Elements | 1 |
| Densities of Selected Elements | 2 |
| Melting and Boiling Points of Selected Elements | 3 |
| Names, Symbols and Relative Atomic Masses of Selected Elements | 4 |
| Flame Colours | 4 |
| Formulae of Selected Ions containing more than one kind of Atom | 4 |
| Solubilities of Selected Compounds in Water | 5 |
| Melting and Boiling Points of Selected Inorganic Compounds | 6 |
| Melting and Boiling Points of Selected Organic Compounds | 6 |
| Electrochemical Series (Reduction Reactions) | 7 |
| Periodic Table of the Elements showing Symbol and Date of Discovery | 8 |

ELECTRON ARRANGEMENTS OF MAIN GROUP ELEMENTS

Key

| |
|----------------------|
| Atomic number |
| Name of element |
| Symbol |
| Electron arrangement |

| Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Group 0 |
|--|--|---|---|--|---|---|--|
| 1 Hydrogen H 1 | | | | | | | 2 Helium He 2 |
| 3 Lithium Li 2, 1 | 4 Beryllium Be 2, 2 | 5 Boron B 2, 3 | 6 Carbon C 2, 4 | 7 Nitrogen N 2, 5 | 8 Oxygen O 2, 6 | 9 Fluorine F 2, 7 | 10 Neon Ne 2, 8 |
| 11 Sodium Na 2, 8, 1 | 12 Magnesium Mg 2, 8, 2 | 13 Aluminium Al 2, 8, 3 | 14 Silicon Si 2, 8, 4 | 15 Phosphorus P 2, 8, 5 | 16 Sulphur S 2, 8, 6 | 17 Chlorine Cl 2, 8, 7 | 18 Argon Ar 2, 8, 8 |
| 19 Potassium K 2, 8, 8, 1 | 20 Calcium Ca 2, 8, 8, 2 | 31 Gallium Ga 2, 8, 18, 3 | 32 Germanium Ge 2, 8, 18, 4 | 33 Arsenic As 2, 8, 18, 5 | 34 Selenium Se 2, 8, 18, 6 | 35 Bromine Br 2, 8, 18, 7 | 36 Krypton Kr 2, 8, 18, 8 |
| 37 Rubidium Rb 2, 8, 18, 8, 1 | 38 Strontium Sr 2, 8, 18, 8, 2 | 49 Indium In 2, 8, 18, 18, 3 | 50 Tin Sn 2, 8, 18, 18, 4 | 51 Antimony Sb 2, 8, 18, 18, 5 | 52 Tellurium Te 2, 8, 18, 18, 6 | 53 Iodine I 2, 8, 18, 18, 7 | 54 Xenon Xe 2, 8, 18, 18, 8 |
| 55 Caesium Cs 2, 8, 18, 18, 8, 1 | 56 Barium Ba 2, 8, 18, 18, 8, 2 | 81 Thallium Tl 2, 8, 18, 32, 18, 3 | 82 Lead Pb 2, 8, 18, 32, 18, 4 | 83 Bismuth Bi 2, 8, 18, 32, 18, 5 | 84 Polonium Po 2, 8, 18, 32, 18, 6 | 85 Astatine At 2, 8, 18, 32, 18, 7 | 86 Radon Rn 2, 8, 18, 32, 18, 8 |
| 87 Francium Fr 2, 8, 18, 32, 18, 8, 1 | 88 Radium Ra 2, 8, 18, 32, 18, 8, 2 | | | | | | |

←

The elements on this side of the dark line are metals.

→

The elements on this side of the dark line are non-metals.

DENSITIES OF SELECTED ELEMENTS

| Group 1 | Group 2 | | | | | | | | | | | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Group 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------------|------------------------|--|------------------|-------------------------|-----------------------|-------------------------|----------------------|----------------------|-------------------------|-------------------------|-----------------------|--------------------------|-----------------------|--------------------------|-----------------------|-------------------------|-----------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|--------------------|----------------------|----------------------|----------------------|--------------------|-----------------------|-------------------------|-----------------------|------------------------|-----------------------|-------------------------|------------------------|-------------------------|-----------------------|-------------------------|-----------------------|--------------------------|--------------------------|-------------------------|-----------------------|-------------------------|----------------------|-----------------------|----------------------|-------------------|------------------------|-------------------------|----------------------|-----------------------|-----------------------|----------------------|-------------------------|-----------------------|------------------------|------------------------|-----------------------|----------------------|-----------------------|------------------------|--------------------|-----------------------|------------------------|--------------------|-----------------------|-----------------------|
| | | Key Atomic number Name of element <u>Density</u> g/cm ³ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Hydrogen 0.00009 | 4 Beryllium 1.85 | 5 Boron 2.34 | 6 Carbon * | 7 Nitrogen 0.0013 | 8 Oxygen 0.0014 | 9 Fluorine 0.0017 | 10 Neon 0.0009 | 11 Sodium 0.97 | 12 Magnesium 1.74 | 13 Aluminium 2.70 | 14 Silicon 2.33 | 15 Phosphorus 1.82 | 16 Sulphur 2.07 | 17 Chlorine 0.0032 | 18 Argon 0.0018 | 19 Potassium 0.86 | 20 Calcium 1.54 | 21 Scandium 2.99 | 22 Titanium 4.50 | 23 Vanadium 5.96 | 24 Chromium 7.20 | 25 Manganese 7.20 | 26 Iron 7.86 | 27 Cobalt 8.90 | 28 Nickel 8.90 | 29 Copper 8.92 | 30 Zinc 7.14 | 31 Gallium 5.90 | 32 Germanium 5.35 | 33 Arsenic 5.73 | 34 Selenium 4.81 | 35 Bromine 3.12 | 36 Krypton 0.0037 | 37 Rubidium 1.53 | 38 Strontium 2.60 | 39 Yttrium 4.47 | 40 Zirconium 6.52 | 41 Niobium 8.57 | 42 Molybdenum 10.2 | 43 Technetium 11.5 | 44 Ruthenium 12.3 | 45 Rhodium 12.4 | 46 Palladium 12.0 | 47 Silver 10.5 | 48 Cadmium 8.64 | 49 Indium 7.31 | 50 Tin 7.28 | 51 Antimony 6.68 | 52 Tellurium 6.25 | 53 Iodine 4.93 | 54 Xenon 0.0059 | 55 Caesium 1.93 | 56 Barium 3.51 | 57 Lanthanum 6.15 | 72 Hafnium 13.3 | 73 Tantalum 16.6 | 74 Tungsten 19.4 | 75 Rhenium 20.5 | 76 Osmium 22.5 | 77 Iridium 22.4 | 78 Platinum 21.5 | 79 Gold 19.3 | 80 Mercury 13.6 | 81 Thallium 11.8 | 82 Lead 11.3 | 83 Bismuth 9.80 | 84 Polonium 9.4 |

* The density of carbon as graphite is 2.25 g/cm³
 The density of carbon as diamond is 3.51 g/cm³

MELTING AND BOILING POINTS OF SELECTED ELEMENTS

| Group | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|--------------------------|---|---|---|---|---|---|---|---|------------------------|
| Group 1 | Hydrogen -259 -253 | | | | | | | | | Helium -272 -269 |
| Group 3 | | | | | | | | | | |
| Group 4 | | | | | | | | | | |
| Group 5 | | | | | | | | | | |
| Group 6 | | | | | | | | | | |
| Group 7 | | | | | | | | | | |
| Group 8 | | | | | | | | | | |
| Group 9 | | | | | | | | | | |
| Group 10 | | | | | | | | | | |

| Atomic number | Name of element | Melting point/°C | Boiling point/°C |
|---------------|-----------------|------------------|------------------|
| 3 | Lithium | 181 | 1347 |
| 4 | Beryllium | 1278 | 2970* |
| 11 | Sodium | 98 | 883 |
| 12 | Magnesium | 649 | 1090 |
| 19 | Potassium | 63 | 759 |
| 20 | Calcium | 842 | 1484 |
| 21 | Scandium | 1541 | 2831 |
| 22 | Titanium | 1660 | 3287 |
| 23 | Vanadium | 1890 | 3380 |
| 24 | Chromium | 1857 | 2672 |
| 25 | Manganese | 1244 | 1962 |
| 26 | Iron | 1535 | 2750 |
| 27 | Cobalt | 1495 | 2927 |
| 28 | Nickel | 1453 | 2913 |
| 29 | Copper | 1083 | 2567 |
| 30 | Zinc | 420 | 907 |
| 31 | Gallium | 30 | 2403 |
| 32 | Germanium | 937 | 2830 |
| 33 | Arsenic | *817 | †613 |
| 34 | Selenium | 217 | 685 |
| 35 | Bromine | -7 | 59 |
| 36 | Krypton | -157 | -152 |
| 37 | Rubidium | 39 | 688 |
| 38 | Strontium | 769 | 1384 |
| 39 | Yttrium | 1522 | 3338 |
| 40 | Zirconium | 1852 | 4377 |
| 41 | Niobium | 2477 | 4742 |
| 42 | Molybdenum | 2623 | 4639 |
| 43 | Technetium | 2157 | 4265 |
| 44 | Ruthenium | 2310 | 3900 |
| 45 | Rhodium | 1966 | 3695 |
| 46 | Palladium | 1552 | 2963 |
| 47 | Silver | 962 | 2212 |
| 48 | Cadmium | 321 | 765 |
| 49 | Indium | 157 | 2080 |
| 50 | Tin | 232 | 2602 |
| 51 | Antimony | 631 | 1750 |
| 52 | Tellurium | 452 | 988 |
| 53 | Iodine | 114 | 184 |
| 54 | Xenon | -112 | -107 |
| 55 | Caesium | 28 | 671 |
| 56 | Barium | 725 | 1640 |
| 57 | Lanthanum | 921 | 3457 |
| 72 | Hafnium | 2227 | 4602 |
| 73 | Tantalum | 2996 | 5425 |
| 74 | Tungsten | 3410 | 5660 |
| 75 | Rhenium | 3180 | 5627 |
| 76 | Osmium | 3033 | 5012 |
| 77 | Iridium | 2410 | 4130 |
| 78 | Platinum | 1772 | 3827 |
| 79 | Gold | 1064 | 2856 |
| 80 | Mercury | -39 | 357 |
| 81 | Thallium | 304 | 1457 |
| 82 | Lead | 328 | 1749 |
| 83 | Bismuth | 271 | 1560 |
| 84 | Polonium | 254 | 962 |
| 85 | Astatine | 302 | -62 |

* at 28 atmospheres

† sublimes

NAMES, SYMBOLS AND RELATIVE ATOMIC MASSES OF SELECTED ELEMENTS

(Relative atomic masses have been rounded to the nearest 0.5)

Relative atomic masses are also known as the average atomic masses.

| Element | Symbol | Relative atomic mass |
|-----------|--------|----------------------|
| aluminium | Al | 27 |
| argon | Ar | 40 |
| bromine | Br | 80 |
| calcium | Ca | 40 |
| carbon | C | 12 |
| chlorine | Cl | 35.5 |
| copper | Cu | 63.5 |
| fluorine | F | 19 |
| gold | Au | 197 |
| helium | He | 4 |
| hydrogen | H | 1 |
| iodine | I | 127 |
| iron | Fe | 56 |
| lead | Pb | 207 |
| lithium | Li | 7 |

| Element | Symbol | Relative atomic mass |
|------------|--------|----------------------|
| magnesium | Mg | 24.5 |
| mercury | Hg | 200.5 |
| neon | Ne | 20 |
| nickel | Ni | 58.5 |
| nitrogen | N | 14 |
| oxygen | O | 16 |
| phosphorus | P | 31 |
| platinum | Pt | 195 |
| potassium | K | 39 |
| silicon | Si | 28 |
| silver | Ag | 108 |
| sodium | Na | 23 |
| sulphur | S | 32 |
| tin | Sn | 118.5 |
| zinc | Zn | 65.5 |

FLAME COLOURS

| Element | Ion | Flame colour |
|---------|------------------|--------------|
| barium | Ba ²⁺ | green |
| calcium | Ca ²⁺ | orange-red |
| copper | Cu ²⁺ | blue-green |
| lithium | Li ⁺ | red |

| Element | Ion | Flame colour |
|-----------|------------------|--------------|
| potassium | K ⁺ | lilac |
| sodium | Na ⁺ | yellow |
| strontium | Sr ²⁺ | red |

FORMULAE OF SELECTED IONS CONTAINING MORE THAN ONE KIND OF ATOM

| one positive | | one negative | | two negative | | three negative | |
|--------------|------------------------------|-------------------|----------------------------------|--------------|--|----------------|-------------------------------|
| Ion | Formula | Ion | Formula | Ion | Formula | Ion | Formula |
| ammonium | NH ₄ ⁺ | ethanoate | CH ₃ COO ⁻ | carbonate | CO ₃ ²⁻ | phosphate | PO ₄ ³⁻ |
| | | hydrogencarbonate | HCO ₃ ⁻ | chromate | CrO ₄ ²⁻ | | |
| | | hydrogensulphate | HSO ₄ ⁻ | dichromate | Cr ₂ O ₇ ²⁻ | | |
| | | hydrogensulphite | HSO ₃ ⁻ | sulphate | SO ₄ ²⁻ | | |
| | | hydroxide | OH ⁻ | sulphite | SO ₃ ²⁻ | | |
| | | nitrate | NO ₃ ⁻ | | | | |
| | | permanganate | MnO ₄ ⁻ | | | | |

SOLUBILITIES OF SELECTED COMPOUNDS IN WATER

The table shows how some compounds behave in water

- vs means very soluble (a solubility greater than 10 g/l)
- s means soluble (a solubility of between 1 and 10 g/l)
- i means insoluble (a solubility of less than 1 g/l)
- no data

| | bromide | carbonate | chloride | iodide | nitrate | phosphate | sulphate | oxide | hydroxide |
|------------|---------|-----------|----------|--------|---------|-----------|----------|-------|-----------|
| aluminium | vs | i | vs | vs | vs | i | vs | i | i |
| ammonium | vs | vs | vs | vs | vs | vs | vs | — | — |
| barium | vs | i | vs | vs | vs | i | i | vs | vs |
| calcium | vs | i | vs | vs | vs | i | s | s | s |
| copper(II) | vs | i | vs | — | vs | i | vs | i | i |
| iron(II) | vs | i | vs | vs | vs | i | vs | i | i |
| iron(III) | vs | — | vs | — | vs | i | vs | i | i |
| lead(II) | s | i | s | i | vs | i | i | i | i |
| lithium | vs | vs | vs | vs | vs | i | vs | vs | vs |
| magnesium | vs | i | vs | vs | vs | i | vs | i | i |
| nickel | vs | i | vs | vs | vs | i | vs | i | i |
| potassium | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| silver | i | i | i | i | va | i | s | i | — |
| sodium | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| tin(II) | vs | i | vs | s | — | i | vs | i | i |
| zinc | vs | i | vs | vs | vs | i | vs | i | i |

Note Some of the compounds in the table hydrolyse significantly in water.

MELTING AND BOILING POINTS OF SELECTED INORGANIC COMPOUNDS

| COVALENT | | |
|------------------|-------|-------|
| Name of compound | mp/°C | bp/°C |
| ammonia | -78 | -33 |
| carbon dioxide | -57 | -78 |
| carbon monoxide | -199 | -192 |
| nitrogen dioxide | -11 | 21 |
| silicon dioxide | 1700 | 2230 |
| sulphur dioxide | -73 | -10 |
| water | 0 | 100 |

| IONIC | | |
|--------------------|-------|-------|
| Name of compound | mp/°C | bp/°C |
| barium chloride | 963 | 1560 |
| calcium oxide | 2570 | — |
| lithium bromide | 547 | 1265 |
| magnesium chloride | 712 | 1418 |
| potassium iodide | 686 | 1330 |
| sodium chloride | — | 1465 |

Under normal conditions, carbon dioxide does not melt but sublimes instead. The melting point and boiling point were measured under different conditions.

MELTING AND BOILING POINTS OF SELECTED ORGANIC COMPOUNDS

| Name of compound | mp/°C | bp/°C |
|------------------|--------|-------|
| methane | -182.5 | -164 |
| ethane | -183 | -89 |
| propane | -190 | -42 |
| butane | -138 | -1 |
| pentane | -130 | 36 |
| hexane | -95 | 69 |
| heptane | -91 | 98 |
| octane | -57 | 126 |
| cyclobutane | -50 | 12 |
| cyclopentane | -94 | 49 |
| cyclohexane | 7 | 81 |

| <i>For use by Standard Grade candidates</i> | | |
|---|-------|-------|
| Name of compound | mp/°C | bp/°C |
| ethene | -169 | -104 |
| propene | -185 | -47 |
| butene † | -185 | -6 |
| pentene † | -138 | 30 |
| hexene † | -140 | 63 |

† These compounds have two or more isomers. Other isomers have slightly different melting points and boiling points.

| <i>For use by Intermediate 2 candidates</i> | | |
|---|-------|-------|
| Name of compound | mp/°C | bp/°C |
| ethene | -169 | -104 |
| propene | -185 | -47 |
| but-1-ene | -185 | -6 |
| pent-1-ene | -138 | 30 |
| hex-1-ene | -140 | 63 |
| methanol | -94 | 65 |
| ethanol | -117 | 79 |
| propan-1-ol | -127 | 97 |
| propan-2-ol | -90 | 82 |
| butan-1-ol | -90 | 117 |
| butan-2-ol | -100 | 100 |
| methanoic acid | 8 | 101 |
| ethanoic acid | 17 | 118 |
| propanoic acid | -21 | 141 |
| butanoic acid | -4 | 164 |

ELECTROCHEMICAL SERIES (REDUCTION REACTIONS)

| Metal | Reaction |
|-----------------|---|
| lithium | $\text{Li}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Li}(\text{s})$ |
| potassium | $\text{K}^+(\text{aq}) + \text{e}^- \longrightarrow \text{K}(\text{s})$ |
| calcium | $\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ca}(\text{s})$ |
| sodium | $\text{Na}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Na}(\text{s})$ |
| magnesium | $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Mg}(\text{s})$ |
| aluminium | $\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Al}(\text{s})$ |
| zinc | $\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Zn}(\text{s})$ |
| iron | $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Fe}(\text{s})$ |
| nickel | $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ni}(\text{s})$ |
| tin | $\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Sn}(\text{s})$ |
| lead | $\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Pb}(\text{s})$ |
| | $\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Fe}(\text{s})$ |
| hydrogen | $2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g})$ |
| | $\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\ell)$ |
| copper | $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Cu}(\text{s})$ |
| | $2\text{H}_2\text{O}(\ell) + \text{O}_2(\text{g}) + 4\text{e}^- \longrightarrow 4\text{OH}^-(\text{aq})$ |
| | $\text{I}_2(\text{s}) + 2\text{e}^- \longrightarrow 2\text{I}^-(\text{aq})$ |
| | $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$ |
| silver | $\text{Ag}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Ag}(\text{s})$ |
| mercury | $\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Hg}(\ell)$ |
| | $\text{Br}_2(\ell) + 2\text{e}^- \longrightarrow 2\text{Br}^-(\text{aq})$ |
| | $\text{Cl}_2(\text{g}) + 2\text{e}^- \longrightarrow 2\text{Cl}^-(\text{aq})$ |
| gold | $\text{Au}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Au}(\text{s})$ |

PERIODIC TABLE OF THE ELEMENTS SHOWING SYMBOL AND DATE OF DISCOVERY

Group 3 4 5 6 7 0

| | | | |
|----|-------------------------|----|-----------------------------|
| 1 | Hydrogen H 1766 | 2 | Helium He 1862 |
| 3 | Lithium Li 1817 | 4 | Beryllium Be 1798 |
| 11 | Sodium Na 1807 | 12 | Magnesium Mg 1775 |
| 19 | Potassium K 1807 | 20 | Calcium Ca 1808 |
| 37 | Rubidium Rb 1861 | 38 | Sr 1790 |
| 55 | Caesium Cs 1860 | 56 | Barium Ba 1808 |
| 87 | Francium Fr* 1939 | 88 | Radium Ra 1898 |
| 5 | Boron B 1808 | 6 | Carbon C Prehistoric |
| 13 | Aluminium Al 1827 | 14 | Silicon Si 1823 |
| 31 | Gallium Ga 1875 | 32 | Germanium Ge 1866 |
| 49 | Indium In 1863 | 50 | Tin Sn Prehistoric |
| 81 | Thallium Tl 1861 | 82 | Lead Pb Prehistoric |
| 83 | Bismuth Bi 1753 | 84 | Polonium Po 1898 |
| 85 | Astatine At* 1940 | 86 | Radon Rn 1900 |
| 7 | Nitrogen N 1772 | 8 | Oxygen O 1774 |
| 15 | Phosphorus P 1669 | 16 | Sulphur S Prehistoric |
| 33 | Arsenic As ~1250 | 34 | Selenium Se 1817 |
| 51 | Antimony Sb ~1450 | 52 | Tellurium Te 1782 |
| 83 | Bismuth Bi 1753 | 84 | Polonium Po 1898 |
| 9 | Fluorine F 1771 | 17 | Chlorine Cl 1774 |
| 35 | Bromine Br 1826 | 36 | Krypton Kr 1898 |
| 53 | Iodine I 1811 | 54 | Xenon Xe 1898 |

← The elements on this side of the dark line are metals. The elements on this side of the dark line are non-metals. →

TRANSITION METALS

| |
|-------------------|
| Atomic number |
| Name of element |
| Symbol |
| Date of discovery |

Key

| | | | | | | | | | | | | | | | | | | | | | |
|-------|------------------------|----|-------------------------|----|------------------------|----|--------------------------|----|--------------------------|----|---------------------------|----|-----------------------|----|--------------------------------|----|-----------------------------|----|------------------------------|----|-------------------------|
| 21 | Scandium Sc 1879 | 22 | Titanium Ti 1791 | 23 | Vanadium V 1830 | 24 | Chromium Cr 1797 | 25 | Manganese Mn 1774 | 26 | Iron Fe Prehistoric | 27 | Cobalt Co 1735 | 28 | Nickel Ni 1751 | 29 | Copper Cu Prehistoric | 30 | Zinc Zn 16th century | | |
| 39 | Yttrium Y 1794 | 40 | Zirconium Zr 1789 | 41 | Niobium Nb 1801 | 42 | Molybdenum Mo 1778 | 43 | Technetium Tc 1937 | 44 | Ruthenium Ru 1844 | 45 | Rhodium Rh 1803 | 46 | Palladium Pd 1803 | 47 | Silver Ag Prehistoric | 48 | Cadmium Cd 1817 | 57 | Lanthanum La 1839 |
| 58-71 | Actinium Ac 1899 | 72 | Hafnium Hf 1923 | 73 | Tantalum Ta 1802 | 74 | Tungsten W 1783 | 75 | Rhenium Re 1925 | 76 | Osmium Os 1804 | 77 | Iridium Ir 1804 | 78 | Platinum Pt 16th century | 79 | Gold Au Prehistoric | 80 | Mercury Hg Prehistoric | 89 | Actinium Ac 1899 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----|-----------------------|----|----------------------------|----|-------------------------|----|--------------------------|----|--------------------------|----|--------------------------|----|--------------------------|----|--------------------------|----|----------------------------|----|----------------------------|-----|------------------------|-----|----------------------------|-----|-------------------------|-----|---------------------------|
| 58 | Cerium Ce 1803 | 59 | Praseodymium Pr 1885 | 60 | Neodymium Nd 1885 | 61 | Promethium Pm 1947 | 62 | Samarium Sm 1879 | 63 | Europium Eu 1896 | 64 | Gadolinium Gd 1880 | 65 | Terbium Tb 1843 | 66 | Dysprosium Dy 1886 | 67 | Holmium Ho 1879 | 68 | Erbium Er 1843 | 69 | Thulium Tm 1879 | 70 | Ytterbium Yb 1907 | 71 | Lutetium Lu 1907 |
| 90 | Thorium Th 1828 | 91 | Protactinium Pa 1917 | 92 | Uranium U 1789 | 93 | Neptunium Np* 1940 | 94 | Plutonium Pu* 1940 | 95 | Americium Am* 1944 | 96 | Curium Cm* 1944 | 97 | Berkelium Bk* 1949 | 98 | Californium Cf* 1952 | 99 | Einsteinium Es* 1953 | 100 | Fermium Fm* 1955 | 101 | Mendelevium Md* 1957 | 102 | Nobelium No* 1961 | 103 | Lawrencium Lr* 1969 |



* = element which is not found in nature either as the element or in a compound, but has been made by scientists