

Chemistry Data Booklet

National 5

For use in National Qualification Courses

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Relationships for National 5 Chemistry

$$E_h = cm\Delta T$$

$$n = CV$$

$$n = \frac{m}{GFM}$$

$$\frac{C_1V_1}{n_1} = \frac{C_2V_2}{n_2}$$

$$rate = \frac{\Delta quantity}{\Delta t}$$

$$\% \text{ by mass} = \frac{m}{GFM} \times 100$$

Specific Heat Capacity of Liquid Water

$$c = 4.18 \text{ kJ kg}^{-1} \text{ }^\circ\text{C}^{-1}$$

Periodic Table of the Elements

Column 1 Column 2

Column 3 Column 4 Column 5 Column 6 Column 7 Column 8

1 Hydrogen H	2 Helium He
--------------------	-------------------

Key
Atomic Number
Name of Element
Symbol

3 Lithium Li	4 Beryllium Be
--------------------	----------------------

11 Sodium Na	12 Magnesium Mg
--------------------	-----------------------

19 Potassium K	20 Calcium Ca
----------------------	---------------------

37 Rubidium Rb	38 Strontium Sr
----------------------	-----------------------

55 Caesium Cs	56 Barium Ba
---------------------	--------------------

87 Francium Fr	88 Radium Ra
----------------------	--------------------

TRANSITION METALS

21 Scandium Sc	22 Titanium Ti	23 Vanadium V	24 Chromium Cr	25 Manganese Mn	26 Iron Fe	27 Cobalt Co	28 Nickel Ni	29 Copper Cu	30 Zinc Zn
39 Yttrium Y	40 Zirconium Zr	41 Niobium Nb	42 Molybdenum Mo	43 Technetium Tc	44 Ruthenium Ru	45 Rhodium Rh	46 Palladium Pd	47 Silver Ag	48 Cadmium Cd
57 Lanthanum La	58-71	72 Hafnium Hf	73 Tantalum Ta	74 Tungsten W	75 Rhenium Re	76 Osmium Os	77 Iridium Ir	78 Platinum Pt	79 Gold Au
89 Actinium Ac	90-103	104 Rutherfordium Rf	105 Dubnium Db	106 Seaborgium Sg	107 Bohrium Bh	108 Hassium Hs	109 Meitnerium Mt	110 Darmstadtium Ds	111 Roentgenium Rg
									112 Copernicium Cn

5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
13 Aluminium Al	14 Silicon Si	15 Phosphorus P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar
31 Gallium Ga	32 Germanium Ge	33 Arsenic As	34 Selenium Se	35 Bromine Br	36 Krypton Kr
49 Indium In	50 Tin Sn	51 Antimony Sb	52 Tellurium Te	53 Iodine I	54 Xenon Xe
81 Thallium Tl	82 Lead Pb	83 Bismuth Bi	84 Polonium Po	85 Astatine At	86 Radon Rn
	114 Flerovium Fl				
			116 Livermorium Lv		

58 Cerium Ce	59 Praseodymium Pr	60 Neodymium Nd	61 Promethium Pm	62 Samarium Sm	63 Europium Eu	64 Gadolinium Gd	65 Terbium Tb	66 Dysprosium Dy	67 Holmium Ho	68 Erbium Er	69 Thulium Tm	70 Ytterbium Yb	71 Lutetium Lu
90 Thorium Th	91 Protactinium Pa	92 Uranium U	93 Neptunium Np	94 Plutonium Pu	95 Americium Am	96 Curium Cm	97 Berkelium Bk	98 Californium Cf	99 Einsteinium Es	100 Fermium Fm	101 Mendelevium Md	102 Nobelium No	103 Lawrencium Lr

Elements below the dark line are metals.

Melting and Boiling Points of Selected Elements

Group 1	Group 2	Key										Group 3	Group 4	Group 5	Group 6	Group 7	Group 0																				
1 Hydrogen –259 –253		3 Lithium 181 1342	4 Beryllium 1287 2471*	11 Sodium 98 883	12 Magnesium 650 1090	21 Scandium 1541 2836	22 Titanium 1668 3287	23 Vanadium 1910 3407	24 Chromium 1907 2672	25 Manganese 1246 2061	26 Iron 1538 2861	27 Cobalt 1495 2927	28 Nickel 1455 2913	29 Copper 1085 2562	30 Zinc 420 907	31 Gallium 30 2204	32 Germanium 938 2833	33 Arsenic *817 †616	34 Selenium 221 685	35 Bromine –7 59	36 Krypton –157 –153	5 Boron 2075 4000	6 Carbon †3825	7 Nitrogen –210 –196	8 Oxygen –219 –183	9 Fluorine –220 –188	10 Neon –249 –246	2 Helium –272 –269									
		Atomic Number Name of Element Melting Point/°C Boiling Point/°C																																			
19 Potassium 63 759	20 Calcium 842 1484	37 Rubidium 39 688	38 Strontium 777 1382	39 Yttrium 1522 3345	40 Zirconium 1855 4409	41 Niobium 2477 4744	42 Molybdenum 2623 4639	43 Technetium 2157 4265	44 Ruthenium 2333 4150	45 Rhodium 1964 3695	46 Palladium 1555 2963	47 Silver 962 2162	48 Cadmium 321 767	49 Indium 157 2072	50 Tin 232 2602	51 Antimony 631 1587	52 Tellurium 449 988	53 Iodine 114 184	54 Xenon –112 –108	55 Caesium 28 671	56 Barium 727 1897	57 Lanthanum 920 3464	72 Hafnium 2223 4602	73 Tantalum 3017 5458	74 Tungsten 3422 5555	75 Rhenium 3185 5596	76 Osmium 3033 5012	77 Iridium 2446 4428	78 Platinum 1768 3825	79 Gold 1064 2856	80 Mercury –39 357	81 Thallium 304 1473	82 Lead 328 1749	83 Bismuth 271 1564	84 Polonium 254 962	85 Astatine 302	86 Radon –71 –62

* at 28 atmospheres

† sublimates

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 Sulfur 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. →

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

Names, Symbols, Relative Atomic Masses, Densities and Dates of Discovery

(Relative atomic masses, also known as average atomic masses, have been rounded to the nearest 0.5)

Element	Symbol	Relative atomic mass	Density (g cm ⁻³)	Date of Discovery
Actinium	Ac	227	10.1	1899
Aluminium	Al	27	2.70	1825
Americium	Am	243	13.7	1944
Antimony	Sb	122	6.68	Ancient
Argon	Ar	40	0.0018	1894
Arsenic	As	75	5.78	~1250
Astatine	At	210	unknown	1940
Barium	Ba	137.5	3.62	1808
Berkelium	Bk	247	14.8	1949
Beryllium	Be	9	1.85	1798
Bismuth	Bi	209	9.79	1753
Boron	B	11	2.47	1808
Bromine	Br	80	3.12	1826
Cadmium	Cd	112.5	8.69	1817
Calcium	Ca	40	1.54	1808
Californium	Cf	251	unknown	1950
Carbon	C	12	*	Prehistoric
Cerium	Ce	140	6.77	1803
Caesium	Cs	133	1.93	1860
Chlorine	Cl	35.5	0.0032	1774
Chromium	Cr	52	7.15	1797
Cobalt	Co	59	8.86	1739
Copper	Cu	63.5	8.96	Ancient
Curium	Cm	247	13.3	1944
Dysprosium	Dy	162.5	8.55	1886
Einsteinium	Es	252	unknown	1952
Erbium	Er	167.5	9.07	1843
Europium	Eu	152	5.24	1896
Fluorine	F	19	0.0017	1886
Francium	Fr	223	unknown	1939
Gadolinium	Gd	157	7.90	1880
Gallium	Ga	69.5	5.91	1875
Germanium	Ge	72.5	5.32	1886
Gold	Au	197	19.3	Ancient
Hafnium	Hf	178.5	13.3	1923
Helium	He	4	0.0002	1868
Holmium	Ho	165	8.80	1879
Hydrogen	H	1	0.00009	1766
Indium	In	115	7.31	1863
Iodine	I	127	4.95	1811
Iridium	Ir	192	22.5	1803
Iron	Fe	56	7.87	Ancient
Krypton	Kr	84	0.0037	1898
Lanthanum	La	139	6.15	1839
Lead	Pb	207	11.3	Ancient
Lithium	Li	7	0.53	1817
Lutetium	Lu	175	9.84	1907
Magnesium	Mg	24.5	1.74	1808

Element	Symbol	Relative atomic mass	Density (g cm ⁻³)	Date of Discovery
Manganese	Mn	55	7.47	1774
Mercury	Hg	200.5	13.5	Ancient
Molybdenum	Mo	96	10.2	1778
Neodymium	Nd	144	7.01	1885
Neon	Ne	20	0.0009	1898
Neptunium	Np	237	20.2	1940
Nickel	Ni	58.5	8.90	1751
Niobium	Nb	93	8.57	1801
Nitrogen	N	14	0.0013	1772
Osmium	Os	190	22.6	1803
Oxygen	O	16	0.0014	1774
Palladium	Pd	106.5	12.0	1803
Phosphorus	P	31	1.82	1669
Platinum	Pt	195	21.5	1735
Plutonium	Pu	244	19.7	1941
Polonium	Po	209	9.20	1898
Potassium	K	39	0.89	1807
Praseodymium	Pr	141	6.77	1885
Promethium	Pm	145	7.26	1944
Protactinium	Pa	231	15.4	1913
Radium	Ra	226	5.00	1898
Radon	Rn	222	0.0097	1900
Rhenium	Re	186	20.8	1925
Rhodium	Rh	103	12.4	1803
Rubidium	Rb	85.5	1.53	1861
Ruthenium	Ru	101	12.1	1844
Samarium	Sm	150.5	7.52	1853
Scandium	Sc	45	2.99	1879
Selenium	Se	79	4.81	1817
Silicon	Si	28	2.33	1824
Silver	Ag	108	10.5	Ancient
Sodium	Na	23	0.97	1807
Strontium	Sr	87.5	2.64	1790
Sulfur	S	32	2.09	Ancient
Tantalum	Ta	181	16.4	1802
Technetium	Tc	98	11	1937
Tellurium	Te	127.5	6.25	1782
Terbium	Tb	159	8.23	1843
Thallium	Tl	204.5	11.8	1861
Thorium	Th	232	11.7	1828
Thulium	Tm	169	9.32	1879
Tin	Sn	118.5	7.26	Ancient
Titanium	Ti	48	4.51	1791
Tungsten	W	184	19.3	1783
Uranium	U	238	19.1	1789
Vanadium	V	51	6.00	1801
Xenon	Xe	131.5	0.0059	1898
Ytterbium	Yb	173	6.90	1878
Yttrium	Y	89	4.47	1789
Zinc	Zn	65.5	7.14	Ancient
Zirconium	Zr	91	6.52	1789

*The density of carbon as graphite is 2.27 g cm⁻³
 The density of carbon as diamond is 3.51 g cm⁻³

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⁻		
		hydrogensulfate	HSO ₄ ⁻	dichromate	Cr ₂ O ₇ ²⁻		
		hydrogensulfite	HSO ₃ ⁻	sulfate	SO ₄ ²⁻		
		hydroxide	OH ⁻	sulfite	SO ₃ ²⁻		
		nitrate	NO ₃ ⁻	thiosulfate	S ₂ O ₃ ²⁻		
		permanganate	MnO ₄ ⁻				

Solubilities of Selected Compounds in Water

The table shows how some compounds behave in cold water

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

	bromide	carbonate	chloride	iodide	nitrate	phosphate	sulfate	oxide	hydroxide
aluminium	vs	–	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	vs	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	-205	-192
nitrogen dioxide	-9	21
silicon dioxide	1713	2950
sulfur dioxide	-75	-10
water	0	100

IONIC		
Name of compound	mp/°C	bp/°C
barium chloride	961	1560
calcium oxide	2614	2850
lithium bromide	550	1265
magnesium chloride	714	1412
potassium iodide	681	1323
sodium chloride	801	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	-162
ethane	-183	-89
propane	-188	-42
butane	-138	-1
pentane	-130	36
hexane	-95	69
heptane	-91	98
octane	-57	126
cyclobutane	-91	13
cyclopentane	-93	49
cyclohexane	7	81

2-methylpropane	-159	-12
2-methylbutane	-160	28
2-methylpentane	-154	60
2-methylhexane	-118	90

Name of compound	mp/°C	bp/°C
ethene	-169	-104
propene	-185	-48
but-1-ene	-185	-6
pent-1-ene	-165	30
hex-1-ene	-140	63

2-methylpropene	-141	-7
2-methylbut-1-ene	-138	31
2-methylpent-1-ene	-136	62
2-methylhex-1-ene	-103	92

methanol	-97.5	65
ethanol	-114	78
propan-1-ol	-124	97
propan-2-ol	-88	82
butan-1-ol	-89	118
butan-2-ol	-89	100

methanoic acid	8	101
ethanoic acid	17	118
propanoic acid	-21	141
butanoic acid	-5	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	$2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g})$
	$\text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{e}^- \longrightarrow 2\text{S}_2\text{O}_3^{2-}(\text{aq})$
	$\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\ell)$
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	$\text{Au}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Au}(\text{s})$
	$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow 2\text{H}_2\text{O}(\ell)$