

Chemistry Data Booklet

National 5

For use in National Qualification Courses.

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Relationships for National 5 Chemistry

$$E_h = cm\Delta T$$

$$n = cV$$

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

$$\frac{c_1V_1}{n_1} = \frac{c_2V_2}{n_2}$$

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

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

Specific Heat Capacity of Liquid Water

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

Periodic Table of the Elements

Column Column
1 2

Column Column Column Column Column
3 4 5 6 7 0

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

Atomic Number
Name of Element
Symbol

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

11 Sodium Na	12 Magne- sium Mg
--------------------	----------------------------

19 Potas- sium K	20 Calcium Ca
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37 Rubidium Rb	38 Stron- tium Sr
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55 Caesium Cs	56 Barium Ba
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87 Francium Fr	88 Radium Ra
----------------------	--------------------

21 Scandium Sc	22 Titanium Ti	23 Van- adium V	24 Chro- mium Cr	25 Manga- nese Mn	26 Iron Fe	27 Cobalt Co	28 Nickel Ni	29 Copper Cu	30 Zinc Zn
39 Yttrium Y	40 Zirco- nium Zr	41 Niobium Nb	42 Molyb- denum Mo	43 Techn- tium Tc	44 Ruth- enium Ru	45 Rhodium Rh	46 Palla- dium Pd	47 Silver Ag	48 Cadmium Cd
57 Lan- thanum La	72 Hafnium Hf	73 Tantalum Ta	74 Tungsten W	75 Rhenium Re	76 Osmium Os	77 Iridium Ir	78 Platinum Pt	79 Gold Au	80 Mercury Hg
89 Actinium Ac	104 Ruther- fordium Rf	105 Dubnium Db	106 Seaborg- ium Sg	107 Bohrium Bh	108 Hassium Hs	109 Meitner- ium Mt	110 Darm- stadtium Ds	111 Roent- genium Rg	112 Coper- nium Cn

5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
13 Alumin- ium Al	14 Silicon Si	15 Phos- phorus P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar
31 Gallium Ga	32 Germa- nium 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
113 Nihonium Nh	114 Flero- vium Fl	115 Mosco- vium Mc	116 Liver- morium Lv	117 Tennes- sine Ts	118 Oganes- son Og

58 Cerium Ce	59 Praseo- dymium Pr	60 Neodym- ium Nd	61 Prom- ethium Pm	62 Samar- ium Sm	63 Europium Eu	64 Gadolin- ium Gd	65 Terbium Tb	66 Dyspro- sium Dy	67 Holmium Ho	68 Erbium Er	69 Thulium Tm	70 Ytter- bium Yb	71 Lutetium Lu
90 Thorium Th	91 Protac- tinium Pa	92 Uranium U	93 Neptun- ium Np	94 Pluto- nium Pu	95 Ameri- cium Am	96 Curium Cm	97 Berke- lium Bk	98 Califor- nium Cf	99 Einstein- ium Es	100 Fermium Fm	101 Mendel- evium Md	102 Nobelium No	103 Lawren- cium Lr

Elements below the dark line are metals.

Melting and Boiling Points of Selected Elements

Group 1		Group 2		Group 3		Group 4		Group 5		Group 6		Group 7		Group 8		Group 9	
1		2		3		4		5		6		7		8		9	
Hydrogen −259 −253																Helium −272 −269	
3		4															
Lithium 181 1342		Beryllium 1287 2471*															
11		12															
Sodium 98 883		Magnesium 650 1090															
19		20		21		22		23		24		25		26		27	
Potassium 63 759		Calcium 842 1484		Scandium 1541 2836		Titanium 1670 3287		Vanadium 1910 3407		Chromium 1907 2671		Manganese 1246 2061		Iron 1538 2861		Cobalt 1495 2927	
37		38		39		40		41		42		43		44		45	
Rubidium 39 688		Strontium 777 1377		Yttrium 1522 3345		Zirconium 1854 4406		Niobium 2477 4741		Molybdenum 2622 4639		Technetium 2157 4262		Ruthenium 2333 4147		Rhodium 1963 3695	
55		56		57		72		73		74		75		76		77	
Caesium 28 671		Barium 727 1845		Lanthanum 920 3464		Hafnium 2233 4600		Tantalum 3017 5455		Tungsten 3414 5555		Rhenium 3185 5590		Osmium 3033 5008		Iridium 2446 4428	

Key

Atomic Number
Name of Element
Melting Point (°C)
Boiling Point (°C)

* at 28 atmospheres
† sublimes

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 Magne- sium Mg 2,8,2	13 Aluminium Al 2,8,3	14 Silicon Si 2,8,4	15 Phos- phorus 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 Germa- nium 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	12.0	1944
Antimony	Sb	122	6.68	Ancient
Argon	Ar	40	0.0018	1894
Arsenic	As	75	5.75	~1250
Astatine	At	210	unknown	1940
Barium	Ba	137.5	3.62	1808
Berkelium	Bk	247	13.3	1949
Beryllium	Be	9	1.85	1798
Bismuth	Bi	209	9.79	1753
Boron	B	11	2.34	1808
Bromine	Br	80	3.10	1826
Cadmium	Cd	112.5	8.69	1817
Calcium	Ca	40	1.54	1808
Californium	Cf	251	15.1	1950
Carbon	C	12	*	Prehistoric
Cerium	Ce	140	6.77	1803
Caesium	Cs	133	1.87	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	13.5	1944
Dysprosium	Dy	162.5	8.55	1886

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

Names, Symbols, Relative Atomic Masses, Densities and Dates of Discovery (continued)

(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
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	4.93	1811
Iridium	Ir	192	22.6	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
Manganese	Mn	55	7.30	1774
Mercury	Hg	200.5	13.5	Ancient
Molybdenum	Mo	96	10.2	1778

Names, Symbols, Relative Atomic Masses, Densities and Dates of Discovery (continued)

(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
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

Names, Symbols, Relative Atomic Masses, Densities and Dates of Discovery (continued)

(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
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	2.00	Ancient
Tantalum	Ta	181	16.4	1802
Technetium	Tc	98	11.0	1937
Tellurium	Te	127.5	6.23	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	7.29	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	7.13	Ancient
Zirconium	Zr	91	6.52	1789

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_3COO^-	carbonate	CO_3^{2-}	phosphate	PO_4^{3-}
		hydrogencarbonate	HCO_3^-	chromate	CrO_4^{2-}		
		hydrogensulfate	HSO_4^-	dichromate	$\text{Cr}_2\text{O}_7^{2-}$		
		hydrogensulfite	HSO_3^-	sulfate	SO_4^{2-}		
		hydroxide	OH^-	sulfite	SO_3^{2-}		
		nitrate	NO_3^-	thiosulfate	$\text{S}_2\text{O}_3^{2-}$		
		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
aluminium	vs	—	vs	vs	vs	i	vs
ammonium	vs	vs	vs	vs	vs	vs	vs
barium	vs	i	vs	vs	vs	i	i
calcium	vs	i	vs	vs	vs	i	s
copper(II)	vs	i	vs	—	vs	i	vs
iron(II)	vs	i	vs	vs	vs	i	vs
iron(III)	vs	—	vs	—	vs	i	vs
lead(II)	s	i	s	i	vs	i	i
lithium	vs	vs	vs	vs	vs	i	vs
magnesium	vs	i	vs	vs	vs	i	vs
nickel	vs	i	vs	vs	vs	i	vs
potassium	vs	vs	vs	vs	vs	vs	vs
silver	i	i	i	i	vs	i	s
sodium	vs	vs	vs	vs	vs	vs	vs
tin(II)	vs	i	vs	s	—	i	vs
zinc	vs	i	vs	vs	vs	i	vs

oxide	hydroxide
i	i
—	—
vs	vs
s	s
i	i
i	i
i	i
vs	vs
i	i
vs	vs
i	—
vs	vs
i	i
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	−78	−57
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	2613	2850
lithium bromide	550	1265
magnesium chloride	714	1412
potassium iodide	681	1323
sodium chloride	802	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	−162
ethane	−183	−89
propane	−188	−42
butane	−138	−1
pentane	−130	36
hexane	−95	69
heptane	−91	98
octane	−57	126

cyclobutane	−90	12
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	−137	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	−20	141
butanoic acid	−5	164

Electrochemical Series (Reduction Reactions)

Metal	Reaction		
lithium	$\text{Li}^+(\text{aq}) + \text{e}^-$	—————→	$\text{Li}(\text{s})$
potassium	$\text{K}^+(\text{aq}) + \text{e}^-$	—————→	$\text{K}(\text{s})$
calcium	$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Ca}(\text{s})$
sodium	$\text{Na}^+(\text{aq}) + \text{e}^-$	—————→	$\text{Na}(\text{s})$
magnesium	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Mg}(\text{s})$
aluminium	$\text{Al}^{3+}(\text{aq}) + 3\text{e}^-$	—————→	$\text{Al}(\text{s})$
zinc	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Zn}(\text{s})$
iron	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Fe}(\text{s})$
nickel	$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Ni}(\text{s})$
tin	$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Sn}(\text{s})$
lead	$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Pb}(\text{s})$
hydrogen	$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^-$	—————→	$\text{Fe}(\text{s})$
	$2\text{H}^+(\text{aq}) + 2\text{e}^-$	—————→	$\text{H}_2(\text{g})$
	$\text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{e}^-$	—————→	$2\text{S}_2\text{O}_3^{2-}(\text{aq})$
	$\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$	—————→	$\text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\ell)$
copper	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Cu}(\text{s})$
	$2\text{H}_2\text{O}(\ell) + \text{O}_2(\text{g}) + 4\text{e}^-$	—————→	$4\text{OH}^-(\text{aq})$
	$\text{I}_2(\text{s}) + 2\text{e}^-$	—————→	$2\text{I}^-(\text{aq})$
	$\text{Fe}^{3+}(\text{aq}) + \text{e}^-$	—————→	$\text{Fe}^{2+}(\text{aq})$
silver	$\text{Ag}^+(\text{aq}) + \text{e}^-$	—————→	$\text{Ag}(\text{s})$
mercury	$\text{Hg}^{2+}(\text{aq}) + 2\text{e}^-$	—————→	$\text{Hg}(\ell)$
	$\text{Br}_2(\ell) + 2\text{e}^-$	—————→	$2\text{Br}^-(\text{aq})$
	$\text{Cl}_2(\text{g}) + 2\text{e}^-$	—————→	$2\text{Cl}^-(\text{aq})$
gold	$\text{Au}^+(\text{aq}) + \text{e}^-$	—————→	$\text{Au}(\text{s})$
	$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$	—————→	$2\text{H}_2\text{O}(\ell)$