Chemistry Data Booklet

National 5

For use in National Qualification Courses.

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Contents

Relationships for National 5 Chemistry

$$E_h = cm\Delta T$$

$$n = cV$$

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

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

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

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

Specific Heat Capacity of Liquid Water

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

Periodic Table of the Elements

Column 1	Column 2			Column 3	Column 4	Column 5	Column 6	Column 7	Column 0
1 Hydrogen **H**									2 Helium **He**
3 Lithium **Li**	4 Beryllium **Be**			5 Boron **B**	6 Carbon **C**	7 Nitrogen **N**	8 Oxygen **O**	9 Fluorine **F**	10 Neon **Ne**
11 Sodium **Na**	12 Magnesium **Mg**			13 Aluminium **Al**	14 Silicon **Si**	15 Phosphorus **P**	16 Sulfur **S**	17 Chlorine **Cl**	18 Argon **Ar**
19 Potassium **K**	20 Calcium **Ca**	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**	31 Gallium **Ga**	32 Germanium **Ge**	33 Arsenic **As**	34 Selenium **Se**	35 Bromine **Br**	36 Krypton **Kr**
37 Rubidium **Rb**	38 Strontium **Sr**	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**	49 Indium **In**	50 Tin **Sn**	51 Antimony **Sb**	52 Tellurium **Te**	53 Iodine **I**	54 Xenon **Xe**
55 Caesium **Cs**	56 Barium **Ba**	57 Lanthanum **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**	81 Thallium **Tl**	82 Lead **Pb**	83 Bismuth **Bi**	84 Polonium **Po**	85 Astatine **At**	86 Radon **Rn**
87 Francium **Fr**	88 Radium **Ra**	89 Actinium **Ac**	104 Rutherfordium **Rf**	105 Dubnium **Db**	106 Seaborgium **Sg**	107 Bohrium **Bh**	108 Hassium **Hs**	109 Meitnerium **Mt**	110 Darmstadtium **Ds**	111 Roent-genium **Rg**	112 Copernicium **Cn**	113 Nihonium **Nh**	114 Flerovium **Fl**	115 Moscovium **Mc**	116 Livermorium **Lv**	117 Tennessine **Ts**	118 Oganesson **Og**

Key

Atomic Number
Name of Element
Symbol

TRANSITION METALS

58–71 ●

90–103 ■

●	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											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1 Hydrogen **–259** *–253*																	2 Helium **–272** *–269*
3 Lithium **181** *1342*	4 Beryllium **1287** *2471**											5 Boron **2077** *4000*	6 Carbon **†3825**	7 Nitrogen **–210** *–196*	8 Oxygen **–219** *–183*	9 Fluorine **–220** *–188*	10 Neon **–249** *–246*
11 Sodium **98** *883*	12 Magnesium **650** *1090*											13 Aluminium **660** *2519*	14 Silicon **1414** *3265*	15 Phosphorus **44** *281*	16 Sulfur **115** *445*	17 Chlorine **–101** *–34*	18 Argon **–189** *–186*
19 Potassium **63** *759*	20 Calcium **842** *1484*	21 Scandium **1541** *2836*	22 Titanium **1670** *3287*	23 Vanadium **1910** *3407*	24 Chromium **1907** *2671*	25 Manganese **1246** *2061*	26 Iron **1538** *2861*	27 Cobalt **1495** *2927*	28 Nickel **1455** *2913*	29 Copper **1085** *2560*	30 Zinc **420** *907*	31 Gallium **30** *2229*	32 Germanium **938** *2833*	33 Arsenic ***817** *†616*	34 Selenium **221** *685*	35 Bromine **–7** *59*	36 Krypton **–157** *–153*
37 Rubidium **39** *688*	38 Strontium **777** *1377*	39 Yttrium **1522** *3345*	40 Zirconium **1854** *4406*	41 Niobium **2477** *4741*	42 Molybdenum **2622** *4639*	43 Technetium **2157** *4262*	44 Ruthenium **2333** *4147*	45 Rhodium **1963** *3695*	46 Palladium **1555** *2963*	47 Silver **962** *2162*	48 Cadmium **321** *767*	49 Indium **157** *2072*	50 Tin **232** *2586*	51 Antimony **631** *1587*	52 Tellurium **450** *988*	53 Iodine **114** *184*	54 Xenon **–112** *–108*
55 Caesium **28** *671*	56 Barium **727** *1845*	57 Lanthanum **920** *3464*	72 Hafnium **2233** *4600*	73 Tantalum **3017** *5455*	74 Tungsten **3414** *5555*	75 Rhenium **3185** *5590*	76 Osmium **3033** *5008*	77 Iridium **2446** *4428*	78 Platinum **1768** *3825*	79 Gold **1064** *2836*	80 Mercury **–39** *357*	81 Thallium **304** *1473*	82 Lead **327** *1749*	83 Bismuth **271** *1564*	84 Polonium **254** *962*	85 Astatine **302**	86 Radon **–71** *–62*

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 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	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
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

*The density of carbon as graphite is 2.27 g cm^{-3}
The density of carbon as diamond is 3.51 g cm^{-3}

Element	Symbol	Relative atomic mass	Density (g cm^{-3})	Date of Discovery
Manganese	Mn	55	7.30	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	2.00	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	$Cr_2O_7^{2-}$		
		hydrogensulfite	HSO_3^-	sulfate	SO_4^{2-}		
		hydroxide	OH^-	sulfite	SO_3^{2-}		
		nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$		
		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	−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	$Li^+(aq) + e^- \longrightarrow Li(s)$
potassium	$K^+(aq) + e^- \longrightarrow K(s)$
calcium	$Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$
sodium	$Na^+(aq) + e^- \longrightarrow Na(s)$
magnesium	$Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$
aluminium	$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$
zinc	$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$
iron	$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$
nickel	$Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$
tin	$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$
lead	$Pb^{2+}(aq) + 2e^- \longrightarrow Pb(s)$
	$Fe^{3+}(aq) + 3e^- \longrightarrow Fe(s)$
hydrogen	$2H^+(aq) + 2e^- \longrightarrow H_2(g)$
	$S_4O_6^{2-}(aq) + 2e^- \longrightarrow 2S_2O_3^{2-}(aq)$
	$SO_4^{2-}(aq) + 2H^+(aq) + 2e^- \longrightarrow SO_3^{2-}(aq) + H_2O(\ell)$
copper	$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$
	$2H_2O(\ell) + O_2(g) + 4e^- \longrightarrow 4OH^-(aq)$
	$I_2(s) + 2e^- \longrightarrow 2I^-(aq)$
	$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$
silver	$Ag^+(aq) + e^- \longrightarrow Ag(s)$
mercury	$Hg^{2+}(aq) + 2e^- \longrightarrow Hg(\ell)$
	$Br_2(\ell) + 2e^- \longrightarrow 2Br^-(aq)$
	$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$
gold	$Au^+(aq) + e^- \longrightarrow Au(s)$
	$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O(\ell)$