STUDY FORMULA BOOKLET

IB Chemistry data booklet: study version for first assessment 2025

The booklet prints 19 equations, three uncertainty rules and 21 data sections, but not percentage yield, Kc, rate equations, Ka or Kb, which you must recall.

IN THE BOOKLET printed in the official booklet LEARN IT not printed: students must recall it

Based on the official **IB Diploma Programme Chemistry data booklet, first assessment 2025, version 1.1 (published February 2023, updated February 2024)**, with what to learn and exam tips added by CuratedPrep.

1. Some relevant equations

The booklet prints these equations with no symbols or units. Rows marked HL content sit in additional higher level statements of the IB guide; the booklet itself does not mark them.

Wave equation for light HL content in the IB guide (the booklet does not mark it). c speed of light, f frequency in Hz, λ wavelength in m.	$c = f\lambda$	IN THE BOOKLET
Photon energy HL content in the IB guide (the booklet does not mark it). E in J, h the Planck constant, f frequency in Hz.	$E = hf$	IN THE BOOKLET
Amount from mass n in mol, m in g, M in g mol^{-1}.	$n = \frac{m}{M}$	IN THE BOOKLET
Amount from concentration and volume n in mol, C in mol dm^{-3}, V in dm^3.	$n = CV$	IN THE BOOKLET
Ideal gas equation Use SI units: P in Pa, V in m^3, T in K.	$PV = nRT$	IN THE BOOKLET
Combined gas law Fixed amount of gas; T in kelvin; the same units on both sides.	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	IN THE BOOKLET
Heat energy from a temperature change Q in J, m in g, c in J g^{-1} K^{-1} (water 4.18).	$Q = mc\Delta T$	IN THE BOOKLET
Percentage atom economy Use the balanced equation, including coefficients.	$\%\ \text{atom economy} = \frac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times 100$	IN THE BOOKLET
Enthalpy change from enthalpies of formation Products minus reactants; multiply each value by its coefficient.	$\Delta H^\ominus = \sum(\Delta H_f^\ominus \text{ products}) - \sum(\Delta H_f^\ominus \text{ reactants})$	IN THE BOOKLET
Enthalpy change from enthalpies of combustion Reactants minus products, the opposite way round to formation data.	$\Delta H^\ominus = \sum(\Delta H_c^\ominus \text{ reactants}) - \sum(\Delta H_c^\ominus \text{ products})$	IN THE BOOKLET
Gibbs energy change HL content in the IB guide (the booklet does not mark it). Use kJ throughout or J throughout; T in K.	$\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$	IN THE BOOKLET

Gibbs energy away from the standard state HL content in the IB guide (the booklet does not mark it). Q is the reaction quotient; R = 8.31 J K^{-1} mol^{-1}.	$\Delta G = \Delta G^{\ominus} + RT \ln Q$	IN THE BOOKLET
Gibbs energy and equilibrium constant HL content in the IB guide (the booklet does not mark it). With R in J, the answer is in J mol^{-1}.	$\Delta G^{\ominus} = -RT \ln K$	IN THE BOOKLET
Gibbs energy and cell potential HL content in the IB guide (the booklet does not mark it). n electrons transferred, F the Faraday constant, E in V.	$\Delta G^{\ominus} = -nFE^{\ominus}$	IN THE BOOKLET
Arrhenius equation HL content in the IB guide (the booklet does not mark it). k rate constant, A Arrhenius factor, Ea in J mol^{-1}, T in K.	$k = Ae^{\frac{-E_a}{RT}}$	IN THE BOOKLET
Arrhenius equation, linear form HL content in the IB guide (the booklet does not mark it). Plot ln k against 1/T: the gradient is -Ea/R.	$\ln k = \frac{-E_a}{RT} + \ln A$	IN THE BOOKLET
pH (oxonium form) The booklet prints this form and the next as alternatives.	$\mathrm{pH} = -\log_{10}[\mathrm{H_3O^+}]$	IN THE BOOKLET
pH (hydrogen ion form)	$\mathrm{pH} = -\log_{10}[\mathrm{H^+}]$	IN THE BOOKLET
Ionic product of water The value at 298.15 K is in table 2.	$K_w = [\mathrm{H^+}][\mathrm{OH^-}]$	IN THE BOOKLET
pOH HL content in the IB guide (the booklet does not mark it).	$\mathrm{pOH} = -\log_{10}[\mathrm{OH^-}]$	IN THE BOOKLET

2. Physical constants

Quantity	Symbol	Approximate value
Elementary charge	e	1.602177×10^{-19} C
Electron rest mass	m_e	9.109384×10^{-31} kg
Proton rest mass	m_p	1.672622×10^{-27} kg
Neutron rest mass	m_n	1.674927×10^{-27} kg
Speed of light in vacuum	c	3.00×10^{8} m s^{-1}
Planck constant	h	6.63×10^{-34} J s
Avogadro constant	N_A	6.02×10^{23} mol^{-1}
Gas constant	R	8.31 J K^{-1} mol^{-1}
Molar volume of an ideal gas at STP	V_m	2.27×10^{-2} m^3 mol^{-1} = 22.7 dm^3 mol^{-1}
Specific heat capacity of water	c_w	4.18 kJ kg^{-1} K^{-1} = 4.18 J g^{-1} K^{-1}
Ionic product constant for water at 298.15 K	K_w	1.00×10^{-14} mol^2 dm^{-6}
Faraday constant	F	9.65×10^{4} C mol^{-1}

3. Metric (SI) multipliers

Prefix	Abbreviation	Value
peta	P	10^{15}
tera	T	10^{12}

Prefix	Abbreviation	Value
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

4. Unit conversions and standard conditions

Item	Value
Temperature	$T/\mathrm{K} = \theta/^{\circ}\mathrm{C} + 273.15$
Volume	1 dm^3 = 1 litre = 1×10^{-3} m^3 = 1×10^{3} cm^3
STP conditions	273.15 K and 100 kPa
SATP conditions	298.15 K and 100 kPa

5. The electromagnetic spectrum

The booklet draws a wavelength scale from 10^{-16} m to 10^{8} m with these regions in order and energy increasing towards short wavelengths. It prints no boundary wavelengths between regions, so none are given here.

Region, shortest wavelength first	Note
Gamma rays	Highest energy
X-rays	
UV	
Visible light	VIBGYOR from 400 nm (violet) to 700 nm (red)
IR	
Microwaves	
Radio waves	Lowest energy

6. Names of the elements

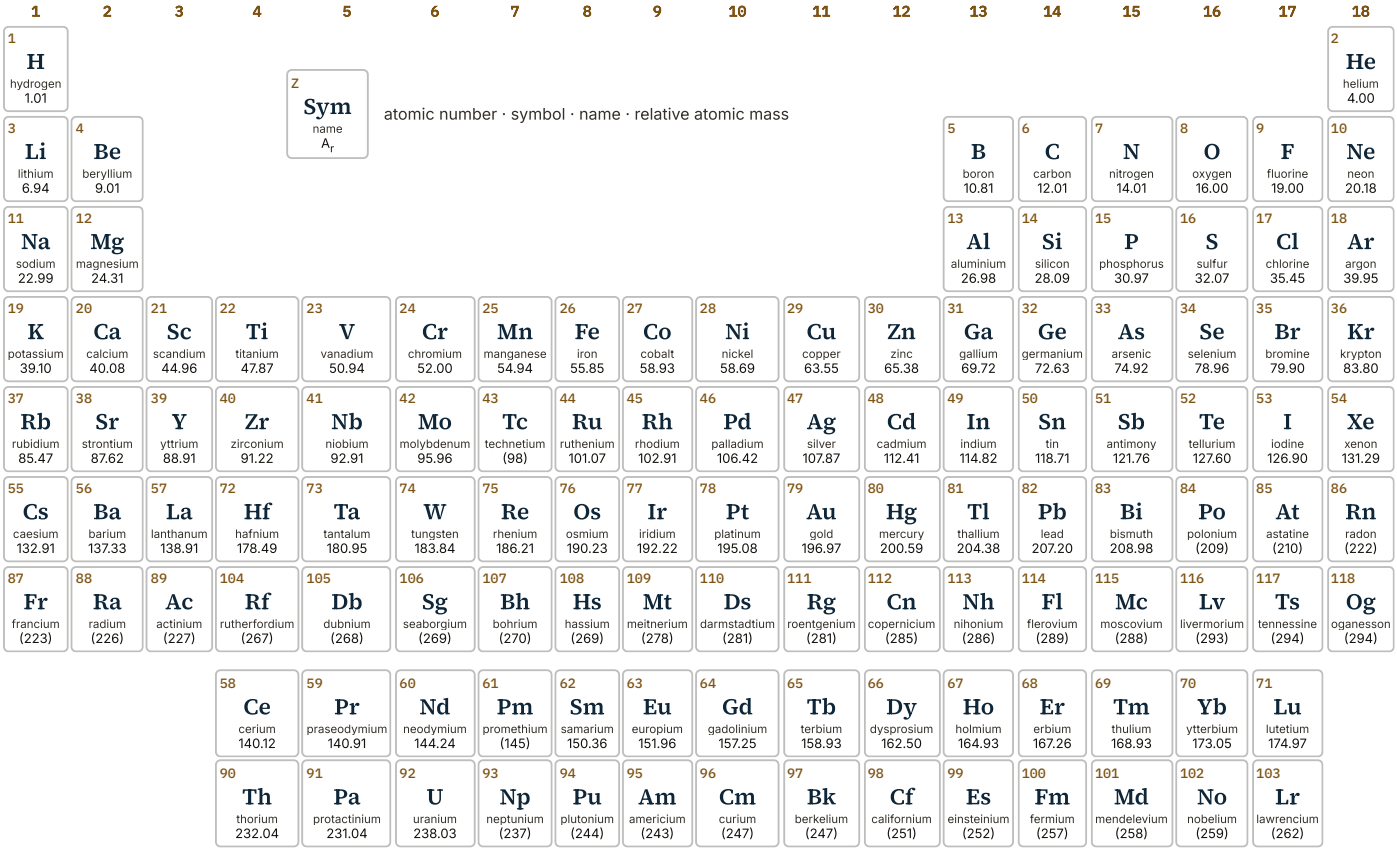
Alphabetical, as printed.

Element	Symbol	Atomic number	Element	Symbol	Atomic number	Element	Symbol	Atomic number
actinium	Ac	89	hafnium	Hf	72	praseodymium	Pr	59
aluminium	Al	13	hassium	Hs	108	promethium	Pm	61
americium	Am	95	helium	He	2	protactinium	Pa	91
antimony	Sb	51	holmium	Ho	67	radium	Ra	88
argon	Ar	18	hydrogen	H	1	radon	Rn	86
arsenic	As	33	indium	In	49	rhenium	Re	75
astatine	At	85	iodine	I	53	rhodium	Rh	45
barium	Ba	56	iridium	Ir	77	roentgenium	Rg	111
berkelium	Bk	97	iron	Fe	26	rubidium	Rb	37
beryllium	Be	4	krypton	Kr	36	ruthenium	Ru	44

Element	Symbol	Atomic number	Element	Symbol	Atomic number	Element	Symbol	Atomic number
bismuth	Bi	83	lanthanum	La	57	rutherfordium	Rf	104
bohrium	Bh	107	lawrencium	Lr	103	samarium	Sm	62
boron	B	5	lead	Pb	82	scandium	Sc	21
bromine	Br	35	lithium	Li	3	seaborgium	Sg	106
cadmium	Cd	48	livermorium	Lv	116	selenium	Se	34
caesium	Cs	55	lutetium	Lu	71	silicon	Si	14
calcium	Ca	20	magnesium	Mg	12	silver	Ag	47
californium	Cf	98	manganese	Mn	25	sodium	Na	11
carbon	C	6	meitnerium	Mt	109	strontium	Sr	38
cerium	Ce	58	mendelevium	Md	101	sulfur	S	16
chlorine	Cl	17	mercury	Hg	80	tantalum	Ta	73
chromium	Cr	24	molybdenum	Mo	42	technetium	Tc	43
cobalt	Co	27	moscovium	Mc	115	tellurium	Te	52
copernicium	Cn	112	neodymium	Nd	60	tennessine	Ts	117
copper	Cu	29	neon	Ne	10	terbium	Tb	65
curium	Cm	96	neptunium	Np	93	thallium	Tl	81
darmstadtium	Ds	110	nickel	Ni	28	thorium	Th	90
dubnium	Db	105	nihonium	Nh	113	thulium	Tm	69
dysprosium	Dy	66	niobium	Nb	41	tin	Sn	50
einsteinium	Es	99	nitrogen	N	7	titanium	Ti	22
erbium	Er	68	nobelium	No	102	tungsten	W	74
europium	Eu	63	oganesson	Og	118	uranium	U	92
fermium	Fm	100	osmium	Os	76	vanadium	V	23
flerovium	Fl	114	oxygen	O	8	xenon	Xe	54
fluorine	F	9	palladium	Pd	46	ytterbium	Yb	70
francium	Fr	87	phosphorus	P	15	yttrium	Y	39
gadolinium	Gd	64	platinum	Pt	78	zinc	Zn	30
gallium	Ga	31	plutonium	Pu	94	zirconium	Zr	40
germanium	Ge	32	polonium	Po	84			
gold	Au	79	potassium	K	19			

7. The periodic table

Groups 1 to 18 as printed, with atomic number, symbol and relative atomic mass. Values in brackets are shown exactly as printed. La and Ac sit in group 3, with cerium to lutetium and thorium to lawrencium in the two rows below, as printed.



8. Melting points and boiling points of the elements at 101.325 kPa

Elements 1 to 103 only; elements 104 to 118 are not in this table. Bracketed values are shown as printed. A blank means no value is printed.

Z	Element	Melting point / °C	Boiling point / °C	Z	Element	Melting point / °C	Boiling point / °C
1	H	−259.2	−252.9	53	I	113.7	184.4
2	He		−268.9	54	Xe	−111.8	−108.1
3	Li	180.5	1342	55	Cs	28.44	670.8
4	Be	1287	2468	56	Ba	725.0	1845
5	B	2077	4000	57	La †	920.0	3464
6	C	3500	4827	58	Ce	795	3433
7	N	−210.0	−195.8	59	Pr	935	3510
8	O	−218.8	−183.0	60	Nd	1024	3074
9	F	−219.7	−188.1	61	Pm	1042	(2730)
10	Ne	−248.6	−246.0	62	Sm	1072	1791
11	Na	97.79	882.9	63	Eu	826	1596
12	Mg	650.0	1090	64	Gd	1313	3273
13	Al	660.3	2519	65	Tb	1360	3230
14	Si	1414	3265	66	Dy	1410	2567
15	P	44.15	280.5	67	Ho	1472	2694
16	S	115.2	444.6	68	Er	1529	2900
17	Cl	−101.5	−34.04	69	Tm	1545	1950
18	Ar	−189.3	−185.8	70	Yb	824	1194
19	K	63.38	758.8	71	Lu	1663	3402

Z	Element	Melting point / °C	Boiling point / °C	Z	Element	Melting point / °C	Boiling point / °C
20	Ca	842.0	1484	72	Hf	2233	4600
21	Sc	1541	2836	73	Ta	3017	5455
22	Ti	1670	3287	74	W	3414	5555
23	V	1910	3407	75	Re	3453	5900
24	Cr	1907	2671	76	Os	3033	5008
25	Mn	1246	2061	77	Ir	2446	4428
26	Fe	1538	2861	78	Pt	1768	3825
27	Co	1495	2927	79	Au	1064	2836
28	Ni	1455	2913	80	Hg	−38.83	356.6
29	Cu	1085	2560	81	Tl	303.8	1473
30	Zn	419.5	907.0	82	Pb	327.5	1749
31	Ga	29.77	2229	83	Bi	271.4	1564
32	Ge	938.2	2833	84	Po	253.8	962.0
33	As	816.8	613.0	85	At	301.8	336.8
34	Se	220.8	684.8	86	Rn	−71.15	−61.85
35	Br	−7.050	58.78	87	Fr	27.00	676.8
36	Kr	−157.4	−153.4	88	Ra	699.8	1140
37	Rb	39.30	687.8	89	Ac ‡	1050	3200
38	Sr	768.8	1377	90	Th	1750	4788
39	Y	1522	3345	91	Pa	1572	(4000)
40	Zr	1854	4406	92	U	1135	3818
41	Nb	2477	4741	93	Np	637	(3900)
42	Mo	2622	4639	94	Pu	640	3230
43	Tc	2157	4262	95	Am	1176	(2067)
44	Ru	2333	4147	96	Cm	1340	3110
45	Rh	1963	3695	97	Bk	986	(2623)
46	Pd	1555	2963	98	Cf	900	
47	Ag	961.8	2162	99	Es	(860)	
48	Cd	321.1	766.8	100	Fm		
49	In	156.6	2027	101	Md	827	
50	Sn	231.9	2586	102	No		
51	Sb	630.6	1587	103	Lr		
52	Te	449.5	987.8				

9. First ionization energy, electron affinity and electronegativity of the elements

Elements 1 to 103 only. Electronegativity has no unit. The second electron affinity is printed in brackets under oxygen and sulfur. A blank means no value is printed.

Z	Element	First ionization energy / kJ mol^{-1}	Electron affinity (EA) / kJ mol^{-1}	2nd EA / kJ mol^{-1}	Electronegativity
1	H	1312	−73		2.2
2	He	2372			
3	Li	520	−60		1.0
4	Be	900			1.6
5	B	801	−27		2.0
6	C	1086	−122		2.6

Z	Element	First ionization energy / kJ mol^{-1}	Electron affinity (EA) / kJ mol^{-1}	2nd EA / kJ mol^{-1}	Electronegativity
7	N	1402			3.0
8	O	1314	−141	(+753)	3.4
9	F	1681	−328		4.0
10	Ne	2081			
11	Na	496	−53		0.9
12	Mg	738			1.3
13	Al	578	−42		1.6
14	Si	787	−134		1.9
15	P	1012	−72		2.2
16	S	1000	−200	(+545)	2.6
17	Cl	1251	−349		3.2
18	Ar	1520			
19	K	419	−48		0.8
20	Ca	590	−2		1.0
21	Sc	633	−18		1.4
22	Ti	659	−8		1.5
23	V	651	−51		1.6
24	Cr	653	−64		1.7
25	Mn	717			1.6
26	Fe	762	−15		1.8
27	Co	760	−64		1.9
28	Ni	737	−112		1.9
29	Cu	745	−119		1.9
30	Zn	906			1.6
31	Ga	579	−41		1.8
32	Ge	762	−119		2.0
33	As	944	−78		2.2
34	Se	941	−195		2.6
35	Br	1140	−325		3.0
36	Kr	1351			
37	Rb	403	−47		0.8
38	Sr	549	−5		1.0
39	Y	600	−30		1.2
40	Zr	640	−41		1.3
41	Nb	652	−88		1.6
42	Mo	684	−72		2.2
43	Tc	702	−53		2.1
44	Ru	710	−101		2.2
45	Rh	720	−110		2.3
46	Pd	804	−54		2.2
47	Ag	731	−126		1.9
48	Cd	868			1.7
49	In	558	−29		1.8
50	Sn	709	−107		2.0

Z	Element	First ionization energy / kJ mol^{-1}	Electron affinity (EA) / kJ mol^{-1}	2nd EA / kJ mol^{-1}	Electronegativity
51	Sb	831	−101		2.0
52	Te	869	−190		2.1
53	I	1008	−295		2.7
54	Xe	1170			
55	Cs	376	−46		0.8
56	Ba	503	−14		0.9
57	La †	538	−45		1.1
58	Ce	534	−63		1.1
59	Pr	528	−93		1.1
60	Nd	533	−185		1.1
61	Pm	539			
62	Sm	545			1.2
63	Eu	547	−83		
64	Gd	593			1.2
65	Tb	566	−112		
66	Dy	573	< 0		1.2
67	Ho	581			1.2
68	Er	589			1.2
69	Tm	597	−99		1.3
70	Yb	603	2		
71	Lu	524	−33		1.0
72	Hf	659	−1		1.3
73	Ta	728	−31		1.5
74	W	759	−79		1.7
75	Re	756	−14		1.9
76	Os	814	−106		2.2
77	Ir	865	−151		2.2
78	Pt	864	−205		2.2
79	Au	890	−223		2.4
80	Hg	1007			1.9
81	Tl	589	−36		1.8
82	Pb	716	−35		1.8
83	Bi	703	−91		1.9
84	Po	812	−183		2.0
85	At		−270		2.2
86	Rn	1037			
87	Fr	393	−47		0.7
88	Ra	509	−10		0.9
89	Ac ‡	499	−34		1.1
90	Th	609			1.3
91	Pa	568			1.5
92	U	598			1.7
93	Np	605			1.3
94	Pu	581			1.3

Z	Element	First ionization energy / kJ mol^{-1}	Electron affinity (EA) / kJ mol^{-1}	2nd EA / kJ mol^{-1}	Electronegativity
95	Am	576			
96	Cm	578			
97	Bk	598			
98	Cf	606			
99	Es	619			
100	Fm	627			
101	Md	635			
102	No	642			
103	Lr	473			

10. Atomic and ionic radii of the elements

The atomic radii are covalent radii. Elements 1 to 103 only. Where an element has more than one ion, each is listed with its charge.

Z	Element	Atomic radius / 10^{-12} m	Ionic radius / 10^{-12} m (charge)
1	H	32	
2	He	37	
3	Li	130	76 (1+)
4	Be	99	45 (2+)
5	B	84	27 (3+)
6	C	75	16 (4+)
7	N	71	146 (3−)
8	O	64	140 (2−)
9	F	60	133 (1−)
10	Ne	62	
11	Na	160	102 (1+)
12	Mg	140	72 (2+)
13	Al	124	54 (3+)
14	Si	114	40 (4+)
15	P	109	38 (5+)
16	S	104	184 (2−)
17	Cl	100	181 (1−)
18	Ar	101	
19	K	200	138 (1+)
20	Ca	174	100 (2+)
21	Sc	159	75 (3+)
22	Ti	148	86 (2+); 61 (4+)
23	V	144	79 (2+); 54 (5+)
24	Cr	130	62 (3+); 44 (6+)
25	Mn	129	83 (2+); 53 (4+)
26	Fe	124	61 (2+); 55 (3+)
27	Co	118	65 (2+); 55 (3+)
28	Ni	117	69 (2+)
29	Cu	122	77 (1+); 73 (2+)
30	Zn	120	74 (2+)
31	Ga	123	62 (3+)

Z	Element	Atomic radius / 10^{-12} m	Ionic radius / 10^{-12} m (charge)
32	Ge	120	53 (4+); 272 (4−)
33	As	120	58 (3+); 46 (5+)
34	Se	118	198 (2−)
35	Br	117	196 (1−)
36	Kr	116	
37	Rb	215	152 (1+)
38	Sr	190	118 (2+)
39	Y	176	90 (3+)
40	Zr	164	72 (4+)
41	Nb	156	72 (3+); 64 (5+)
42	Mo	146	65 (4+)
43	Tc	138	65 (4+)
44	Ru	136	68 (3+); 62 (4+)
45	Rh	134	67 (3+); 60 (4+)
46	Pd	130	86 (2+); 62 (4+)
47	Ag	136	115 (1+)
48	Cd	140	95 (2+)
49	In	142	80 (+3)
50	Sn	140	118 (2+); 69 (4+)
51	Sb	140	76 (3+)
52	Te	137	221 (2−)
53	I	136	220 (1−)
54	Xe	136	
55	Cs	238	167 (1+)
56	Ba	206	135 (2+)
57	La †	194	103 (3+)
58	Ce	184	101 (3+); 87 (4+)
59	Pr	190	99 (3+); 85 (4+)
60	Nd	188	98 (3+)
61	Pm	186	97 (3+)
62	Sm	185	96 (3+)
63	Eu	183	117 (2+); 95 (3+)
64	Gd	182	94 (3+)
65	Tb	181	92 (3+); 76 (4+)
66	Dy	180	91 (3+)
67	Ho	179	90 (+3)
68	Er	177	89 (3+)
69	Tm	177	88 (3+)
70	Yb	178	87 (3+)
71	Lu	174	86 (3+)
72	Hf	164	71 (4+)
73	Ta	158	64 (5+)
74	W	150	66 (4+); 60 (6+)
75	Re	141	63 (4+); 53 (7+)

Z	Element	Atomic radius / 10^{-12} m	Ionic radius / 10^{-12} m (charge)
76	Os	136	63 (4+); 55 (6+)
77	Ir	132	68 (3+); 63 (4+)
78	Pt	130	80 (2+); 63 (4+)
79	Au	130	137 (1+); 85 (3+)
80	Hg	132	119 (1+); 102 (2+)
81	Tl	144	150 (1+); 89 (3+)
82	Pb	145	119 (2+); 78 (4+)
83	Bi	150	103 (3+); 76 (5+)
84	Po	142	97 (4+)
85	At	148	
86	Rn	146	
87	Fr	242	
88	Ra	211	
89	Ac ‡	201	
90	Th	190	94 (4+)
91	Pa	184	104 (3+); 90 (4+)
92	U	183	89 (4+); 73 (6+)
93	Np	180	101 (3+); 87 (4+)
94	Pu	180	100 (3+); 86 (4+)
95	Am	173	98 (3+); 85 (4+)
96	Cm	168	97 (3+)
97	Bk	168	96 (3+)
98	Cf	168	95 (3+)
99	Es	165	
100	Fm	167	
101	Md	173	
102	No	176	110 (2+)
103	Lr	161	

11. Covalent or average covalent bond lengths: single bonds

Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m
H-H	74	N-S	175	P-S	210
H-F	92	N-F	136	P-F	154
H-Cl	128	N-Cl	197	P-Cl	203
H-Br	141	N-Br	214	P-Br	220
H-I	160	O-H	97	P-I	247
C-H	108	O-O	148	S-H	134
C-C	154	O-Si	163	S-S	205
C-N	147	O-P	154	S-F	158
C-O	143	O-S	161	S-Cl	199
C-Si	185	O-F	142	S-Br	227
C-P	184	O-Cl	170	F-F	142
C-S	182	Si-H	148	F-Cl	163
C-F	138	Si-Si	232	F-Br	176

Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m
C-Cl	177	Si-S	215	F-I	191
C-Br	194	Si-F	156	Cl-Cl	199
C-I	214	Si-Cl	202	Cl-Br	214
N-H	101	Si-Br	216	Cl-I	232
N-N	146	Si-I	243	Br-Br	228
N-O	136	P-H	142	Br-I	247
N-Si	174	P-P	221	I-I	267

11. Covalent or average covalent bond lengths: multiple bonds

Double bonds are written with =; triple bonds are written with three lines.

Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m	Bond	Length / 10^{-12} m
C=C	134	$C \equiv N$	116	O=O	121
C=N	130	$C \equiv O$	113	O=S	143
C=O	122	N=N	125	S=S	189
C=S	156	N=O	114		
$C \equiv C$	120	$N \equiv N$	110		

12. Bond enthalpies or average bond enthalpies at 298.15 K: single bonds

Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}
H-H	436	N-F	278	P-F	490
H-F	567	N-Cl	192	P-Cl	322
H-Cl	431	O-H	463	P-Br	264
H-Br	366	O-O	144	P-I	184
H-I	298	O-Si	466	S-H	364
C-H	414	O-P	363	S-S	266
C-C	346	O-F	191	S-F	327
C-N	286	O-Cl	206	S-Cl	271
C-O	358	O-Br	201	S-Br	218
C-Si	307	O-I	201	F-F	159
C-P	264	Si-H	323	F-Cl	255
C-S	289	Si-Si	226	F-Br	249
C-F	492	Si-S	293	F-I	280
C-Cl	324	Si-F	597	Cl-Cl	242
C-Br	285	Si-Cl	400	Cl-Br	219
C-I	228	Si-Br	330	Cl-I	211
N-H	391	Si-I	234	Br-Br	193
N-N	158	P-H	322	Br-I	178
N-O	214	P-P	198	I-I	151

12. Bond enthalpies or average bond enthalpies at 298.15 K: multiple bonds

Double bonds are written with =; triple bonds are written with three lines.

Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}
C=C	614	$C \equiv N$	890	O=O	498
C=N	615	$C \equiv O$	1077	O=S	522

Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}
C=O	804	N=N	470	S=S	429
C=S	536	N=O	587		
$\mathrm{C \equiv C}$	839	$\mathrm{N \equiv N}$	945		

13. Thermodynamic data (selected compounds)

A blank means no value is printed.

Substance	Formula	State	$\Delta H_f^\ominus$ / kJ mol^{-1}	$\Delta G_f^\ominus$ / kJ mol^{-1}	$S^\ominus$ / J K^{-1} mol^{-1}
methane	CH_4	g	−74	−50	+186
ethane	C_2H_6	g	−84	−32	+230
propane	C_3H_8	g	−105	−24	+270
butane	C_4H_{10}	g	−126	−17	+310
pentane	C_5H_{12}	l	−173		
hexane	C_6H_{14}	l	−199		
ethene	C_2H_4	g	+52	+68	+220
propene	C_3H_6	g	+20	+62	+267
but-1-ene	C_4H_8	g	+0.1	+71	+306
cis-but-2-ene	C_4H_8	g	−7	+66	+301
trans-but-2-ene	C_4H_8	g	−11	+63	+297
ethyne	C_2H_2	g	+228	+211	+201
propyne	C_3H_4	g	+185	+194	+248
buta-1,3-diene	C_4H_6	g	+110	+151	+279
cyclohexane	C_6H_{12}	l	−156		
benzene	C_6H_6	l	+49	+125	+173
methylbenzene	$C_6H_5CH_3$	l	+12		
ethylbenzene	$C_6H_5CH_2CH_3$	l	−12		
phenylethene	$C_6H_5CHCH_2$	l	+104		
chloromethane	CH_3Cl	g	−82	−58	+235
dichloromethane	CH_2Cl_2	l	−124		+178
trichloromethane	$CHCl_3$	l	−134	−74	+202
bromomethane	CH_3Br	g	−36	−26	+246
iodomethane	CH_3I	l	−14		+163
chloroethane	C_2H_5Cl	g	−137	−53	
bromoethane	C_2H_5Br	l	−90	−26	+199
chlorobenzene	C_6H_5Cl	l	+11		
methanol	CH_3OH	l	−239	−167	+127
ethanol	C_2H_5OH	l	−278	−175	+161
phenol	C_6H_5OH	s	−165		+144
methanal	$HCHO$	g	−109	−102	+219
ethanal	CH_3CHO	g	−166	−133	+264
propanone	$(CH_3)_2CO$	l	−248		+200
methanoic acid	$HCOOH$	l	−425	−361	+129
ethanoic acid	CH_3COOH	l	−484	−390	+160
benzoic acid	C_6H_5COOH	s	−385		+168
methylamine	CH_3NH_2	g	−23	+32	+243

Substance	Formula	State	$\Delta H_f^\ominus$ / kJ mol^{-1}	$\Delta G_f^\ominus$ / kJ mol^{-1}	$S^\ominus$ / J K^{-1} mol^{-1}
water	H_2O	l	−286	−237	+70
steam	H_2O	g	−242	−229	+189
carbon monoxide	CO	g	−111	−137	+198
carbon dioxide	CO_2	g	−394	−394	+214
hydrogen bromide	HBr	g	−36	−53	+199
hydrogen chloride	HCl	g	−92	−95	+187
hydrogen fluoride	HF	g	−273	−275	+174
hydrogen iodide	HI	g	+26	+2	+207

14. Enthalpies of combustion

Molar enthalpies of combustion at 298.15 K and 100 kPa.

Substance	Formula	State	$\Delta H_c^\ominus$ / kJ mol^{-1}
hydrogen	H_2	g	−286
sulfur	S	s	−297
carbon (graphite)	C	s	−394
carbon monoxide	CO	g	−283
methane	CH_4	g	−891
ethane	C_2H_6	g	−1561
propane	C_3H_8	g	−2219
butane	C_4H_{10}	g	−2878
pentane	C_5H_{12}	l	−3509
hexane	C_6H_{14}	l	−4163
octane	C_8H_{18}	l	−5470
cyclohexane	C_6H_{12}	l	−3920
ethene	C_2H_4	g	−1411
buta-1,3-diene	C_4H_6	g	−2541
ethyne	C_2H_2	g	−1301
benzene	C_6H_6	l	−3268
methylbenzene	$C_6H_5CH_3$	l	−3910
naphthalene	$C_{10}H_8$	s	−5156
chloroethane	C_2H_5Cl	g	−1413
iodoethane	C_2H_5I	l	−1463
trichloromethane	$CHCl_3$	l	−473
methanol	CH_3OH	l	−726
ethanol	C_2H_5OH	l	−1367
propan-1-ol	C_3H_7OH	l	−2021
butan-1-ol	C_4H_9OH	l	−2676
cyclohexanol	$C_6H_{11}OH$	s	−3728
phenol	C_6H_5OH	s	−3053
ethoxyethane	$(C_2H_5)_2O$	l	−2724
methanal	HCHO	g	−571
ethanal	CH_3CHO	g	−1167
benzaldehyde	C_6H_5CHO	l	−3525
propanone	$(CH_3)_2CO$	l	−1790

Substance	Formula	State	$\Delta H_c^\ominus$ / kJ mol^{-1}
pentan-3-one	$(C_2H_5)_2CO$	l	−3100
phenylethanone	$CH_3COC_6H_5$	l	−4149
methanoic acid	HCOOH	l	−255
ethanoic acid	CH_3COOH	l	−874
benzoic acid	C_6H_5COOH	s	−3228
ethanedioic acid	$(COOH)_2$	s	−243
ethyl ethanoate	$CH_3COOC_2H_5$	l	−2238
ethanamide	CH_3CONH_2	s	−1186
methylamine	CH_3NH_2	g	−1086
phenylamine	$C_6H_5NH_2$	l	−3393
nitrobenzene	$C_6H_5NO_2$	l	−3088
urea	$CO(NH_2)_2$	s	−633
glucose	$C_6H_{12}O_6$	s	−2803
sucrose	$C_{12}H_{22}O_{11}$	s	−5640

15. Colour wheel with wavelengths of the visible spectrum

The wheel is a circle in six equal sectors with the wavelength printed at each boundary. The opposite colour is the sector directly across the wheel.

Colour	Wavelength range / nm	Opposite colour on the wheel
Violet	400 to 424	Yellow
Blue	424 to 491	Orange
Green	491 to 575	Red
Yellow	575 to 585	Violet
Orange	585 to 647	Blue
Red	647 to 700	Green

16. Lattice enthalpies at 298.15 K (experimental values): alkali metal halides

The values are for the endothermic process in which the gaseous ions of a crystal are separated to an infinite distance. They are experimental values from Born-Haber cycles.

$\Delta H_{\text{lattice}}^\ominus$ / kJ mol^{-1}	F	Cl	Br	I
Li	1049	864	820	764
Na	930	790	754	705
K	829	720	691	650
Rb	795	695	668	632
Cs	759	670	647	613

16. Lattice enthalpies at 298.15 K (experimental values): other substances

Substance	$\Delta H_{\text{lattice}}^\ominus$ / kJ mol^{-1}	Substance	$\Delta H_{\text{lattice}}^\ominus$ / kJ mol^{-1}
CaF_2	2651	SrO	3223
$BeCl_2$	3033	BaO	3054
$MgCl_2$	2540	$CuCl_2$	2824
$CaCl_2$	2271	AgF	974
$SrCl_2$	2170	AgCl	918
$BaCl_2$	2069	AgBr	905
MgO	3791	AgI	892

Substance	$\Delta H^{\ominus}_{\text{lattice}}$ / kJ mol^{-1}	Substance	$\Delta H^{\ominus}_{\text{lattice}}$ / kJ mol^{-1}
CaO	3401		

17. Triangular bonding diagram (van Arkel-Ketelaar triangle): formulas

The two quantities that place a compound on the triangle.

Electronegativity difference
χa and χb are the electronegativities of the two elements. Vertical axis.

$$\Delta\chi = |\chi_a - \chi_b|$$

IN THE BOOKLET

Average electronegativity
Horizontal axis. The booklet prints this with a sigma sign.

$$\overline{\chi} = \frac{\chi_a + \chi_b}{2}$$

IN THE BOOKLET

17. Triangular bonding diagram (van Arkel-Ketelaar triangle): what the diagram shows

The triangle is a drawing, so only its labels, axes and scales are written out here. Look up the region boundaries on the booklet diagram itself.

Item	What is printed
Regions labelled	Ionic, polar covalent, metallic and covalent (a shaded triangle drawing)
Vertical axis	Electronegativity difference, 0 to 3.0 in steps of 0.5
Horizontal axis	Average electronegativity, labelled 0.79, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0
Scale on the right: % covalent and % ionic	8 and 92; 25 and 75; 50 and 50; 75 and 25; 100 and 0

18. Acid-base indicators

Indicator	pKa	pH range	Colour in acid	Colour in alkali
methyl orange	3.7	3.1 to 4.4	red	yellow
bromophenol blue	4.2	3.0 to 4.6	yellow	blue
bromocresol green	4.7	4.0 to 5.6	yellow	blue
methyl red	5.1	4.4 to 6.2	red	yellow
bromothymol blue	7.0	6.0 to 7.6	yellow	blue
phenol red	7.9	6.4 to 8.0	yellow	red
phenolphthalein	9.6	8.0 to 10.0	colourless	pink

19. Standard reduction potentials at 298.15 K

Each half-equation is written as printed, as a reduction with the reversible arrow.

Half-equation (oxidized species on the left, reduced species on the right)	$E^{\ominus}$ / V
$\mathrm{Li^+(aq) + e^- \rightleftharpoons Li(s)}$	−3.04
$\mathrm{K^+(aq) + e^- \rightleftharpoons K(s)}$	−2.93
$\mathrm{Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)}$	−2.87
$\mathrm{Na^+(aq) + e^- \rightleftharpoons Na(s)}$	−2.71
$\mathrm{Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)}$	−2.37
$\mathrm{Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)}$	−1.66
$\mathrm{Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)}$	−1.18
$\mathrm{H_2O(l) + e^- \rightleftharpoons \tfrac{1}{2}H_2(g) + OH^-(aq)}$	−0.83
$\mathrm{Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)}$	−0.76
$\mathrm{Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)}$	−0.45
$\mathrm{Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)}$	−0.26
$\mathrm{Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)}$	−0.14
$\mathrm{Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)}$	−0.13
$\mathrm{H^+(aq) + e^- \rightleftharpoons \tfrac{1}{2}H_2(g)}$	0.00

Half-equation (oxidized species on the left, reduced species on the right)	$E^{\ominus}$ / V
$Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$	+0.15
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons H_2SO_3(aq) + H_2O(l)$	+0.17
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq)$	+0.40
$Cu^+(aq) + e^- \rightleftharpoons Cu(s)$	+0.52
$\frac{1}{2}I_2(s) + e^- \rightleftharpoons I^-(aq)$	+0.54
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$\frac{1}{2}Br_2(l) + e^- \rightleftharpoons Br^-(aq)$	+1.09
$\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O(l)$	+1.23
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$	+1.36
$\frac{1}{2}Cl_2(g) + e^- \rightleftharpoons Cl^-(aq)$	+1.36
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$\frac{1}{2}F_2(g) + e^- \rightleftharpoons F^-(aq)$	+2.87

20. Infrared data

Characteristic ranges for infrared absorption due to stretching vibrations in organic molecules.

Bond	Types of organic molecules	Wavenumber / cm^{-1}	Intensity
C-I	iodoalkanes	490 to 620	strong
C-Br	bromoalkanes	500 to 600	strong
C-Cl	chloroalkanes	600 to 800	strong
C-F	fluoroalkanes	1000 to 1400	strong
C-O	alcohols, esters, ethers	1050 to 1410	strong
C=C	alkenes	1620 to 1680	medium-weak; multiple bands
C=O	aldehydes, ketones, carboxylic acids and esters	1700 to 1750	strong
$C \equiv C$	alkynes	2100 to 2260	variable
O-H	carboxylic acids (with hydrogen bonding)	2500 to 3000	strong, very broad
C-H	alkanes, alkenes, arenes	2850 to 3090	strong
O-H	alcohols and phenols (with hydrogen bonding)	3200 to 3600	strong, broad
N-H	primary amines	3300 to 3500	medium; two bands

21. 1H NMR data

Typical proton chemical shifts relative to TMS. R is an alkyl group and Hal is F, Cl, Br or I. Values may vary with solvent and conditions. The booklet draws these as structures, written here in text.

Type of proton (bold H is the proton described)	In words	Chemical shift / ppm
$-C\mathbf{H}_3$	methyl group	0.9 to 1.0
$-C\mathbf{H}_2-R$	CH2 in an alkyl chain	1.3 to 1.4
$-C\mathbf{H}R_2$	CH with two alkyl groups	1.5
$RO-C(=O)-C\mathbf{H}_2-$	CH2 next to the C=O of an ester (acid side)	2.0 to 2.5
$R-C(=O)-C\mathbf{H}_2-$	CH2 next to the C=O of a ketone or aldehyde	2.2 to 2.7
$Ar-C\mathbf{H}_3$	CH3 on a benzene ring (Ar = benzene ring)	2.5 to 3.5
$-C \equiv C-\mathbf{H}$	hydrogen on a terminal alkyne	1.8 to 3.1
$-C\mathbf{H}_2-Hal$	CH2 next to a halogen (Hal = F, Cl, Br or I)	3.5 to 4.4
$R-O-C\mathbf{H}_2-$	CH2 next to the O of an ether or alcohol	3.3 to 3.7
$R-C(=O)-O-C\mathbf{H}_2-$	CH2 on the alcohol side of an ester	3.7 to 4.8

Type of proton (bold H is the proton described)	In words	Chemical shift / ppm
$\mathrm{R-C(=O)-O-\mathbf{H}}$	carboxylic acid O-H	9.0 to 13.0
$\mathrm{R-O-\mathbf{H}}$	alcohol O-H	1.0 to 6.0
$\mathrm{-CH=C\mathbf{H}_2}$	hydrogen on an alkene C=C	4.5 to 6.0
$\mathrm{Ar-O\mathbf{H}}$	phenol O-H (OH on a benzene ring)	4.0 to 12.0
$\mathrm{Ar-\mathbf{H}}$	hydrogen on a benzene ring	6.9 to 9.0
$\mathrm{R-C(=O)-\mathbf{H}}$	aldehyde hydrogen	9.4 to 10.0

22. Mass spectral fragments lost

Mass lost (M_r)	Possible neutral fragment lost
15	•CH_3
17	•OH
18	H_2O
28	CH_2=CH_2 or CO
29	•CH_2CH_3 or •CHO
31	•OCH_3
45	•COOH

23. Uncertainties

Three propagation rules for processed data (added in the February 2024 version).

Adding or subtracting measurements
Add the absolute uncertainties, even when you subtract the values.

$$y = a \pm b \;\Rightarrow\; \Delta y = \Delta a + \Delta b$$

IN THE BOOKLET

Multiplying or dividing measurements
Add the fractional (percentage) uncertainties.

$$y = \frac{ab}{c} \;\Rightarrow\; \frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$$

IN THE BOOKLET

Raising to a power
Multiply the fractional uncertainty by the size of the power.

$$y = a^n \;\Rightarrow\; \frac{\Delta y}{y} = \left| n\frac{\Delta a}{a} \right|$$

IN THE BOOKLET

Learn these: not in the booklet

Number of particles

$$N = nN_A$$

Relative atomic mass from isotopes

$$A_r = \frac{\sum(\text{abundance} \times \text{isotope mass})}{\sum \text{abundance}}$$

Gas volume at STP

$$n = \frac{V}{V_m}, \quad V_m = 22.7\ \mathrm{dm^3\,mol^{-1}}$$

The value is printed; the relationship is not.

Mass concentration

$$\text{concentration in g dm}^{-3} = C \times M$$

Dilution

$$C_1V_1 = C_2V_2$$

Percentage yield

$$\frac{\text{experimental yield}}{\text{theoretical yield}} \times 100$$

Enthalpy change per mole from calorimetry

$$\Delta H = -\frac{Q}{n}$$

Bond enthalpy sum

$$\Delta H = \sum(\text{bonds broken}) - \sum(\text{bonds formed})$$

Rate of reaction

$$\text{rate} = \frac{\Delta[\text{reactant or product}]}{\Delta t}$$

Equilibrium constant expression

$$K_c = \frac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$$

Hydrogen ion concentration

$$[\mathrm{H^+}] = 10^{-\mathrm{pH}}$$

Percentage uncertainty

$$\frac{\Delta a}{a} \times 100$$

Standard entropy change (HL)

$$\Delta S^\circ = \sum S^\circ(\text{products}) - \sum S^\circ(\text{reactants})$$

Reaction quotient (HL)

$$Q = \frac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$$

Uses concentrations that are not at equilibrium.

Rate equation (HL)

$$\text{rate} = k[\mathrm{A}]^m[\mathrm{B}]^n$$

Ionic product link (HL)

$$\mathrm{pH} + \mathrm{pOH} = 14 \text{ at } 298 \text{ K}, and [\mathrm{OH}^-] = 10^{-\mathrm{pOH}}$$

Acid and base constants (HL)

$$K_a = \frac{[\mathrm{H}^+][\mathrm{A}^-]}{[\mathrm{HA}]}, \quad K_b = \frac{[\mathrm{BH}^+][\mathrm{OH}^-]}{[\mathrm{B}]}$$

Conjugate pair relationship (HL)

$$K_a \times K_b = K_w$$

pK values (HL)

$$\mathrm{p}K_a = -\log_{10} K_a, \quad \mathrm{p}K_b = -\log_{10} K_b$$

Buffer pH (HL, derived from the K_a expression)

$$\mathrm{pH} = \mathrm{p}K_a + \log_{10} \frac{[\mathrm{A}^-]}{[\mathrm{HA}]}$$

Standard cell potential (HL)

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

Use standard reduction potentials for both electrodes.

Formal charge (HL)

$$\mathrm{FC} = V - N - \tfrac{1}{2}B$$

V valence electrons, N non-bonding electrons, B bonding electrons.

Using the booklet in the exam

- Work with the booklet open throughout the course so you know where each table sits before the exam.
- Match units before substituting: ΔH is in kJ mol^{-1} but ΔS and R use J, so convert before using ΔG equations.
- The bond enthalpy table gives values only; write the broken minus formed sum yourself and show each bond and its count.
- With the reduction potentials table, do not change the sign of E when you multiply a half-equation to balance electrons.
- For Arrhenius data (HL), plot ln k against 1/T: the gradient is -Ea/R, so convert Ea to kJ mol^{-1} only at the end.

Based on: International Baccalaureate Diploma Programme Chemistry (SL and HL, first assessment 2025), Chemistry data booklet, first assessment 2025, version 1.1. Statistical tables are calculated by CuratedPrep to the same layout. Updated 31 October 2026. Always practise with the version of the official booklet your exam uses. More free sheets and topic worksheets at curatedprep.com.