STUDY FORMULA BOOKLET

AQA A Level Chemistry 7405 data booklet and equations

The AQA booklet prints the periodic table, IR and NMR data and biochemistry structures; you must learn every calculation equation, such as pV = nRT.

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

Based on the official **AQA A-level Chemistry 7405 Data Booklet (insert provided with the question papers, code IB/M/Insert to A-level Chemistry/E8)**, with what to learn and exam tips added by CuratedPrep.

What the data booklet gives you

All of it is printed for the exam. The booklet has no equations and no constants.

Relative atomic mass Page 2, the periodic table: atomic (proton) number, symbol, name and relative atomic mass.	A_r for every element	IN THE BOOKLET
Infrared absorption (Table A) Page 3. Ranges for N-H, O-H, C-H, C≡N, C=O, C=C, C-O and C-C.	C=O: 1680 to 1750 cm^{-1}	IN THE BOOKLET
1H NMR chemical shift (Table B) Page 3. Ranges for 12 types of proton, relative to TMS.	δ for RCH_3 = 0.7 to 1.2 ppm	IN THE BOOKLET
13C NMR chemical shift (Table C) Page 3. Ranges for 10 types of carbon.	δ for C=O (aldehyde or ketone) = 190 to 220 ppm	IN THE BOOKLET
Biochemistry structures Page 4. Structures only; know how they are used in the specification (DNA, proteins).	phosphate, sugars, bases, amino acids, haem B	IN THE BOOKLET

The periodic table of the elements

Printed in the booklet with groups 1 to 7 and 0 and the group numbers (1) to (18) as printed. Masses in square brackets are as printed. La and Ac sit in group 3, with cerium to lutetium and thorium to lawrencium in the two rows below, as printed.

1	2											3	4	5	6	7	0
1 H hydrogen 1.0																	2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 96.0	43 Tc technetium [97]	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57 La lanthanum 138.9	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium [209]	85 At astatine [210]	86 Rn radon [222]
87 Fr francium [223]	88 Ra radium [226]	89 Ac actinium [227]	104 Rf rutherfordium [267]	105 Db dubnium [270]	106 Sg seaborgium [269]	107 Bh bohrium [270]	108 Hs hassium [270]	109 Mt meitnerium [278]	110 Ds darmstadtium [281]	111 Rg roentgenium [281]	112 Cn copernicium [285]	113 Nh nihonium [286]	114 Fl flerovium [289]	115 Mc moscovium [289]	116 Lv livermorium [293]	117 Ts tennessine [294]	118 Og oganesson [294]

			58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium [145]	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0	
			90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium [237]	94 Pu plutonium [244]	95 Am americium [243]	96 Cm curium [247]	97 Bk berkelium [247]	98 Cf californium [251]	99 Es einsteinium [252]	100 Fm fermium [257]	101 Md mendelevium [258]	102 No nobelium [259]	103 Lr lawrencium [262]	

Z Sym name A_r — atomic number · symbol · name · relative atomic mass

Table A: infrared absorption data

Wavenumber ranges for the bond shown.

Bond	Printed note	Wavenumber / cm^{-1}
N-H	amines	3300 to 3500
O-H	alcohols	3230 to 3550
C-H		2850 to 3300
O-H	acids	2500 to 3000
C≡N		2220 to 2260
C=O		1680 to 1750
C=C		1620 to 1680
C-O		1000 to 1300
C-C		750 to 1100

Table B: 1H NMR chemical shift data

The bold H is the proton described.

Type of proton	Description	δ / ppm
$RO\mathbf{H}$	hydroxyl proton	0.5 to 5.0
$RC\mathbf{H}_3$	methyl	0.7 to 1.2
$RN\mathbf{H}_2$	amine N-H	1.0 to 4.5
$R_2C\mathbf{H}_2$	methylene	1.2 to 1.4
$R_3C\mathbf{H}$	methine	1.4 to 1.6
R-CO-C-**H**	H on a carbon next to C=O	2.1 to 2.6

Type of proton	Description	δ / ppm
R-O-C-**H**	H on a carbon next to O	3.1 to 3.9
R**CH**$_2$Cl or Br	H on a carbon next to a halogen	3.1 to 4.2
R-CO-O-C-**H**	H on a carbon next to the O of an ester	3.7 to 4.1
R-C**H**=C	alkene C-H	4.5 to 6.0
R-CO-**H**	aldehyde	9.0 to 10.0
R-CO-O-**H**	carboxylic acid	10.0 to 12.0

Table C: 13C NMR chemical shift data

The bold C is the carbon described.

Type of carbon	Description	δ / ppm
$-\mathbf{C}-\mathbf{C}-$	C-C	5 to 40
R-**C**-Cl or Br	C-halogen	10 to 70
R-CO-**C**-	carbon next to C=O	20 to 50
R-**C**-N	C-N	25 to 60
$-\mathbf{C}$-O-	alcohols, ethers or esters	50 to 90
C=**C**	C=C	90 to 150
R-**C** ≡ N	nitrile	110 to 125
benzene ring (drawn)	aromatic carbon	110 to 160
R-**C**(=O)-	esters or acids	160 to 185
R-**C**(=O)-	aldehydes or ketones	190 to 220

Phosphate, sugars, bases, amino acids and haem B

The booklet draws these as structural or skeletal formulae. They are listed here by name with a short description of the drawing.

Name	Group	How it is drawn
phosphate	phosphate and sugars	P bonded to two OH groups, one P=O and one O with a negative charge
glucose	phosphate and sugars	six-membered ring with one ring O, a CH2OH group and OH groups
2-deoxyribose	phosphate and sugars	five-membered ring with one ring O, a HOCH2 group and OH groups
adenine	bases	fused two-ring base with an NH2 group
guanine	bases	fused two-ring base with a C=O group and an NH2 group
cytosine	bases	single-ring base with an NH2 group and a C=O group
thymine	bases	single-ring base with a CH3 group and two C=O groups
alanine	amino acids	H_2N-CH(CH_3)-COOH
aspartic acid	amino acids	H_2N-CH(CH_2COOH)-COOH
cysteine	amino acids	H_2N-CH(CH_2SH)-COOH
lysine	amino acids	H_2N-CH($CH_2CH_2CH_2CH_2NH_2$)-COOH
phenylalanine	amino acids	H_2N-CH(CH_2-benzene ring)-COOH
serine	amino acids	H_2N-CH(CH_2OH)-COOH
haem B	haem	Fe at the centre of a ring of four nitrogen-containing rings, with CH3, vinyl (CH=CH2) and CH2CH2COOH side groups

Constants and data the question supplies

None of these is printed in the data booklet. The specification says you are not expected to recall R, the Avogadro constant or specific heat capacities; other values are normally given in the question.

Avogadro constant
Not in the booklet. The specification says you will not be expected to recall it.

$$L \approx 6.02 \times 10^{23}\ \text{mol}^{-1}$$

LEARN IT

Gas constant
Not in the booklet. The specification says you will not be expected to recall it. Use it with p in Pa, V in m^3 and T in K.

$$R = 8.31\ \text{J K}^{-1}\,\text{mol}^{-1}$$

LEARN IT

Specific heat capacity of water
Not in the booklet. The specification says you will not be expected to recall c; the question gives the value to use.

$$c = 4.18\ \text{J g}^{-1}\,\text{K}^{-1}$$

LEARN IT

Ionic product of water at 298 K
Not in the booklet. Kw changes with temperature, so use the value in the question for any other temperature.

$$K_\text{w} = 1.00 \times 10^{-14}\ \text{mol}^2\,\text{dm}^{-6}$$

LEARN IT

Electrode potentials, bond enthalpies and entropies
Not in the booklet. Questions normally supply the values they need.

$$E^\ominus\ (\text{V}), \quad \Delta H\ (\text{kJ mol}^{-1}), \quad S^\ominus\ (\text{J K}^{-1}\,\text{mol}^{-1})$$

LEARN IT

Amount of substance and concentration

None of these equations is printed in the AQA booklet. Learn them and the units.

Moles from mass
n in mol, m in g, Mr in g mol^{-1}. Use Ar from the periodic table.

$$n = \frac{m}{M_\text{r}}$$

LEARN IT

Relative atomic mass from isotopes
Use the abundances (or percentages) from the mass spectrum. Give the answer to the number of decimal places asked for.

$$A_\text{r} = \frac{\sum(\text{isotopic abundance} \times \text{isotopic mass})}{\sum \text{abundance}}$$

LEARN IT

Moles in solution
c in mol dm^{-3}, V in dm^3. Convert cm^3 to dm^3 by dividing by 1000.

$$n = c \times V$$

LEARN IT

Concentration
Mass concentration in g dm^{-3} = c x Mr.

$$c = \frac{n}{V}$$

LEARN IT

Number of particles
L is the Avogadro constant. Use it for atoms, molecules, ions or electrons.

$$N = n \times L$$

LEARN IT

Dilution
A rearrangement of n = cV with n unchanged. Keep both volumes in the same unit.

$$c_1V_1 = c_2V_2$$

LEARN IT

Empirical formula
Divide by the smallest number of moles, then scale up if you get halves or thirds.

$$\text{moles of each element} = \frac{\text{mass}}{A_\text{r}} \Rightarrow \text{simplest whole-number ratio}$$

LEARN IT

Ideal gas equation

Ideal gas equation
p in Pa, V in m^3, n in mol, T in K. 1 dm^3 = 1 × 10^{-3} m^3; 1 kPa = 1000 Pa. R is given in the question.

$$pV = nRT$$

LEARN IT

Relative molecular mass of a volatile liquid
Rearranged from pV = nRT with n = m/Mr. Mass in g gives Mr in g mol^{-1}.

$$M_\text{r} = \frac{mRT}{pV}$$

LEARN IT

Percentage yield and atom economy

Percentage yield
Compare moles with moles or mass with mass, not one of each.

$$\%\ \text{yield} = \frac{\text{actual amount of product}}{\text{theoretical amount of product}} \times 100$$

LEARN IT

Percentage atom economy
Use the balanced equation and include the coefficients. This is the AQA definition.

$$\%\ \text{atom economy} = \frac{M_\text{r}\text{ of desired product}}{\text{sum of } M_\text{r}\text{ of all reactants}} \times 100$$

LEARN IT

Energetics: calorimetry, Hess and bond enthalpies

Heat change in calorimetry
m in g (mass of the substance heated, usually the water or solution), c in J g^{-1} K^{-1}, q in J. c is given in the question.

$$q = mc\Delta T$$

LEARN IT

Molar enthalpy change
Convert q to kJ first (divide by 1000) so that the answer is in kJ mol^{-1}. Negative for a temperature rise (exothermic).

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

LEARN IT

Hess's law with formation data
Multiply each value by its coefficient. Elements in their standard states have Delta_f H = 0.

$$\Delta_\text{r}H = \sum \Delta_\text{f}H^\ominus(\text{products}) - \sum \Delta_\text{f}H^\ominus(\text{reactants})$$

LEARN IT

Hess's law with combustion data
Note the reversed order compared with formation data.

$$\Delta_\text{r}H = \sum \Delta_\text{c}H^\ominus(\text{reactants}) - \sum \Delta_\text{c}H^\ominus(\text{products})$$

LEARN IT

Mean bond enthalpies
Gives an approximate value because the bond enthalpies are averages and the species are gases.

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

LEARN IT

Enthalpy of solution from a cycle
A-level only. Lattice dissociation enthalpy is the negative of lattice formation enthalpy.

$$\Delta_\text{sol}H = \Delta H_\text{lattice dissociation} + \sum \Delta_\text{hyd}H$$

LEARN IT

Born-Haber cycle
A-level only. Draw the cycle and apply Hess's law to find any one missing step, usually the lattice enthalpy.

$$\Delta_\text{f}H = \text{atomisation} + \text{ionisation energies} + \text{bond enthalpy terms} + \text{electron affinities} + \text{lattice formation}$$

LEARN IT

Equilibrium: Kc and Kp

For the reaction aA + bB ⇌ cC + dD at a fixed temperature.

Equilibrium constant Kc
Concentrations in mol dm^{-3} at equilibrium. Work out the units from the expression. Only temperature changes Kc.

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

LEARN IT

Equilibrium constant Kp
A-level only. Gases only, partial pressures at equilibrium. Units follow from the pressure unit used.

$$K_p = \frac{p_\text{C}^c\, p_\text{D}^d}{p_\text{A}^a\, p_\text{B}^b}$$

LEARN IT

Mole fraction
Moles of the gas at equilibrium divided by the total moles of gas.

$$x_\text{A} = \frac{n_\text{A}}{n_\text{total}}$$

LEARN IT

Partial pressure
The partial pressures add up to the total pressure, which is a quick check.

$$p_\text{A} = x_\text{A} \times P_\text{total}$$

LEARN IT

Rate equations and the Arrhenius equation

A-level only. The AQA spec says the Arrhenius equations and R will be given when required, but they are not in the booklet, so the question supplies them.

Rate equation
m and n are orders (0, 1 or 2) found from experiment, not from the balanced equation. k is the rate constant.

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

LEARN IT

Overall order
Use it to work out the units of k, for example $\text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$ for second order.

$$\text{overall order} = m + n$$

LEARN IT

Arrhenius equation
Supplied in the question when required. Ea in J mol^{-1}, T in K, A is the Arrhenius constant. Raising T increases k.

$$k = Ae^{-E_a/RT}$$

LEARN IT

Arrhenius, logarithmic form
Supplied when required. Plot ln k (y) against 1/T (x): gradient = -Ea/R and intercept = ln A. Convert Ea to kJ mol^{-1} at the end.

$$\ln k = -\frac{E_a}{RT} + \ln A$$

LEARN IT

Acids, bases, pH and buffers

A-level only. Use the units and approximations the AQA spec describes.

pH
Convert back with [H+] = 10^-pH. For a strong monoprotic acid, [H+] equals the acid concentration.

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

LEARN IT

Ionic product of water
Use it to find the pH of a strong base: [H+] = Kw / [OH-], then take -log.

$$K_w = [\text{H}^+][\text{OH}^-]$$

LEARN IT

Acid dissociation constant
Units mol dm^{-3}. Written for HA ⇌ H+ + A-.

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

LEARN IT

pKa
Convert back with Ka = 10^-pKa. pKa has no units.

$$\text{p}K_a = -\log_{10} K_a$$

LEARN IT

pH of a weak acid (approximation)
Assumes [H+] = [A-] and that [HA] at equilibrium equals the starting concentration. State both assumptions.

$$[\text{H}^+] = \sqrt{K_a\,[\text{HA}]}$$

LEARN IT

Acidic buffer
Rearranged from Ka with [HA] and [A-] taken as the amounts of weak acid and its salt. Take -log to get pH.

$$[\text{H}^+] = K_a \times \frac{[\text{HA}]}{[\text{A}^-]}$$

LEARN IT

Acidic buffer, Henderson form
Equivalent to the line above. Check what your teacher accepts, but the previous form follows the AQA wording.

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

LEARN IT

Titration calculation
Find moles from c x V of the known solution, then use the equation ratio.

$$n(\text{acid}) = \frac{\text{coefficient of acid}}{\text{coefficient of base}} \times n(\text{base})$$

LEARN IT

Entropy and Gibbs free-energy change

A-level only.

Entropy change of a reaction
Absolute entropies are supplied in the question. Units J K^{-1} mol^{-1}.

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

LEARN IT

Gibbs free-energy change
The spec gives this as the relationship to learn. Convert ΔS to kJ K^{-1} mol^{-1} (divide by 1000) so all terms are in kJ mol^{-1}.

$$\Delta G = \Delta H - T\Delta S$$

LEARN IT

Feasibility condition A reaction is feasible when the free-energy change is zero or negative.	$\Delta G \leq 0$	LEARN IT
Temperature at which a reaction becomes feasible Set ΔG = 0 and rearrange. Check the units of ΔS first.	$T = \dfrac{\Delta H}{\Delta S}$	LEARN IT
ΔG against T graph Plot ΔG (y) against T (x) in kelvin.	$\text{gradient} = -\Delta S, \quad \text{intercept} = \Delta H$	LEARN IT

Electrode potentials and cells

A-level only. AQA does not require the Nernst equation.

EMF of a cell The more positive half-cell is the positive electrode. The E° values are supplied in the question.	$E^{\ominus}_{\text{cell}} = E^{\ominus}_{\text{positive}} - E^{\ominus}_{\text{negative}}$	LEARN IT
Conventional cell representation Negative electrode on the left, positive on the right. A double line is the salt bridge.	$\text{Pt} \mid \text{Fe}^{2+}, \text{Fe}^{3+} \mid\mid \text{Ag}^{+} \mid \text{Ag}$	LEARN IT
Feasibility from E° The direction is predicted only; the rate may still be too slow, and non-standard conditions change E.	$E^{\ominus}_{\text{cell}} > 0 \Rightarrow \text{reaction predicted to go}$	LEARN IT

Chromatography

Rf value Measure from the baseline. Rf has no units and is always less than 1.	$R_{\text{f}} = \dfrac{\text{distance moved by the solute}}{\text{distance moved by the solvent front}}$	LEARN IT

Learn these: not in the booklet

Standard conditions

100 kPa and a stated temperature, usually 298 K. Standard electrode potentials are measured at 298 K, 100 kPa and 1.00 mol dm^{-3} solutions of ions.

Unit conversions

$1\ \text{dm}^3 = 1000\ \text{cm}^3 = 10^{-3}\ \text{m}^3, \quad 1\ \text{kPa} = 1000\ \text{Pa}, \quad T/\text{K} = \theta/^{\circ}\text{C} + 273$

Use Pa, m^3 and K in pV = nRT.

pH and [H+]

$\text{pH} = -\log_{10}[\text{H}^+], \quad [\text{H}^+] = 10^{-\text{pH}}$

Strong base

$[\text{H}^+] = \dfrac{K_{\text{w}}}{[\text{OH}^-]}$

Then take pH = -log10 [H+]. Kw = [H+][OH-].

Ka and pKa

$K_{\text{a}} = \dfrac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}, \quad \text{p}K_{\text{a}} = -\log_{10} K_{\text{a}}$

Units of the rate constant k

Zero order: mol dm^{-3} s^{-1}. First order: s^{-1}. Second order: mol^{-1} dm^3 s^{-1}. Work them out from the rate equation.

Units of Kc and Kp

Work them out from the expression; there are no units if the powers cancel.

Standard enthalpy change of formation

One mole of a compound formed from its elements in their standard states, under standard conditions.

Standard enthalpy change of combustion

One mole of a substance burned completely in oxygen, under standard conditions.

Bond dissociation enthalpy and mean bond enthalpy

The enthalpy change to break one mole of a covalent bond in gaseous molecules; the mean value is averaged over different molecules.

Enthalpy changes in a Born-Haber cycle

Atomisation, first ionisation energy, first electron affinity, lattice enthalpy of formation (or dissociation), enthalpy of hydration and enthalpy of solution: know each definition and the sign.

Oxidation numbers

The sum equals the charge on the species; H is +1 (-1 in metal hydrides); O is -2 (-1 in peroxides); fluorine is -1.

Standard hydrogen electrode

Platinum in 1.00 mol dm^{-3} H+(aq) with H2(g) at 100 kPa and 298 K; E = 0.00 V by definition.

Percentage uncertainty

$\%\ \text{uncertainty} = \dfrac{\text{uncertainty}}{\text{measured value}} \times 100$

Used in practical and data questions.

Using the booklet in the exam

- No equations are printed. Write each equation from memory first, then take only the data from the booklet.
- Find the periodic table on page 2 and the spectroscopy tables on page 3 before the exam so you do not search for them under time pressure.
- Convert before you substitute: cm^3 to dm^3 for concentrations, dm^3 to m^3 and kPa to Pa for pV = nRT, and J to kJ when combining ΔH and T ΔS.
- For infrared, remember that the O-H of an acid (2500 to 3000) is lower and broader than the O-H of an alcohol (3230 to 3550); a C=O peak at 1680 to 1750 is the strongest clue.
- When a question gives R, Ka, Kw or c, use exactly that value and keep to the number of significant figures in the data.

Based on: AQA A Level Chemistry (7405), A-level Chemistry 7405 Data Booklet and specification (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.