STUDY FORMULA BOOKLET

Edexcel IAL Chemistry Unit 4 (WCH14): rates, equilibria and further organic chemistry

The data booklet is issued for Unit 4 but prints only constants and tables, so every equation is Learn it unless the question prints it. Learn first the entropy, Kc, Kp, pH and buffer equations; the Arrhenius equation was always printed.

GIVEN in the data booklet LEARN IT not in the booklet: learn it

Built by CuratedPrep from 22 past question papers for Unit 4 in our question bank, June 2019 to January 2026. Given means it is in the data booklet handed out for Units 2, 4 and 5. Learn it means a past question needed it and the exam did not print it.

Data booklet constants

The data booklet is issued for Unit 4. These are the constants from it that the papers needed.

Gas constant (R)

Use R with ΔH and Ea in joules, not kilojoules. Some questions also print the value. Used in: Jan 2026 Q13(b), activation energy from a graph gradient; Jun 2024 Q16(b); Jan 2022 Q22(d), ln K from ΔStotal.

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

GIVEN

Ionic product of water (Kw)

At 298 K. Use it to turn [OH-] of a strong base into [H+], then take the pH. Some questions also print it. Used in: Jan 2026 Q9, concentration of calcium hydroxide from its pH; Jun 2022 Q8; Jan 2026 (A) Q20(b)(iii).

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

GIVEN

Volume conversion

Convert dm^3 to m^3 for pV = nRT, and cm^3 to dm^3 for titration amounts. Used in: Oct 2023 Q15(b), 15 dm^3 vessel; Jun 2019 Q22(b)(iii), volume of 25.00 cm^3 acid.

$$1\ \text{dm}^3 = 1000\ \text{cm}^3 = 0.001\ \text{m}^3$$

GIVEN

Molar volume of a gas at room temperature and pressure (r.t.p.)

The molar volume at r.t.p.; the question printed 24.0 as well. Used in: Oct 2019 Q18(c), a vapour at 10 parts per billion in air changed to mol dm^{-3}.

$$V_\text{m} = 24\ \text{dm}^3\ \text{mol}^{-1}$$

GIVEN

Kinetics

Orders come from experiments, so the rate equation and the rate constant are learned; the Arrhenius and half-life equations were printed.

Rate equation

Find each order by comparing two experiments in which only one concentration changes. Used in: Jan 2026 Q13(a)(i), second order in NO and first order in O2; Jan 2024 Q16(b)(ii); Jun 2019 Q21(b)(ii).

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

LEARN IT

Rate constant from initial-rate data

Rearrange the rate equation, substitute one experiment, then work the units out from the powers: rate = k[NO]^2[O2] gives dm^6 mol^{-2} s^{-1}. Used in: Jan 2026 Q13(a)(ii); Oct 2023 Q15(c)(ii); Jun 2022 Q20(a)(iii), first order so s^{-1}.

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

LEARN IT

Half-life and rate constant of a first-order reaction

Not on the sheet: the question printed it. Read t(1/2) from the concentration-time graph and keep it in seconds to get k in s^{-1}. Used in: Oct 2022 Q16(b)(ii), azomethane, half-life in minutes; Oct 2021 Q17(a)(iii).

$$k = \frac{\ln 2}{t_{1/2}}$$

GIVEN

Arrhenius equation, logarithmic form

Not on the sheet: the question printed it. Plot ln k (y) against 1/T (x): gradient = -Ea/R, so Ea = -gradient x R in J mol^{-1}. Divide by 1000 for kJ mol^{-1} and give a positive Ea with units. Used in: Jan 2026 Q13(b); Oct 2025 (A) Q18(a)(iii); Jun 2024 Q16(b).

$$\ln k = -\frac{E_a}{R} \cdot \frac{1}{T} + \text{constant}$$

GIVEN

Arrhenius equation at two temperatures

Subtract the logarithmic equation at T1 from the one at T2 so the constant cancels; a rate that is 4.45 times faster means k2/k1 = 4.45. Oct 2022 Q16 printed a log10 version of this and Jan 2023 Q17 printed only the one-temperature equation. Used in: Jan 2023 Q17(b); Oct 2022 Q16(c)(ii).

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

LEARN IT

Entropy and energetics

Entropy change of the system

Multiply each entropy by its coefficient in the balanced equation, and keep the units J K^{-1} mol^{-1}. Used in: Jan 2026 (A) Q4, ammonia from nitrogen and hydrogen; Jun 2025 Q19(a)(ii); Jun 2022 Q21(a)(ii).

$$\Delta S_{\text{system}} = \sum S(\text{products}) - \sum S(\text{reactants})$$

LEARN IT

Entropy change of the surroundings

Change ΔH from kJ to J first and use T in kelvin. Used in: Jun 2024 Q15(a)(iii), at 23.0 °Celsius; Jun 2021 Q15(a), ammonium nitrate dissolving; Oct 2019 Q16(a)(iii).

$$\Delta S_{\text{surroundings}} = -\frac{\Delta H}{T}$$

LEARN IT

Converting a temperature to kelvin

Add 273 before you use T in ΔSsurroundings = -ΔH/T. Used in: Oct 2019 Q16(a)(iii), 160 °Celsius; Oct 2024 Q20(a)(ii), 712 °Celsius; Jun 2024 Q15(a)(iii).

$$T/\text{K} = \theta/^{\circ}\text{C} + 273$$

LEARN IT

Total entropy change

A reaction is feasible when ΔStotal is positive, even if ΔSsystem or ΔSsurroundings is negative. Used in: Jan 2021 Q20(a); Jan 2020 Q19(a)(i); Oct 2019 Q16(a)(iv).

$$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$$

LEARN IT

Temperature at which a reaction becomes feasible

The minimum temperature at which the reaction is feasible. Convert ΔH to J and check the units of ΔS. Oct 2024 Q20(a)(ii) runs it backwards to find ΔH from the lowest temperature. Used in: Jun 2025 Q19(a)(iii), hydrated copper(II) sulfate; Jun 2022 Q21(a)(iii); Jan 2026 (A) Q17(b)(iii).

$$T = \frac{\Delta H}{\Delta S_{\text{system}}}$$

LEARN IT

Total entropy change and the equilibrium constant

The specification says ΔStotal = R ln K (spec 13.8). A positive ΔStotal means K is greater than 1, and K rises when ΔStotal rises with temperature. Jun 2024 Q5 printed it; the others did not. Used in: Jan 2026 Q5; Jun 2025 Q13(c); Jan 2020 Q19(a)(iii), K from ΔStotal.

$$\Delta S_{\text{total}} = R \ln K$$

LEARN IT

Gibbs free-energy change

Optional, but the schemes accept it as an alternative to setting ΔStotal = 0. Oct 2022 Q18 printed it; Jun 2022 Q21 and Jun 2019 Q24 did not. Used in: Oct 2022 Q18(c)(vi), solving for ΔSsystem; Jun 2022 Q21(a)(iii); Jun 2019 Q24(a)(iii).

$$\Delta G = \Delta H - T\Delta S_{\text{system}}$$

LEARN IT

Free-energy change and the equilibrium constant

Not on the sheet: the question printed it. Use R = 8.31 J mol^{-1} K^{-1} and T in kelvin, so ΔG comes out in J mol^{-1}. Used in: Oct 2022 Q18(c)(v), ΔG at 620 K.

$$\Delta G = -RT \ln K_{\text{c}}$$

GIVEN

Hess's law with formation data

Multiply each value by its coefficient; elements in their standard states have ΔfH = 0. Used in: Jun 2025 Q19(a)(i); Jan 2023 Q20(a)(ii); Jun 2022 Q21(a)(i).

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

LEARN IT

Born-Haber cycle for a 1:1 ionic solid MX

The unknown step in the cycle is the enthalpy change of formation, so add all the other steps. Use the second electron affinity of oxygen with its positive sign. Used in: Jan 2026 Q14(a)(iii), magnesium oxide; Jun 2022 Q21(c)(ii), solving for a second ionisation energy; Jan 2020 Q19(b)(ii).

$$\Delta_{\text{f}} H = \Delta_{\text{at}} H(\text{M}) + \Delta_{\text{IE}} H(\text{M}) + \Delta_{\text{at}} H(\text{X}) + \Delta_{\text{EA}} H(\text{X}) + \Delta_{\text{latt}} H$$

LEARN IT

Enthalpy change of solution

Add the enthalpies of hydration of the two ions and subtract the lattice energy; or rearrange it to find a hydration enthalpy or the lattice energy. Used in: Jan 2026 Q14(b); Jun 2025 Q19(c)(iii); Jun 2022 Q16(b)(ii).

$$\Delta_{\text{sol}} H = -\Delta_{\text{latt}} H + \sum \Delta_{\text{hyd}} H$$

LEARN IT

Energy transferred

The question gives c: 4.18 J g^{-1} per degree Celsius in Oct 2024 Q20 and 3.7 in Jun 2025 Q19, so use the value you are given. m is the mass of solution in g. Used in: Oct 2024 Q20(b), magnesium chloride dissolving; Jun 2025 Q19(b), finding the temperature change.

$$q = mc\Delta T$$

LEARN IT

Enthalpy change of an experiment

Convert q to kJ for ΔH in kJ mol^{-1}; n is the amount that dissolves or reacts. Used in: Oct 2024 Q20(b); Jun 2025 Q19(b).

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

LEARN IT

Chemical equilibria

Kc expression

Leave solids out of the expression for a heterogeneous system, and work the units out from the powers. Used in: Jan 2026 Q8(a); Oct 2025 (A) Q4; Oct 2022 Q18(a).

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

LEARN IT

Kp expression

Partial pressures in atm; leave solids out, for example MgO(s) in Oct 2024 Q9. Used in: Jan 2026 Q15(a), the Haber process written for one mole of ammonia; Oct 2025 (A) Q14(a)(i); Jun 2022 Q16(a)(i).

$$K_\mathrm{p} = \frac{p_\mathrm{C}^{c}\, p_\mathrm{D}^{d}}{p_\mathrm{A}^{a}\, p_\mathrm{B}^{b}}$$

LEARN IT

Mole fraction

Moles of the gas divided by the total moles of gas at equilibrium. Used in: Jan 2026 Q15(b), 80.0 mol of hydrogen in 150 mol; Jun 2022 Q16(a)(ii); Jun 2021 Q20.

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

LEARN IT

Partial pressure

Multiply each mole fraction by the total pressure, then substitute into Kp. Used in: Jan 2026 Q15(c); Jun 2022 Q16(a)(ii); Jun 2019 Q25(a)(ii).

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

LEARN IT

Ideal gas equation

Not on the sheet: the question printed it. p in Pa, V in m^3, n in mol, T in K. Used in: Oct 2023 Q15(b), temperature of an equilibrium mixture of nitrogen oxides.

$$pV = nRT$$

GIVEN

Gradient of ln Kc against 1/T

Not on the sheet: the question printed it. Multiply the gradient by -R to get ΔH in J mol^{-1}. Used in: Oct 2022 Q18(c)(iv), the hydrogen and iodine equilibrium.

$$\text{gradient} = -\frac{\Delta H}{R}$$

GIVEN

Acids, bases and buffers

pH

Convert back with [H+] = 10^-pH. A strong monoprotic acid has [H+] equal to its concentration; diluting it ten times raises the pH by 1. Used in: Jun 2025 Q4, 1.25 mol dm^{-3} hydrochloric acid; Jun 2022 Q11(b); Jun 2019 Q8.

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

LEARN IT

Ionic product of water

For a strong base [H+] = Kw / [OH-]; a base such as Ca(OH)2 or Ba(OH)2 gives two OH- per formula unit. The value of Kw is in the data booklet. Used in: Jan 2026 Q9; Jan 2024 Q10; Oct 2025 (A) Q6.

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

LEARN IT

pKw

So pH = pKw - pOH. Some questions give a pKw that is not 14, for example at another temperature. Used in: Jan 2025 Q11; Oct 2021 Q9.

$$\mathrm{p}K_\mathrm{w} = -\log_{10} K_\mathrm{w}$$

LEARN IT

Acid dissociation constant

Write the expression from the equation HA = H+ + A-; the units are mol dm^{-3}. Used in: Jan 2026 (A) Q20(a)(ii), benzoic acid; Jun 2025 Q17(a)(i); Jun 2019 Q22(a)(i).

$$K_\mathrm{a} = \frac{[\mathrm{H^+}][\mathrm{A^-}]}{[\mathrm{HA}]}$$

LEARN IT

pKa

Convert back with Ka = 10^-pKa. Used in: Jan 2026 (A) Q20(a)(iii), pKa 4.20 given; Jun 2022 Q19(a)(iii), Ka from a titration curve; Jan 2022 Q20.

$$\mathrm{p}K_\mathrm{a} = -\log_{10} K_\mathrm{a}$$

LEARN IT

pH of a weak acid

State both assumptions: [H+] = [A-], and [HA] equals the starting concentration. Used in: Jan 2026 (A) Q20(a)(iii); Jan 2026 Q18(d)(ii), saturated 3-methylbutanoic acid; Jun 2022 Q7.

$$[\mathrm{H^+}] = \sqrt{K_\mathrm{a}[\mathrm{HA}]}$$

LEARN IT

Acidic buffer

Work out the concentrations of acid and salt in the final volume first. The Henderson-Hasselbalch form is accepted; Jan 2025 Q13 printed it and Jan 2026 Q16 did not. Used in: Jan 2026 Q16(b), a phosphate buffer; Jun 2024 Q6; Oct 2022 Q9.

$$[\mathrm{H^+}] = K_\mathrm{a} \times \frac{[\mathrm{HA}]}{[\mathrm{A^-}]}$$

LEARN IT

pH when a weak acid is half neutralised

At half the equivalence volume [HA] = [A-], so [H+] = Ka; read the pH off the titration curve and convert it to Ka. Used in: Jun 2022 Q19(a)(iii); Jun 2019 Q22(b)(i).

$$\mathrm{pH} = \mathrm{p}K_\mathrm{a} \quad \text{when } [\mathrm{HA}] = [\mathrm{A^-}]$$

LEARN IT

Titration

Find moles from c x V of the known solution (V in dm^3, then use the equation ratio to get the volume or concentration of the other. Used in: Jan 2026 (A) Q20(b)(ii); Jun 2022 Q19(a)(ii); Jun 2019 Q22(b)(iii).

$$n(\mathrm{A}) = \frac{\text{coefficient of A}}{\text{coefficient of B}} \times n(\mathrm{B})$$

LEARN IT

Amount of substance, yield and chromatography

Amount from mass

Use molar masses worked out from the periodic table unless the question gives them. Used in: Jan 2026 Q18(b)(i), moles of butanone from 25.0 kg; Jan 2026 Q16(b); Oct 2023 Q15(a)(i).

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

LEARN IT

Concentration

For a concentration given in g dm^{-3}, divide by the molar mass; divide moles in a vessel by its volume in dm^3 for Kc. Used in: Jan 2026 (A) Q20(a)(iii); Jan 2026 Q16(b); Oct 2023 Q15(a)(ii).

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

LEARN IT

Percentage yield

Compare moles with moles or mass with mass. Used in: Jan 2021 Q15, ethanoic acid from ethanol.

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

LEARN IT

Percentage atom economy

Divide by the sum of the molar masses of all the products in the balanced equation. Used in: Jan 2026 Q18(b)(ii), 206 divided by 224 as a percentage; Jan 2025 Q20(a).

$$\%\ \text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100$$

LEARN IT

Rf value

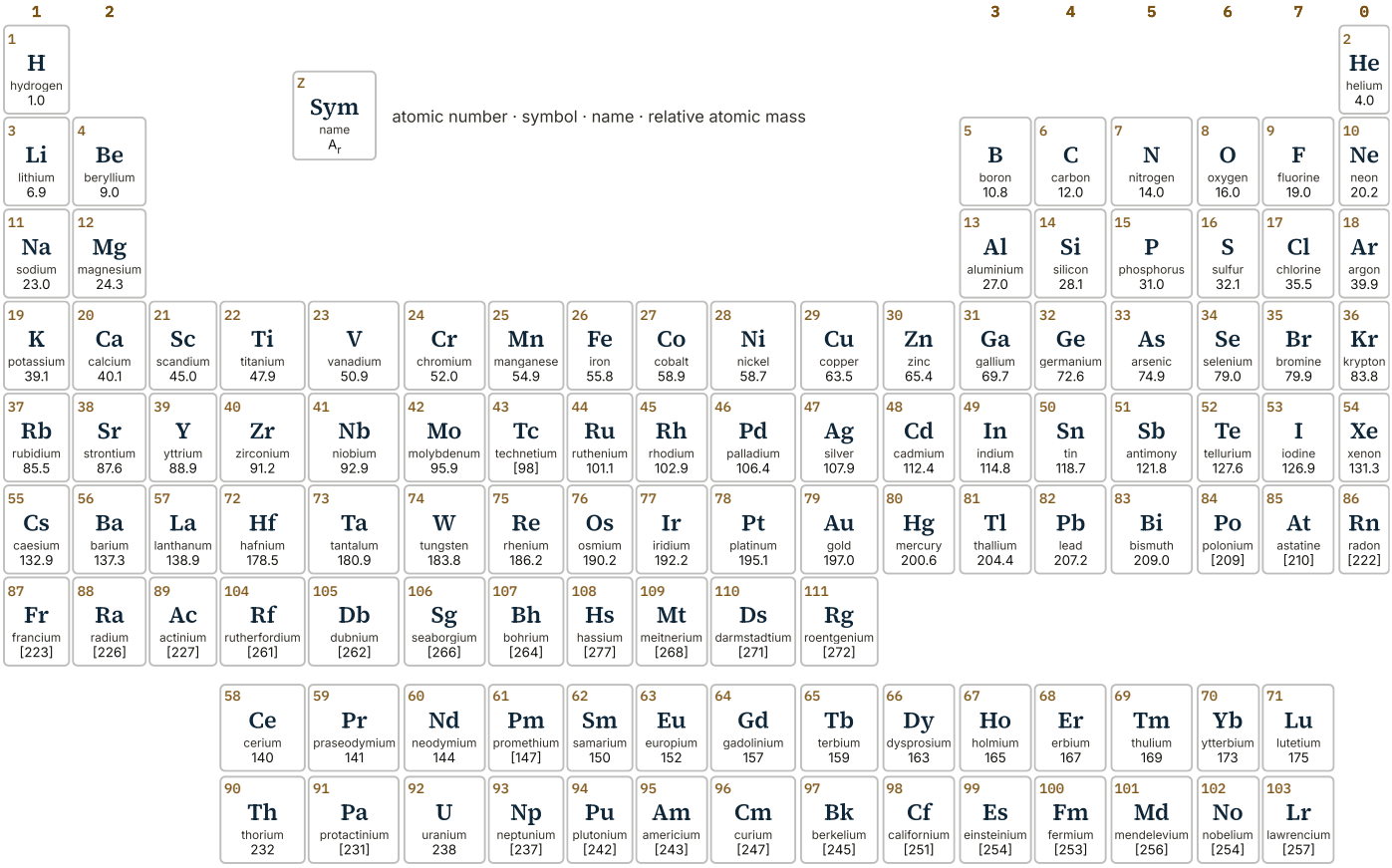
Measure both distances from the baseline; Rf is never above 1. Used in: Jun 2025 Q8; Jan 2023 Q16; Jun 2022 Q4.

$$R_\mathrm{f} = \frac{\text{distance moved by the solute}}{\text{distance moved by the solvent front}}$$

LEARN IT

The periodic table of elements

Groups are numbered 1 to 7 and 0 (8), with the group numbers (1) to (18) as printed. Elements with atomic numbers 112 to 116 have been reported but not fully authenticated (as printed). Masses in square brackets are as printed; lanthanide and actinide masses are whole numbers as printed.



Infrared spectroscopy: correlation of infrared absorption wavenumbers with molecular structure

Vibration	Group	Wavenumber range / cm^{-1}
C-H stretching	alkane	2962 to 2853
C-H stretching	alkene	3095 to 3010
C-H stretching	alkyne	3300
C-H stretching	arene	3030
C-H stretching	aldehyde	2900 to 2820 and 2775 to 2700
C-H bending	alkane	1485 to 1365
C-H bending	arene, 5 adjacent hydrogen atoms	750 and 700
C-H bending	arene, 4 adjacent hydrogen atoms	750
C-H bending	arene, 3 adjacent hydrogen atoms	780
C-H bending	arene, 2 adjacent hydrogen atoms	830
C-H bending	arene, 1 isolated hydrogen atom	880
N-H stretching	amine	3500 to 3300
N-H stretching	amide	3500 to 3140
O-H stretching	alcohols and phenols	3750 to 3200
O-H stretching	carboxylic acids	3300 to 2500
C=C stretching	isolated alkene	1669 to 1645
C=C stretching	arene	1600, 1580, 1500, 1450

Vibration	Group	Wavenumber range / cm^{-1}
C=O stretching	aldehydes, saturated alkyl	1740 to 1720
C=O stretching	ketones, alkyl	1720 to 1700
C=O stretching	ketones, aryl	1700 to 1680
C=O stretching	carboxylic acids, alkyl	1725 to 1700
C=O stretching	carboxylic acids, aryl	1700 to 1680
C=O stretching	carboxylic acid anhydrides	1850 to 1800 and 1790 to 1740
C=O stretching	acyl halides, chlorides	1795
C=O stretching	acyl halides, bromides	1810
C=O stretching	esters, saturated	1750 to 1735
C=O stretching	amides	1700 to 1630
Triple bond stretching	C≡N	2260 to 2215
Triple bond stretching	C≡C	2260 to 2100

1H nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)

The booklet prints this as a chart of boxes on a scale from 12.0 to 0.0 ppm, with no numbers on the boxes. The ranges here were measured from the box edges against the printed scale and rounded to the nearest 0.5 ppm, so treat them as approximate: the chart is a guide, and its own reference marks sit up to 0.3 ppm from the scale. The bold H in the booklet marks the proton described.

Proton	Environment as labelled	δ / ppm (about)
$\mathrm{C}\mathbf{H}$ in $\mathrm{R_3CH} > \mathrm{R_2CH_2} > \mathrm{RCH_3}$	alkane, H-C-C	0.0 to 1.5
H-C=C	alkene	4.5 to 6.5
Ar-**H**	arene ring	6.5 to 8.5
$-\mathrm{CO}$-**H**	aldehyde	9.0 to 10.0
H-C-halogen ($\mathrm{R_2CHF} > \mathrm{R_2CHCl} > \mathrm{R_2CHBr} > \mathrm{R_2CHI}$)	halogenoalkane	2.0 to 4.0
H-C-O-	alcohol, ether, ester	3.0 to 4.0
$-\mathrm{O}$-**H**	alcohol	2.0 to 4.0
COO-**H**	carboxylic acid	10.0 to 12.0
Ar-O-**H**	phenol	4.0 to 7.5
H-C-C=O	aldehyde, ketone, ester, amide, acid	1.5 to 3.0
H-C-C=C	alkenes, arenes	1.5 to 3.0
H-C-N	amine, amide	2.5 to 3.5
Ar-N-**H**	phenylamines	3.0 to 5.0
C-N-**H**	amine	0.5 to 3.0
CON-**H**	amide	5.0 to 9.0

13C nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)

The booklet prints this as a chart with boxes on a δ / ppm axis (220 to -40), not as a table of numbers. The ranges below are read off the chart to the nearest 5 ppm and are approximate; use the chart in your booklet for the exact edges. The bold C is the carbon described.

Carbon	Environment as labelled	δ / ppm (about)
C-**C**	C-C	5 to 55
C-N	C-N	35 to 60
C-OH	C-OH	55 to 70
C-Cl, **C**-Br	halogenoalkane	30 to 70
C=C	alkene	115 to 140
C-C in an arene	arene	110 to 160

Carbon	Environment as labelled	δ / ppm (about)
$-\mathbf{C}(=O)\text{-}O$	acid, ester carbonyl	165 to 185
$-\mathbf{C}(=O)\text{-}N$	amide carbonyl	165 to 185
$C\text{-}\mathbf{C}(=O)\text{-}C$	ketone carbonyl	195 to 220
$C\text{-}\mathbf{C}(=O)\text{-}H$	aldehyde carbonyl	195 to 220
TMS (reference)		0

Pauling electronegativities (Pauling electronegativity index)

Columns are groups 1 to 18. Each cell gives the element and its value; the noble gases have no value printed. Hydrogen is printed above the middle of the table and is shown here under group 1. La is shown under group 3.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H 2.1																	He
2	Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
3	Na 0.9	Mg 1.2											Al 1.5	Si 1.9	P 2.1	S 2.5	Cl 3.0	Ar
4	K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 2.0	As 2.0	Se 2.4	Br 2.8	Kr
5	Rb 0.8	Sr 1.0	Y 1.2	Zr 1.3	Nb 1.6	Mo 2.1	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.6	In 1.7	Sn 1.9	Sb 1.9	Te 2.1	I 2.5	Xe
6	Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 2.3	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.5	Hg 2.0	Tl 1.6	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn

Indicators

pKin is given at 298 K. No pKin value is printed for litmus.

No.	Indicator	pKin	Colour in acid	pH range	Colour in alkali
1	Thymol blue (acid)	1.7	red	1.2 to 2.8	yellow
2	Screened methyl orange	3.7	purple	3.2 to 4.2	green
3	Methyl orange	3.7	red	3.2 to 4.4	yellow
4	Bromophenol blue	4.0	yellow	2.8 to 4.6	blue
5	Bromocresol green	4.7	yellow	3.8 to 5.4	blue
6	Methyl red	5.1	red	4.2 to 6.3	yellow
7	Litmus		red	5.0 to 8.0	blue
8	Bromothymol blue	7.0	yellow	6.0 to 7.6	blue
9	Phenol red	7.9	yellow	6.8 to 8.4	red
10	Phenolphthalein (in ethanol)	9.3	colourless	8.2 to 10.0	red

Also learn these

Units of the rate constant

Work them out from the rate equation: zero order mol dm^{-3} s^{-1}, first order s^{-1}, second order mol^{-1} dm^3 s^{-1}. Used in: Jan 2020 Q15(b); Oct 2021 Q1(b); Jun 2024 Q1(b).

Units of Kc and Kp

Work them out from the expression; there are no units when the powers cancel, and Kp uses atm. Used in: Jun 2019 Q10; Jan 2022 Q4; Jun 2023 Q3.

Orders from graphs

A constant half-life means first order; on a rate against concentration graph a horizontal line is zero order and a straight line through the origin is first order. Used in: Jun 2022 Q10; Jan 2026 Q1(b); Jun 2024 Q16(a)(ii).

Initial rate from a tangent

Draw the tangent at t = 0 on the concentration-time graph and take its gradient, changing minutes to seconds. Used in: Jun 2024 Q16(a)(i).

Reciprocal of time as a rate

In a clock reaction the same amount forms in every run, so 1/t is proportional to the rate. Used in: Jan 2026 (A) Q16(a)(ii); Jan 2024 Q16(a)(ii); Jan 2023 Q17(a)(i).

Rate-determining step and mechanism

The species in the rate equation appear in the slow step, and the steps must add up to the overall equation. Used in: Jan 2026 Q13(a)(iii); Oct 2023 Q15(c)(iv); Jun 2019 Q21(c)(ii).

Effect of temperature, pressure and a catalyst on equilibrium

Only a change in temperature changes the value of K; pressure and a catalyst do not, and a catalyst leaves the yield unchanged. Used in: Jan 2026 Q15(d); Jan 2026 Q8(b); Jun 2022 Q16(a)(iv).

Entropy trends

Entropy rises from solid to liquid to gas, with more moles of gas, and for larger molecules at the same state. Used in: Jan 2026 (A) Q3; Jan 2026 (A) Q2; Jun 2022 Q14.

Lattice energy and polarisation

Lattice energy is more exothermic for smaller, more highly charged ions; a gap between the experimental and theoretical values shows covalent character from polarisation. Used in: Jan 2026 Q7; Jan 2026 Q14(a)(iv); Jun 2022 Q15.

Definitions of enthalpy changes

Know the definitions of atomisation, electron affinity, lattice energy, solution and hydration. Used in: Jan 2026 Q6; Jun 2025 Q19(c)(i).

Assumptions for a weak acid

Ionisation of water is ignored, [H+] = [A-], and the equilibrium [HA] equals the starting [HA]. Used in: Jan 2026 (A) Q20(a)(iv); Jan 2025 Q12.

Buffers and titration curves

A buffer holds a reservoir of weak acid and its salt, so adding OH- or H+ changes the ratio, and the pH, only a little; choose an indicator whose range sits in the steep part of the curve, using the table of indicators. Used in: Jan 2026 (A) Q20(c); Jun 2022 Q9(b); Jun 2019 Q7.

Splitting and peaks in NMR

The n + 1 rule gives the splitting of a proton peak, peak areas give the ratio of protons, and symmetry cuts the number of carbon-13 peaks. Used in: Jan 2026 Q11(d); Jan 2026 Q12(a); Jun 2022 Q1.

Accurate relative molecular mass

Add the accurate relative atomic masses of every atom in the formula, then match the total to the molecular ion peak. Used in: Jun 2022 Q2.

Using the booklet in the exam

- Write the entropy, Kc, Kp, pH and buffer equations from memory before you start: the data booklet holds no equations, only constants and tables.
- Read the question for what it prints. The Arrhenius equation, k = ln 2 / t(1/2), pV = nRT and ΔG = -RT ln Kc were printed in every question in the bank that needed them; ΔStotal = R ln K usually was not.
- Convert before you substitute: kJ to J for ΔSsurroundings = -ΔH/T and for Ea, °Celsius to kelvin, cm^3 to dm^3, and minutes to seconds for k.
- Work out the units of k, Kc and Kp from the expression, and put them in the final line of every calculation.
- For ΔSsystem and Hess cycles, multiply each value by its coefficient in the balanced equation and take products minus reactants.
- For a weak acid, state both assumptions when you use [H+] = sqrt(Ka x [HA]), and check that your pH is below 7.

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