

Unit 2: Energetics, groups and organic reactions

Pearson acquired Topics 6–10, core practicals 2–8; practical experience and bank holds remain explicit.

Choose the chemical model

- 1** Energy, attractions, electron transfer and collision models explain different observations.
- 2** Use Unit 1 mole ratios, polarity and structural formulae; state conditions before predicting products.

The sign belongs to the reaction

- 1 At constant pressure, ΔH is the reaction heat change.
- 2 Exothermic: surroundings warm and reaction ΔH is negative.
- 3 Standard data specify 100 kPa, temperature and physical states.

Definitions fix the mole basis

- 1** Formation: one mole of compound from standard-state elements.
- 2** Combustion: complete burning of one mole of substance.
- 3** Neutralisation: one mole of water formed; atomisation: one mole of gaseous atoms.

Calorimetry: energy then amount

1 $q = mc\Delta T = 100.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1} \times 6.8 \text{ }^{\circ}\text{C} = 2.842 \text{ kJ}.$

2 $n(\text{H}_2\text{O}) = cV = 1.00 \text{ mol dm}^{-3} \times 0.0500 \text{ dm}^3 = 0.0500 \text{ mol}.$

3 $\Delta H = -q/n = -56.8 \text{ kJ mol}^{-1}$; use total heated mass and limiting amount.

Check the sign and denominator

Your turn

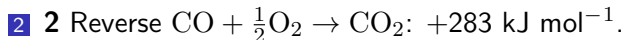
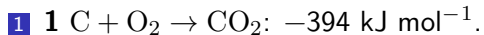
The solution gains 1.20 kJ while 0.0200 mol reacts. What is the molar reaction enthalpy?

- A. $+60.0 \text{ kJ mol}^{-1}$
- B. $-60.0 \text{ kJ mol}^{-1}$
- C. $-0.0240 \text{ kJ mol}^{-1}$
- D. $-1.20 \text{ kJ mol}^{-1}$

Energy conservation gives the answer

- 1 $\Delta H = -q/n = -1.20 \text{ kJ}/0.0200 \text{ mol} = -60.0 \text{ kJ mol}^{-1}$.
- 2 B is correct. A uses the solution sign; C multiplies by amount; D omits the mole basis.

Hess: cancel species first



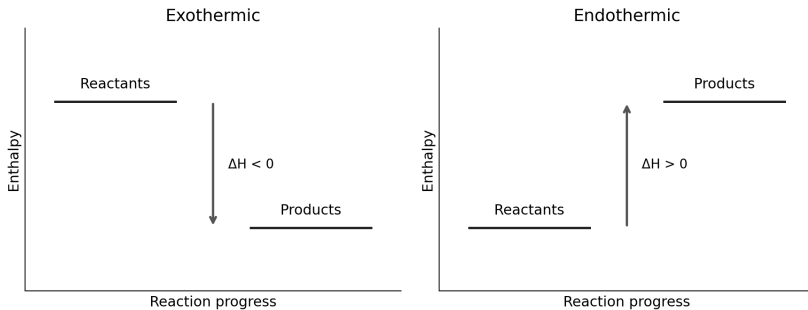
Bond estimates have assumptions

- 1 Count bonds broken minus bonds formed, including coefficients.
- 2 For $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$: $436 + 243 - 2(431) = -183 \text{ kJ mol}^{-1}$.
- 3 Mean values describe gas-phase bonds in averaged environments; ΔH does not determine rate.

Your turn: the level fixes the sign

- 1 Set up** Draw exothermic and endothermic enthalpy-level diagrams.
- 2 Reason** Label both levels and the signed ΔH arrow; the horizontal axis is reaction progress.

Initial and final levels determine ΔH



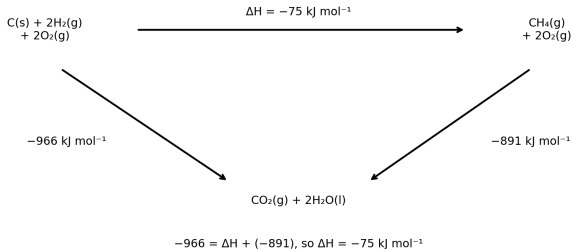
- 1 Set up** Exothermic products lie lower: the reaction ΔH arrow points down.
- 2 Reason** Endothermic products lie higher: the arrow points up.

Your turn: draw the whole Hess cycle

- 1 Set up** Find $\text{C}(\text{graphite}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$ using combustion data.
- 2 Reason** C: -394 ; H_2 : -286 ; CH_4 : -891 kJ mol^{-1} . Draw a common final state with the correct oxygen amount.

Match both routes before subtracting

Same initial and final states: include oxygen on both top routes

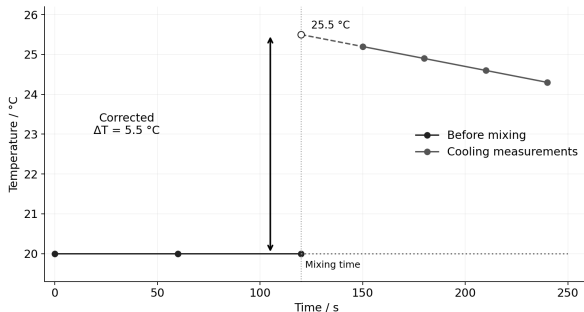


- 1 **Set up** Carbon + two hydrogen moles: $-394 + 2(-286) = -966 \text{ kJ mol}^{-1}$.
- 2 **Reason** $-966 = \Delta H + (-891)$, so $\Delta H = -75 \text{ kJ mol}^{-1}$.

Your turn: correct the mixing temperature

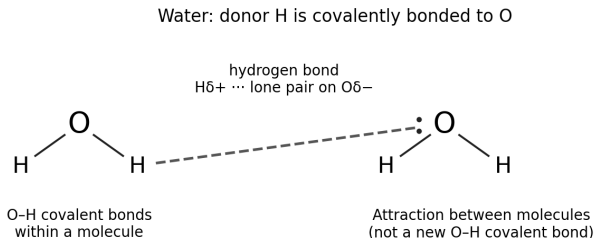
- 1 Set up** Before mixing at 120 s: 20.0 °C. After: 25.2 °C at 150 s, then 24.9, 24.6, 24.3 °C at 180, 210, 240 s.
- 2 Reason** Plot and extrapolate to mixing. Then use 80.0 g, $c = 4.18 \text{ J g}^{-1} \text{ °C}^{-1}$ and 0.0400 mol water to find ΔH .

Cooling correction restores the missing rise



- 1 **Set up** Extrapolate to 25.5 °C at 120 s: corrected $\Delta T = 5.5$ °C.
- 2 **Reason** $q = 80.0(4.18)(5.5) = 1839.2$ J; $\Delta H = -1.8392/0.0400 = -46.0$ kJ mol⁻¹.

Hydrogen bonding needs a donor



H bonded to N, O or F can attract a suitable lone pair on another molecule.

Boiling separates molecules

- 1 More electrons usually strengthen London forces; alkane boiling temperatures rise with chain length.
- 2 Branching reduces effective contact between isomers.
- 3 Alcohols also hydrogen-bond; HF is unusually high compared with HCl/HBr/HI.

Water, ice and solvent evidence

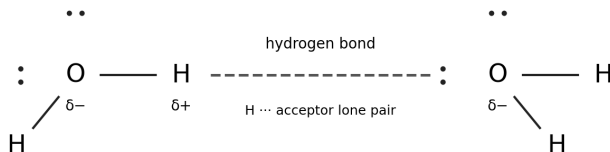
- 1 An open hydrogen-bonded ice structure gives lower density than liquid water.
- 2 Water hydrates ions and hydrogen-bonds with small alcohols.
- 3 A polar C–X bond alone does not make a halogenoalkane water-soluble.

Your turn: three hydrogen-bonded liquids

- 1 Attempt** Draw one hydrogen-bonded pair each for water, ammonia and HF.
- 2 Label** Show all atoms, covalent bonds, acceptor lone pairs and the donor/acceptor partial charges.

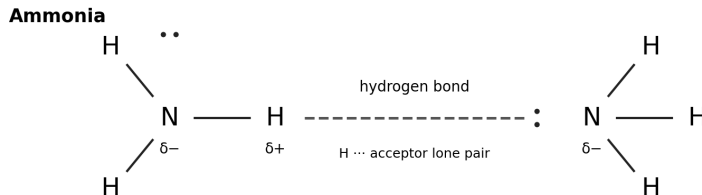
Water: donor H and acceptor lone pair

Water



- 1 **Donor** The donor H is covalently bonded to O; the dashed line is between molecules.
- 2 **Acceptor** The neighbouring O lone pair attracts $H\delta^+$; solid lines retain the covalent bonds.

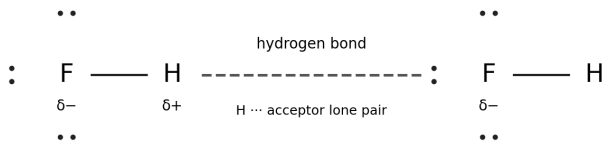
Ammonia: donor H and acceptor lone pair



- 1 Donor** The donor H is covalently bonded to N; the dashed line is between molecules.
- 2 Acceptor** The neighbouring N lone pair attracts $\text{H}\delta^+$; solid lines retain the covalent bonds.

Hydrogen fluoride: donor H and acceptor lone pair

Hydrogen fluoride



- 1 Donor** The donor H is covalently bonded to F; the dashed line is between molecules.
- 2 Acceptor** The neighbouring F lone pair attracts $H\delta+$; solid lines retain the covalent bonds.

Oxidation numbers and agents

- 1** Oxidation loses electrons and raises oxidation number; reduction does the reverse.
- 2** The oxidising agent gains electrons and is reduced.
- 3** O is -2 in peroxides; H is $+1$ in metal hydrides. Sum values to the species charge.

Balance electrons and charge

- 1** $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$ and $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$.
- 2** Multiply by 2 and 3 so six electrons cancel.
- 3** $2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}$; Cu^{2+} is the oxidising agent.

Group trends need two models

- 1** Down Groups 1/2, radius and shielding increase; outer electrons are lost more easily.
- 2** Small high-charge-density cations polarise anions strongly, lowering carbonate/nitrate thermal stability.
- 3** Group 2 hydroxides become more soluble down the group; sulfates less soluble.

Observe without mixing up reactions

- 1** Li_2CO_3 and Group 2 carbonates give oxide + CO_2 on heating.
- 2** Most Group 1 nitrates give nitrite + O_2 ; lithium and Group 2 nitrates also give NO_2 .
- 3** Flame-test colours arise from electron transitions, not the ordinary colour of the solid.

Your turn: two Group 2 solubility trends

- 1 Set up** Equal volumes of saturated $\text{Mg}(\text{OH})_2$ and $\text{Ba}(\text{OH})_2$ are titrated with the same acid. Which needs more?
- 2 Reason** Equal $\text{Mg}^{2+}/\text{Ba}^{2+}$ concentrations receive excess sulfate. Which gives more precipitate? Explain both.

Opposite solubility trends explain the evidence

- 1 **Set up** $\text{Ba}(\text{OH})_2$ is more soluble: its equal saturated volume contains more OH^- and needs more acid.
- 2 **Reason** BaSO_4 is less soluble: equal initial cation amounts give more solid with excess sulfate.
- 3 **Conclude** Solubility controls dissolved amount; it is different from dissociation strength.

Controls distinguish chemical evidence from contamination

- 1 Set up** Match measured amounts, particle size, apparatus and heating rate; compare sample temperature at a consistent decomposition criterion.
- 2 Reason** CO_2 : milky limewater; O_2 : glowing splint relights; NO_2 : brown and acidic.
- 3 Conclude** Clean flame-test wire and keep the flame region/loading consistent. Na yellow, K lilac, Ca brick-red, Sr crimson-red; sodium carry-over can mask another colour.

Separate aliquots protect the evidence

- 1 Carbonate + acid gives CO_2 ; confirm with limewater.
- 2 Sulfate: dilute HCl then BaCl_2 gives white BaSO_4 .
- 3 Ammonium + warm NaOH gives NH_3 ; damp red litmus turns blue.

A titre is a difference

- 1 Rinse burette/pipette with their own solutions; fill the jet and remove the funnel.
- 2 Use concordant accurate titres, not the rough trial.
- 3 Two $\pm 0.05 \text{ cm}^3$ readings give $\pm 0.10 \text{ cm}^3$ maximum titre uncertainty.

Titration: ratio before concentration

- 1 25.00 cm³ of 0.0500 mol dm⁻³ Na₂CO₃ uses 24.60 cm³ HCl; ratio is 1:2.
- 2 $n(\text{carbonate}) = cV = 0.001250 \text{ mol}$; $n(\text{HCl}) = 0.002500 \text{ mol}$.
- 3 $c(\text{HCl}) = n/V = 0.002500 \text{ mol}/0.02460 \text{ dm}^3 = 0.1016 \text{ mol dm}^{-3}$.

Your turn: retain both possible anions

- 1 Set up** A salt releases gas turning limewater milky with acid. A fresh aliquot gives ammonia with warm NaOH.
- 2 Reason** Identify the supported ions and write both NH_3 production and HCl-fume equations. Can you distinguish carbonate from hydrogencarbonate?

A positive gas test has a limited conclusion

- 1 **Set up** $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$ supports ammonium.
- 2 **Reason** $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$ explains the white fumes.
- 3 **Conclude** Both carbonate and hydrogencarbonate release CO_2 with acid; the evidence does not select just one.

Your turn: a solid acid measures NaOH

- 1 Set up** H_2A has $M = 126.0 \text{ g mol}^{-1}$; dissolve 1.575 g and make to 250.0 cm^3 .
- 2 Reason** 25.00 cm^3 acid requires 23.80 cm^3 NaOH. Use $\text{H}_2\text{A} + 2\text{NaOH} \rightarrow \text{Na}_2\text{A} + 2\text{H}_2\text{O}$ to find NaOH concentration.

The acid aliquot determines twice the alkali amount

- 1 Set up** $n(\text{acid, total}) = 1.575 \text{ g} / (126.0 \text{ g mol}^{-1}) = 0.01250 \text{ mol}$.
- 2 Reason** One tenth is pipetted: $n(\text{NaOH}) = 2(0.001250 \text{ mol}) = 0.002500 \text{ mol}$.
- 3 Conclude** $c(\text{NaOH}) = 0.002500 \text{ mol} / 0.02380 \text{ dm}^3 = 0.1050 \text{ mol dm}^{-3}$.

Your turn: determine HCl concentration

- 1 Set up** 25.00 cm³ HCl uses 24.60 cm³ of 0.1000 mol dm⁻³ NaOH.
- 2 Reason** Calculate concentration, then explain rinsing, meniscus readings and the phenolphthalein endpoint.

The ratio precedes the concentration

- 1 Set up** $n(\text{NaOH}) = 0.1000 \times 0.02460 = 0.002460 \text{ mol}$; $c(\text{HCl}) = 0.002460/0.02500 = 0.09840 \text{ mol dm}^{-3}$.
- 2 Reason** Rinse pipette with HCl, burette with NaOH, flask with deionised water; fill the jet and read at eye level.
- 3 Conclude** Swirl and add dropwise near the first persistent pale-pink endpoint; repeat to concordance and exclude the rough titre.

Halogen oxidising power decreases

- 1 Cl_2 displaces Br^- and I^- ; Br_2 displaces I^- ; I_2 displaces neither.
- 2 Increasing radius/shielding weakens attraction for an incoming electron.
- 3 Iodine is brown in water but violet in a suitable non-polar organic solvent.

Conditions change the chlorine product

Your turn

Hot concentrated alkali reacts with chlorine. Which oxyanion forms?

- A. ClO^-
- B. ClO_3^-
- C. Cl^- only
- D. No reaction

Disproportionation balances electron changes

- 1 $3\text{Cl}_2 + 6\text{OH}^- \rightarrow 5\text{Cl}^- + \text{ClO}_3^- + 3\text{H}_2\text{O}$.
- 2 Answer B. Chlorine goes $0 \rightarrow -1$ and $0 \rightarrow +5$.
- 3 Cold dilute alkali instead forms ClO^- . Conditions belong in the answer.

Halide tests and reducing power

- 1 Acidify with HNO_3 before AgNO_3 : AgCl white, AgBr cream, AgI yellow.
- 2 AgCl dissolves in dilute NH_3 ; AgBr needs concentrated NH_3 ; AgI remains.
- 3 With concentrated H_2SO_4 , bromide and especially iodide can reduce sulfur; chloride normally only gives HCl .

Name the attracted electron pair

- 1 Set up** Electronegativity concerns a shared bonding pair; oxidising power concerns electron gain in redox.
- 2 Reason** Both decrease from Cl to Br to I as radius and shielding weaken attraction despite greater nuclear charge.

Your turn: name the solvent before the colour

- 1 Set up** Add a small amount of Br_2 to excess KI or KCl, then extract into cyclohexane.
- 2 Reason** Bromine is orange and iodine purple in this solvent. Predict both layers and write the reaction.

Displacement changes the halogen species

- 1 **Set up** KI gives purple I_2 : $Br_2 + 2I^- \rightarrow 2Br^- + I_2$.
- 2 **Reason** KCl retains orange Br_2 because bromine cannot oxidise chloride under these conditions.

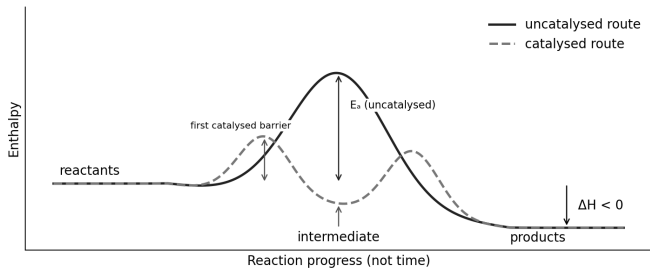
Your turn: three sulfur reduction products

- 1 **Set up** HI reduces H_2SO_4 to SO_2 , S or H_2S while forming I_2 .
- 2 **Reason** Balance each route and state all three final sulfur oxidation numbers.

Balance atoms and track sulfur

- 1 Set up** $2\text{HI} + \text{H}_2\text{SO}_4 \rightarrow \text{I}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$; S: $+6 \rightarrow +4$.
- 2 Reason** $6\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 3\text{I}_2 + \text{S} + 4\text{H}_2\text{O}$; S: $+6 \rightarrow 0$.
- 3 Conclude** $8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$; S: $+6 \rightarrow -2$.
- 4 Check** Iodide is oxidised from -1 to 0 ; oxidising sulfuric acid consumes the desired HI.

The catalyst changes the pathway



The catalysed route has an intermediate and lower activation barriers.

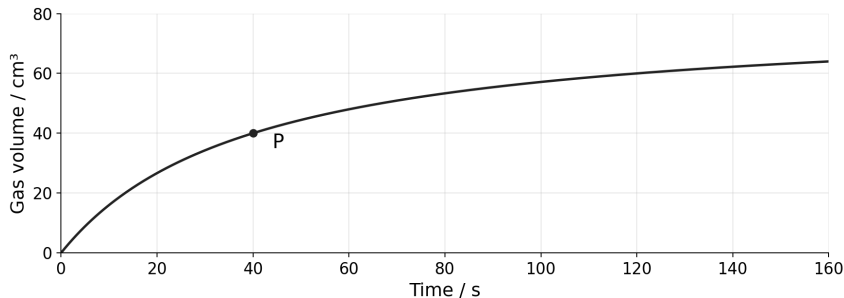
Rate measurements answer different questions

- 1 For a fixed endpoint, comparative rate is $1/t$ in s^{-1} .
- 2 Instantaneous gas rate is a tangent gradient, not final volume / total time.
- 3 Higher temperature increases the fraction beyond E_a ; a catalyst lowers E_a without changing the distribution.

Equilibrium is dynamic

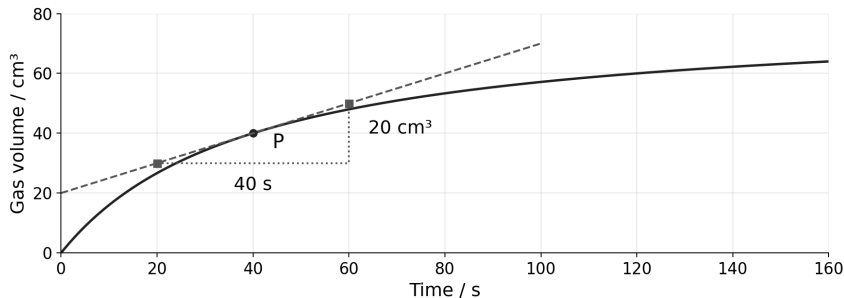
- 1** Forward and reverse rates are equal in a closed system; concentrations need not be equal.
- 2** Higher pressure favours fewer gas moles; higher temperature favours the endothermic direction.
- 3** A catalyst reaches the same equilibrium sooner. Industrial operation balances rate, yield and cost.

Your turn: draw a tangent at P



- 1 Set up** Draw the tangent at P, then choose two separated points on that straight line.
- 2 Reason** Find the instantaneous gas-production rate with units.

A tangent gives the local rate

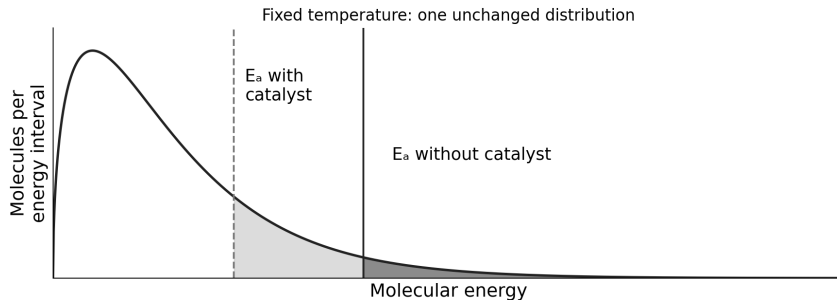


- 1 **Set up** Use tangent points (20 s, 30 cm³) and (60 s, 50 cm³).
- 2 **Reason** Rate = $(50 - 30)/(60 - 20) = 0.50 \text{ cm}^3 \text{ s}^{-1}$. Origin to P gives the earlier average, $1.0 \text{ cm}^3 \text{ s}^{-1}$.

Your turn: a catalyst changes which feature?

- 1 Set up** At fixed temperature, draw the energy distribution and two activation thresholds.
- 2 Reason** Shade the sufficiently energetic fraction for each pathway. State what remains unchanged.

Lower threshold, unchanged molecular energies



- 1 Set up** Catalysed E_a lies to the left; more collisions have enough energy.
- 2 Reason** The same curve, total population and mean energy remain. Equilibrium yield at this temperature is unchanged.

Your turn: test both plant requirements

- 1 Set up** 450 / 550 / 650 K: yields 92 / 76 / 46%; rates 0.040 / 0.60 / 2.5 mol min⁻¹.
- 2 Reason** Require yield $\geq 70\%$ and rate ≥ 0.50 mol min⁻¹. Choose the temperature and reject the others using the data.

Both limits define the compromise

- 1 **Set up** 550 K passes: 76% $\geq$ 70% and 0.60 $\geq$ 0.50 mol min⁻¹.
- 2 **Reason** 450 K is too slow; 650 K gives too little equilibrium product.
- 3 **Conclude** For an exothermic forward reaction, heating favours reverse reaction but raises the energetic collision fraction.

Solvent chooses the reaction emphasis

- 1 Warm aqueous KOH: bromoethane $\rightarrow$ ethanol by substitution.
- 2 Hot ethanolic KOH: bromoethane $\rightarrow$ ethene by elimination.
- 3 Alcoholic KCN gives propanenitrile; alcoholic excess NH_3 under pressure gives ethylamine.

Electron arrows show the mechanism

- 1** OH^- lone pair $\rightarrow$ carbon bearing Br; C-Br bond $\rightarrow$ Br.
- 2** With NH_3 , an alkylammonium ion forms first; a second NH_3 removes a proton.
- 3** For matched hydrolysis, weaker C-I reacts faster than C-Br then C-Cl; control temperature and concentrations.

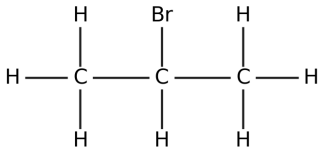
Your turn: names and two drawing conventions

- 1 Set up** Name $\text{CH}_3\text{CHBrCH}_3$ and $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$.
- 2 Reason** Draw each displayed and skeletal formula. Check every carbon valence and the O–H hydrogen.

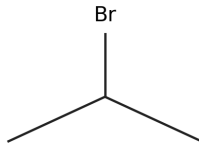
2-Bromopropane has a secondary functional carbon

2-Bromopropane: $\text{CH}_3\text{CHBrCH}_3$

Displayed formula



Skeletal formula

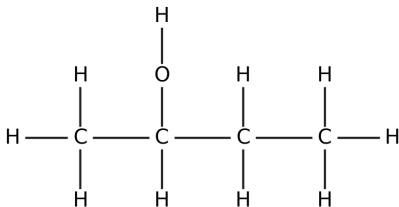


- 1 Set up** The central carbon has two carbon neighbours, one Br and one H.
- 2 Reason** The skeletal corner and both ends represent three carbons.

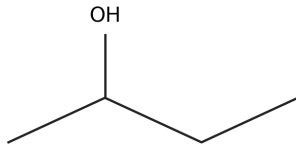
Butan-2-ol retains the O-H hydrogen

Butan-2-ol: $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

Displayed formula



Skeletal formula



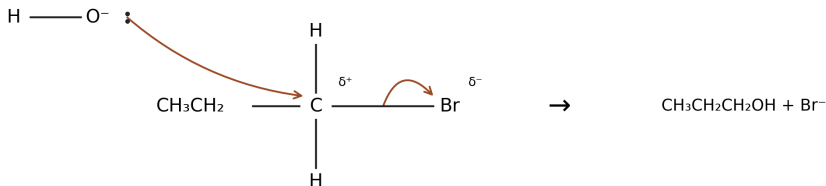
- 1 Set up** Four carbons form the main chain; OH is on carbon 2.
- 2 Reason** The OH-bearing carbon has two carbon neighbours, so the alcohol is secondary.

Your turn: draw hydroxide substitution

- 1 Set up** Use 1-bromopropane and aqueous OH^- .
- 2 Reason** Show the donating pair, two curly arrows, C–Br polarity and products.

Two arrows preserve electron pairs

Hydroxide substitutes for bromide



Only donating lone pairs are shown.

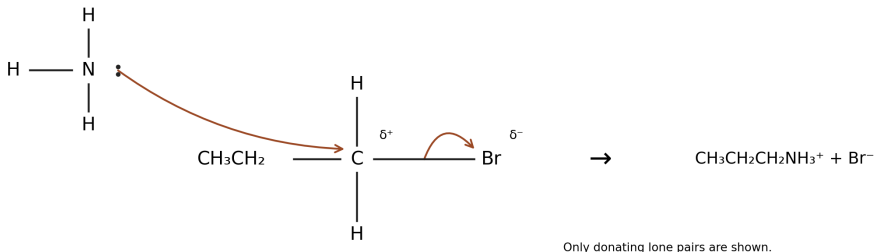
- 1 Set up** O lone pair $\rightarrow$ the carbon bearing Br; C-Br bond pair $\rightarrow$ Br.
- 2 Reason** Propan-1-ol and Br^- form; total charge remains -1 .

Your turn: ammonia needs two stages

- 1 Set up** Use excess alcoholic NH_3 under pressure with 1-bromopropane.
- 2 Reason** Draw attack and proton transfer; retain every charge and show the second ammonia.

Attack forms the positively charged intermediate

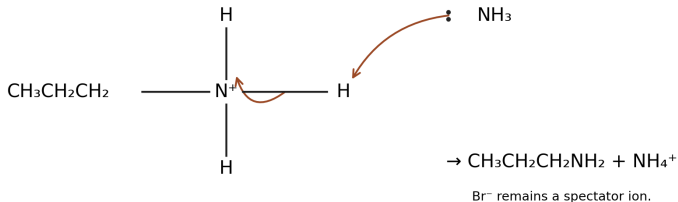
1 Ammonia attacks; an alkylammonium ion forms



- 1 Set up** NH₃ donates its lone pair to carbon while the C–Br pair goes to Br.
- 2 Reason** The nitrogen has four bonds in CH₃CH₂CH₂NH₃⁺; bromide balances its charge.

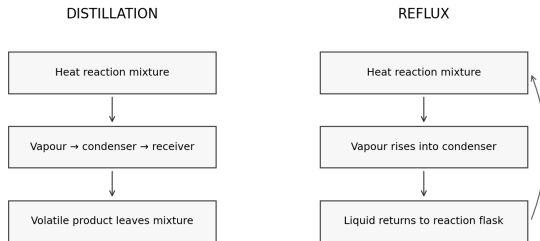
Proton transfer restores the neutral amine

2 A second ammonia removes a proton



- 1 **Set up** A second NH₃ lone pair → N-bound H; the N-H pair returns to N.
- 2 **Reason** Propan-1-amine and NH₄⁺ form; Br⁻ remains. The amine lone pair allows further substitution.

Product removal controls oxidation



Process comparison only; use the approved apparatus and risk assessment.

Distillation removes volatile aldehyde before further oxidation.

Combine tests rather than guessing

- 1 Primary alcohol $\rightarrow$ aldehyde or acid; secondary $\rightarrow$ ketone; tertiary resists the stated oxidant.
- 2 Aldehyde reduces warm Fehling's solution; acid gives CO_2 with carbonate.
- 3 Use molecular-ion mass, IR absorptions and chemical tests together; a carbonyl peak alone is ambiguous.

Your turn: separate three purification purposes

- 1 Set up** The organic product has density 0.87 g cm^{-3} ; the aqueous phase has density 1.00 g cm^{-3} .
- 2 Reason** Identify the layer, then explain separation, drying, salt removal and boiling-temperature evidence.

Bulk water and residual water need different actions

- 1 **Set up** The stated product is the upper layer; separation removes the bulk aqueous phase.
- 2 **Reason** A suitable anhydrous salt removes residual water; filter or decant before distillation.
- 3 **Conclude** Measure vapour temperature at the condenser entrance and compare at the same pressure. A narrow range supports purity, not unique identity.

Your turn: a fragment is not a full structure

- 1 Set up** $\text{C}_3\text{H}_6\text{O}$ has molecular ion 58, fragment 29, carbonyl absorption and positive warm Fehling's test.
- 2 Reason** Check the mass, propose two ion formulae of mass 29 and choose propanal or propanone from all evidence.

Combined evidence selects the aldehyde

- 1 Set up** Both isomers have $M_r = 3(12)+6+16 = 58$. C_2H_5^+ and CHO^+ both have mass 29.
- 2 Reason** Positive Fehling's evidence supports propanal. One fragment or carbonyl alone cannot uniquely establish the isomer.

Supplied IR data: carbon environments

Bond / environment	Supplied region / cm^{-1}
Alkane C-H	2850–3000
Alkene C-H	3000–3100
Aldehyde C-H	2700–2900
C=C	1620–1680
C=O	1680–1750

Supplied IR data: heteroatom environments

Bond / environment	Supplied region / cm^{-1}
Alcohol O-H	3200–3600, broad
Acid O-H	2500–3300, very broad
C-Cl	500–800
Amine N-H	3300–3500

Your turn: predict bonds before peaks

- 1 Set up** Use the supplied tables for $\text{CH}_2=\text{CHCH}_2\text{NH}_2$ and HOCH_2CHO .
- 2 Reason** List all relevant C–H environments and each additional functional-group absorption.

Each structural environment contributes evidence

- 1 **Set up** $\text{CH}_2=\text{CHCH}_2\text{NH}_2$: alkene/alkane C–H, C=C and N–H.
- 2 **Reason** HOCH_2CHO : alkane/aldehyde C–H, broad alcohol O–H and C=O.
- 3 **Conclude** Use the given ranges; alcohol O–H differs from the very broad acid O–H of CH_3COOH .

Your turn: combine inorganic and organic evidence

- 1 Set up** A/B: white BaSO_4 . Only A releases NH_3 with warm NaOH . C/D: M^+ 58 and carbonyl; only C gives positive Fehling's.
- 2 Reason** Candidates: sodium sulfate, ammonium sulfate, propanal and propanone. Assign each and write the two ionic equations.

Independent tests separate the four candidates

- 1 **Set up** A: ammonium sulfate; B: sodium sulfate; C: propanal; D: propanone.
- 2 **Reason** $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$; $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4(\text{s})$.
- 3 **Conclude** Use fresh aliquots. Shared mass and carbonyl evidence do not distinguish C/D; the aldehyde reducing test does.

Independent identification

Your turn

$\text{C}_3\text{H}_6\text{O}$ has a carbonyl IR absorption and gives a positive Fehling's test. Which structure fits all evidence?

- A. CH_3COCH_3
- B. $\text{CH}_3\text{CH}_2\text{CHO}$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D. CH_3COOH

Check yourself

- 1 B: propanal has formula $\text{C}_3\text{H}_6\text{O}$, a carbonyl and a reducing aldehyde group.
- 2 A is propanone: formula and carbonyl fit, but Fehling's result does not.
- 3 C and D have different formulae. No one test is a whole structural proof.