



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

AQA CHEMISTRY 7405

HALOALKANES I

NUCLEOPHILIC SUBSTITUTION

POLARITY • HYDROXIDE • CYANIDE • AMMONIA • MECHANISMS

			
SPEC	CRACK IT	TEST IT	DONE WHEN

One functional group, three useful routes

Learn why the C–X bond reacts, then use OH^- , CN^- and NH_3 to make alcohols, nitriles and amines. Work through the arrows, practise on different molecules and check every answer at the back.

AQA SECTION	YOUR ROUTE
3.3.3.1: Part I	C–X polarity; nucleophilic substitution with OH^- , CN^- and NH_3 ; mechanisms, reagents and conditions.
Bring forward: 3.3.1.1–3.3.1.2	Organic names and structural formulae; lone pairs; heterolytic fission and full curly arrows.
Part II follows separately	Hydrolysis-rate comparisons and C–X bond enthalpy; elimination and competing conditions; CFCs and ozone depletion.

BRING FORWARD A full curly arrow represents movement of an electron pair. It starts at a lone pair or covalent bond, not at a charge symbol.

HOW TO USE Read the teaching and worked examples, then complete each TEST IT. Draw in the labelled boxes and use the dotted lines for written answers. Complete mechanisms are included in the answer section.

The official AQA specification calls this topic “Halogenoalkanes”. Haloalkanes means the same class of compounds. Reaction mechanisms here use methyl and primary substrates so the electron-pair movements can be learnt clearly.

AQA specification checked 13 October 2026. Original practice questions with complete worked answers.

1. Recognise a haloalkane



SPEC 3.3.3.1 Recognise the C–X functional group and apply familiar organic naming rules.



CRACK IT Find the carbon bonded to the halogen. Keep the carbon skeleton when you name or classify the molecule.

FULL-MARK LANGUAGE A haloalkane (halogenoalkane) is an alkane derivative in which one or more hydrogen atoms have been replaced by halogen atoms. X represents F, Cl, Br or I; R represents an alkyl group.

The functional group is a carbon–halogen bond, C–X. An acyclic haloalkane with one halogen atom has general formula $C_nH_{2n+1}X$. This formula does not apply unchanged to compounds with two halogen atoms or to rings.

Worked examples: name, then classify



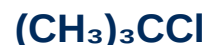
chloroethane

primary



2-bromopropane

secondary



2-chloro-2-methylpropane

tertiary

Choose the longest carbon chain, give the halogen the lowest possible locant, then use fluoro-, chloro-, bromo- or iodo-. For $CH_3CHBrCH_3$, the parent is propane and Br is on carbon 2: 2-bromopropane.

TYPE	CARBON NEIGHBOURS OF THE C–X CARBON
Primary (1°)	One other carbon atom
Secondary (2°)	Two other carbon atoms
Tertiary (3°)	Three other carbon atoms

Count carbon neighbours of the carbon carrying X, not halogen atoms or the total carbons in the molecule. CH_3X is a methyl halide. This pack uses methyl and primary haloalkanes for mechanisms.



TEST IT 1

a) Name $CH_3CH_2CH_2CH_2I$ and classify it as primary, secondary or tertiary. [2 marks]

.....

.....

b) Write the structural formula of 2-chlorobutane and state its molecular formula. [2 marks]

.....

.....

✓ **DONE WHEN** I can locate C–X, name the molecule and count the carbon neighbours of the C–X carbon.

2. Why the C–X carbon is attacked



SPEC 3.3.3.1 Explain C–X bond polarity and identify OH^- , CN^- and NH_3 as nucleophiles.



CRACK IT The nucleophile supplies an electron pair. The partially positive carbon accepts it.

DEFINITION BANK Electronegativity: the power of an atom to attract the pair of electrons in a covalent bond.
Nucleophile: an electron-pair donor.

The halogen is more electronegative than carbon. It attracts the C–X bonding pair more strongly, producing $\text{C}\delta^+ - \text{X}\delta^-$. The bond is polar; δ means a partial charge, not a full ionic charge.



Br attracts the bonding pair more strongly than carbon.

The δ^+ carbon accepts an electron pair from a nucleophile.

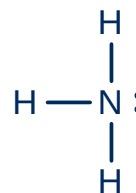
Worked examples: identify the donating atom



O donates



C donates



N donates

OH^- donates a lone pair on O; CN^- donates a lone pair on C in these reactions; NH_3 donates its lone pair on N. Only the reacting lone pair is shown. Ammonia is neutral: a nucleophile does not have to carry a negative charge.

EXAM TRAP Say “the halogen attracts the bonding pair more strongly”. Do not claim that the halogen removes the electron pair before the substitution occurs.



TEST IT 2

a) Explain why the carbon bonded to Cl in chloroethane has a partial positive charge. [2 marks]

.....

.....

b) Define nucleophile and explain why neutral NH_3 can act as one. [2 marks]

.....

.....

✓ **DONE WHEN** I can explain $\text{C}\delta^+ - \text{X}\delta^-$ and identify the electron pair on each incoming nucleophile.

3. Read the two curly arrows



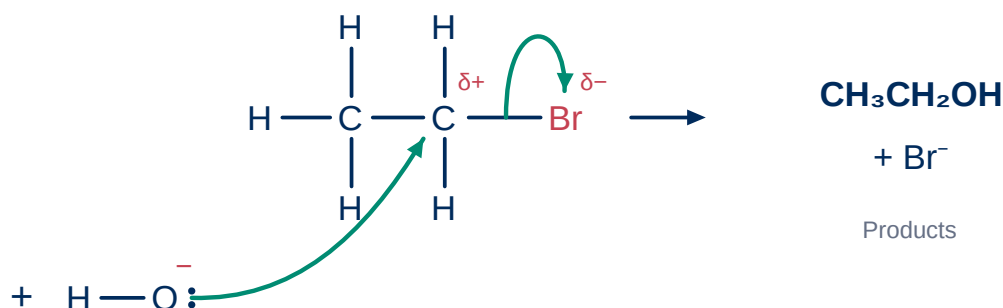
SPEC 3.3.3.1 Use curly arrows to show bond formation and heterolytic C–X bond breaking.



CRACK IT A full curly arrow shows movement of an electron pair. Its tail starts at the pair's source; its head shows where that pair goes.

TWO DEFINITIONS Substitution: an atom or group is replaced by another atom or group. Heterolytic fission: a covalent bond breaks and both bonding electrons go to one of the bonded atoms.

Worked example: bromoethane + hydroxide



1. The O lone pair forms a bond to the δ^+ carbon: draw an arrow from the lone pair on O to that carbon.
2. The C–Br bond breaks heterolytically: draw an arrow from the C–Br bond to Br. Br leaves as Br^- .
3. Br is replaced by OH, so the reaction is nucleophilic substitution. Charge is -1 on both sides.

ARROW CHECK Use a complete arrowhead for two electrons. Start the breaking-bond arrow on C–X, not on X. Carbon must not be left with five bonds.



TEST IT 3

a) Draw the nucleophilic substitution mechanism for $\text{CH}_3\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + \text{Cl}^-$. Show the O lone pair, both curly arrows and both products. [3 marks]

3(a) Draw the two arrows and products for chloromethane + OH^- .

b) What does one full curly arrow represent? [1 mark]

✓ **DONE WHEN** I can place both arrow tails correctly and conserve atoms, bonds and charge.

4. Make an alcohol with hydroxide



SPEC 3.3.3.1 Give the reagent, conditions and equations for substitution by OH⁻.



CRACK IT Use aqueous hydroxide and heat under reflux. Replace X with OH; the carbon chain stays the same length.

REAGENT	CONDITIONS	ORGANIC PRODUCT
Aqueous NaOH or KOH	Heat under reflux	Alcohol, R-OH

HYDROLYSIS Hydrolysis is bond breaking by reaction with water or an aqueous reagent. Here, aqueous hydroxide replaces the halogen in the haloalkane with OH.

Worked example 1: a complete equation



Bromoethane forms ethanol. OH replaces Br; Na⁺ is a spectator ion. Removing Na⁺ from the equation gives the ionic equation below.



Worked example 2: read the position



The OH group occupies the carbon that carried Cl: 2-chloropropane gives propan-2-ol. The carbon skeleton and the number of carbon atoms are unchanged.

REAGENT ≠ NUCLEOPHILE If asked for the reagent, give aqueous sodium hydroxide or potassium hydroxide. If asked for the nucleophile, give OH⁻. The word “aqueous” is part of the conditions.



TEST IT 4

a) Give the reagent and heating condition needed to convert 1-iodobutane to butan-1-ol. [2 marks]

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b) Write a full equation, using structural formulae, for 1-chloropropane reacting with aqueous KOH. [2 marks]

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c) State the number of carbon atoms in the organic product in part (b). [1 mark]

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✓ **DONE WHEN** I can distinguish the reagent from OH⁻ and write balanced alcohol-forming equations.

5. Draw the hydroxide mechanism

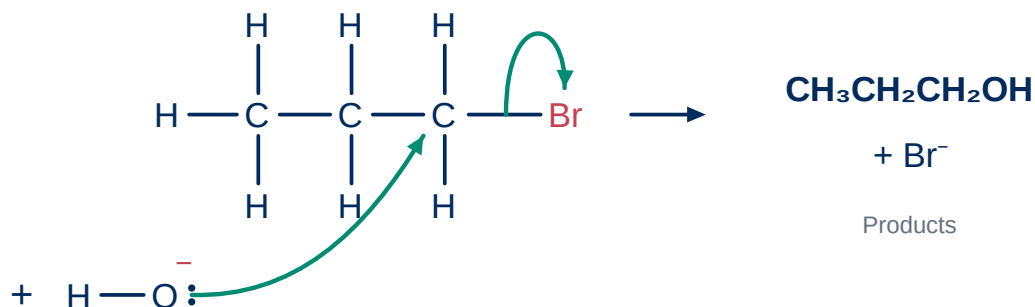


SPEC 3.3.3.1 Apply the two-arrow method to a fresh haloalkane without changing its skeleton.



CRACK IT Find C–X first. Connect the O of OH[–] to that carbon and send the C–X pair to X.

Worked example: 1-bromopropane → propan-1-ol



1. The nucleophile is OH[–]. Mark its negative charge and a lone pair beside O.
2. Draw the forming-bond arrow from that O lone pair to the end carbon carrying Br.
3. Draw the breaking-bond arrow from C–Br to Br. The products are neutral propan-1-ol and Br[–].

CHECK	WHAT THE CORRECT DIAGRAM SHOWS
Connectivity	A C–O bond forms; the C–Br bond breaks.
Atoms	Three carbons remain in the organic product.
Charge	OH [–] supplies –1 on the left; Br [–] carries –1 on the right.

DO NOT AIM AT H OH[–] bonds through O. An arrow aimed at one of the attached H atoms would show a different electron movement.



TEST IT 5

a) Draw the mechanism for 1-iodobutane reacting with OH[–] to form butan-1-ol. Include the reacting lone pair, both curly arrows, the organic product as a structural formula and the other product with its charge. [4 marks]

5(a) Mechanism: 1-iodobutane + OH[–] → butan-1-ol + iodide.

b) Name the reaction mechanism. [1 mark]

✓ **DONE WHEN** I can draw the OH[–] mechanism with the correct atom, bonds, products and charges.

6. Add one carbon with cyanide



SPEC 3.3.3.1 Give the cyanide reagent and conditions, and name the resulting nitrile.

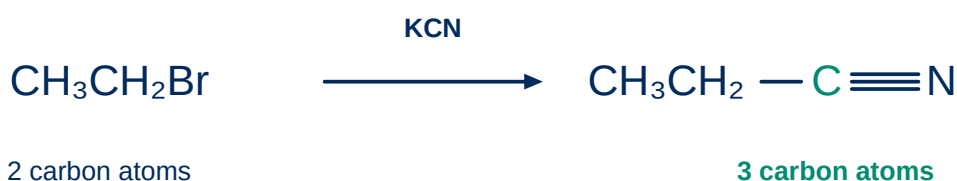


CRACK IT CN^- joins through C. Keep that carbon in the product and include it when you count the parent chain.

REAGENT	CONDITIONS	ORGANIC PRODUCT
KCN or NaCN	Aqueous ethanol; heat under reflux	Nitrile, $\text{R}-\text{C}\equiv\text{N}$

NITRILE A nitrile contains a $\text{C}\equiv\text{N}$ group. For a simple chain nitrile, include the nitrile carbon in the parent chain; it is carbon 1. Replace the alkane ending -e with -enitrile: propane $\rightarrow$ propanenitrile.

Worked example 1: the extra carbon



The carbon from CN^- becomes carbon 1 of the nitrile.



The structural formula $\text{CH}_3\text{CH}_2\text{CN}$ contains three carbons. "CN" in a nitrile represents $\text{C}\equiv\text{N}$; nitrogen has three bonds and the nitrile carbon has four bonds in total.

Worked example 2: retain the branch



The product has four carbon atoms in total. The longest chain containing the nitrile carbon has three carbons; a methyl group is on C2. Its name is 2-methylpropanenitrile.



TEST IT 6

a) Write the structural formula and name of the nitrile made from $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ with CN^- . [2 marks]

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b) Give a suitable reagent and the solvent/heating conditions for this conversion. [2 marks]

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c) Explain why the product has one more carbon atom than the haloalkane. [1 mark]

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✓ **DONE WHEN** I can retain $\text{C}\equiv\text{N}$, count the added carbon and name the nitrile correctly.

7. Draw the cyanide mechanism

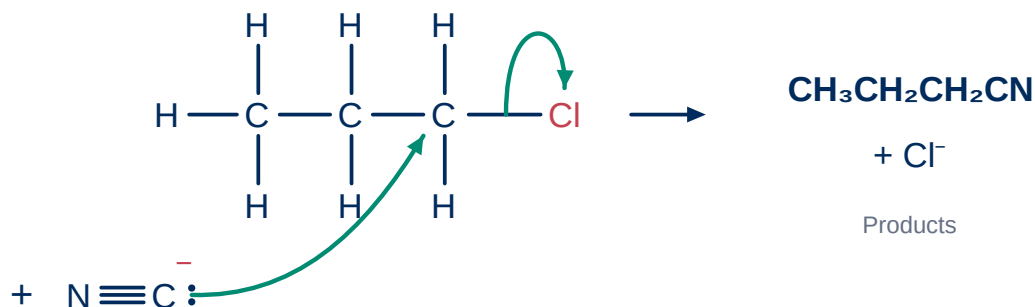


SPEC 3.3.3.1 Show cyanide bonding through carbon and preserve the C≡N triple bond.



CRACK IT Start the incoming arrow at the carbon lone pair in CN⁻. Its destination is the C–X carbon.

Worked example: 1-chloropropane → butanenitrile



1. Draw CN⁻ as N≡C⁻ with the reacting lone pair beside C. Orientation can vary; the donating atom cannot.
2. Draw a curly arrow from that lone pair to the carbon bonded to Cl. Draw the second arrow from C–Cl to Cl.
3. The C≡N triple bond stays intact. A new C–C bond forms and Cl⁻ leaves.

COUNT BEFORE NAMING The three carbons in 1-chloropropane plus the cyanide carbon make a four-carbon nitrile: butanenitrile. The product formula is C₄H₇N.

EXAM TRAP An arrow starting at N would show the wrong connectivity for the nitrile product required here. Do not replace CN⁻ with HCN as the reagent.



TEST IT 7

a) Draw the mechanism for bromomethane reacting with CN⁻ to form ethanenitrile. Show C≡N, the reacting lone pair, both curly arrows and both products. [4 marks]

7(a) Mechanism: bromomethane + CN⁻ → ethanenitrile + bromide.

b) State the molecular formula of the organic product. [1 mark]

✓ **DONE WHEN** I can draw the C-donating nucleophile and preserve the nitrile triple bond.

8. Make an amine with ammonia



SPEC 3.3.3.1 State the reagent, conditions, organic product and overall equation for NH_3 substitution.



CRACK IT Use excess ethanolic ammonia. One NH_3 forms the C–N bond; another accepts a proton.

REAGENT	CONDITIONS	ORGANIC PRODUCT
Excess NH_3 in ethanol	Heat under pressure in a sealed vessel	Primary amine, R-NH_2

PRIMARY AMINE A primary amine has one carbon-containing group bonded to N, with two N–H bonds: R-NH_2 . “Primary” here describes the groups attached to nitrogen.

Worked example 1: account for both NH_3 molecules



Bromomethane forms methylamine. One ammonia molecule supplies N to the organic product. The second removes H^+ from the initial positive organic intermediate, forming NH_4^+ ; Br^- is its counter-ion.

Worked example 2: keep the carbon chain



The product is propan-1-amine (propylamine). Replace the halogen with NH_2 and keep all three carbons. The two ammonia molecules have different roles; section 9 shows bond formation and section 10 shows proton removal.

WHY EXCESS AMMONIA? The amine product can also act as a nucleophile. Excess NH_3 favours reaction with ammonia and reduces further substitution of the amine product.

Heating under pressure keeps volatile ammonia in the reaction mixture. These conditions are different from the open reflux apparatus used with aqueous hydroxide.



TEST IT 8

a) Write the overall equation for 1-bromobutane reacting with excess ammonia. Use structural formulae for the organic substances. [2 marks]

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b) Give the solvent and the heating condition for this reaction. [2 marks]

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c) Explain why excess ammonia is used. [1 mark]

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✓ **DONE WHEN** I can give the ammonia conditions and balance the equation using two NH_3 molecules.

9. Ammonia mechanism: form the C–N bond

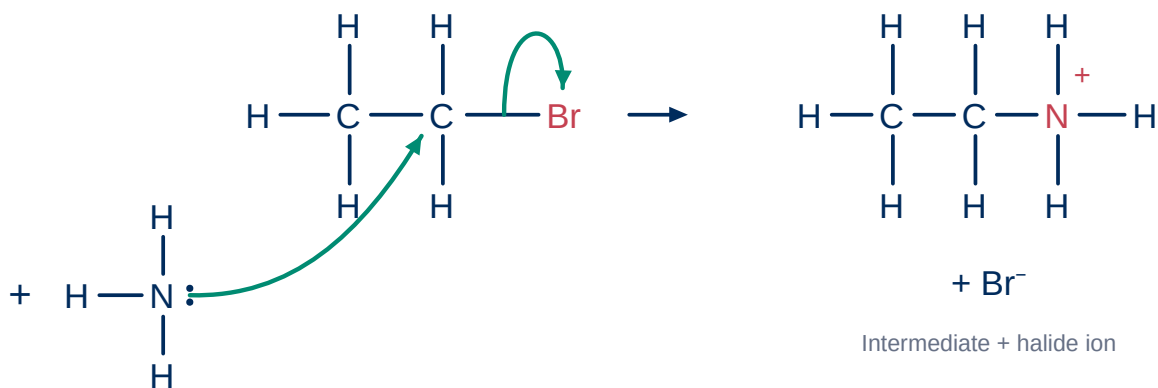


SPEC 3.3.3.1 Draw the substitution step and the positively charged organic intermediate.



CRACK IT Neutral NH_3 uses its lone pair to make a fourth bond. Nitrogen then carries a positive charge.

Worked example: bromoethane + NH_3



1. Start the first curly arrow at the lone pair on N in NH_3 and end it at the carbon carrying Br.
2. Start the second at the C–Br bond and end it at Br. Br leaves as Br^- .
3. The organic intermediate is $\text{CH}_3\text{CH}_2\text{NH}_3^+$: nitrogen has four bonds and no lone pair. This is an ethylammonium ion, not yet the neutral amine.

CHARGE AUDIT Both reactants in this step are neutral. The products carry +1 and –1, so the total charge is still zero. Do not put a negative charge on NH_3 .

This first step is nucleophilic substitution. A second ammonia molecule is needed to remove a proton from the positive nitrogen; that step follows on the next page.



TEST IT 9

a) Draw the first step of the reaction between 1-chloropropane and NH_3 . Show the N lone pair, two curly arrows, the organic intermediate with its charge and the other product. [4 marks]

9(a) First step only: 1-chloropropane + NH_3 .

b) Explain why the nitrogen in the organic intermediate is positive. [1 mark]

✓ **DONE WHEN** I can show the charged intermediate rather than jumping directly to the neutral amine.

10. Ammonia mechanism: remove a proton

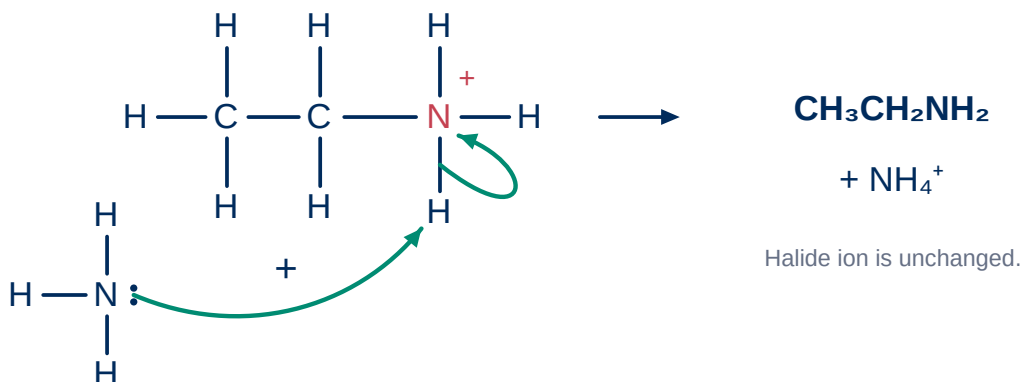


SPEC 3.3.3.1 Complete the mechanism using a second NH_3 molecule and show the neutral amine.



CRACK IT The second NH_3 accepts H^+ . The N-H bonding pair returns to the positive nitrogen.

Worked example: ethylammonium $\rightarrow$ ethylamine



1. Draw an arrow from the second ammonia molecule's N lone pair to an H bonded to the positive N.
2. Draw another arrow from that N-H bond back to the positive N. This removes H^+ , not $\text{H}^\bullet$.
3. The organic product is $\text{CH}_3\text{CH}_2\text{NH}_2$, ethylamine (ethanamine). The second NH_3 becomes NH_4^+ ; Br^- remains unchanged.

TWO ROLES First NH_3 : nucleophile, forming C-N. Second NH_3 : base, accepting a proton. A base is a proton acceptor.



TEST IT 10

a) Draw the proton-transfer step for $\text{CH}_3\text{NH}_3^+ + \text{NH}_3 \rightarrow \text{CH}_3\text{NH}_2 + \text{NH}_4^+$. Show all N-H bonds involved, the incoming lone pair, both curly arrows and product charges. [4 marks]

10(a) Proton transfer: methylammonium ion + NH_3 .

b) State the role of the second NH_3 molecule in this step. [1 mark]

✓ **DONE WHEN** I can complete both electron movements and obtain an amine plus NH_4^+ .

11. Choose the correct substitution route



SPEC 3.3.3.1 Link the reagent, conditions, donor atom and product without mixing the three routes.



CRACK IT Read the required product first. OH makes C–O; CN makes C–C; NH₃ makes C–N.

NUCLEOPHILE / DONOR	REAGENT & CONDITIONS	PRODUCT / CARBON COUNT
OH [−] / O	Aqueous NaOH or KOH; heat under reflux	Alcohol R–OH; unchanged
CN [−] / C	KCN or NaCN in aqueous ethanol; heat under reflux	Nitrile R–C≡N; increases by one
NH ₃ / N	Excess ethanolic NH ₃ ; heat under pressure	Primary amine R–NH ₂ ; unchanged

Worked example: choose the route from the product

To turn 1-iodopropane into butanenitrile, compare the carbon counts: three → four. The new carbon and nitrogen arrive together as CN[−]. Choose KCN or NaCN in aqueous ethanol and heat under reflux.



Contrast: making propan-1-ol from the same starting molecule retains three carbons. Choose aqueous hydroxide and reflux; CN[−] would give the wrong functional group and carbon count.

THREE FINAL CHECKS Name the reagent, not just the ion. Include the solvent and heating condition. Count the carbon atoms and check the atom bonded to the original C–X carbon.



TEST IT 11

a) Give the reagent and conditions to convert 1-chlorobutane to butan-1-amine. [2 marks]

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b) Write the structural formula of the organic product when iodoethane reacts with aqueous KOH under reflux. [1 mark]

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c) A student uses NaCN to try to make methanol from chloromethane. State the product's structural formula and explain the error. [2 marks]

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✓ **DONE WHEN** I can choose the route from the required functional group and carbon count.

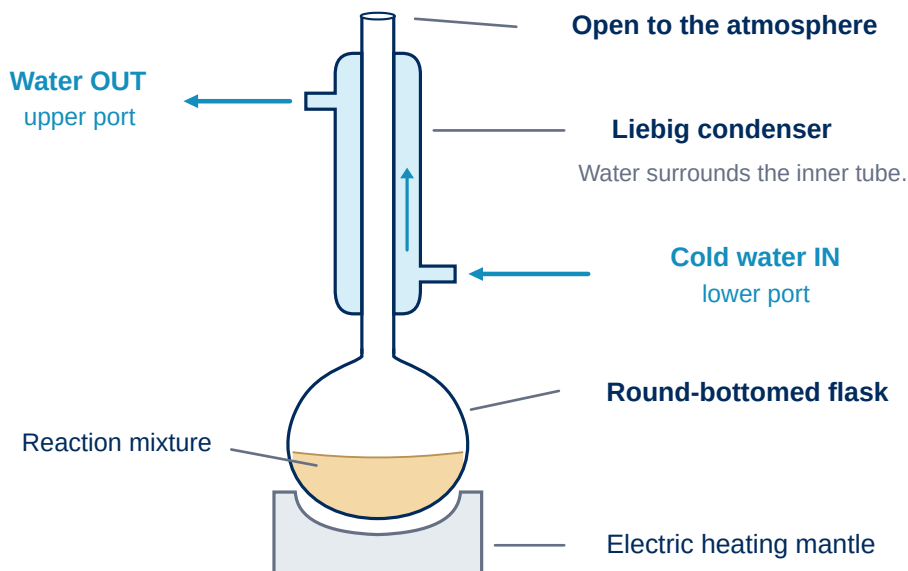
12. Understand heating under reflux



SPEC 3.3.3.1 Explain reflux and condenser water flow for the aqueous hydroxide route.



CRACK IT Reflux returns condensed vapour to the flask, so the reaction can be heated without losing volatile material.



Cold water enters the lower condenser port and leaves through the upper port. This keeps the jacket full of water and provides effective cooling along the condenser. The cooling water does not mix with the reaction mixture.

REFLUX $\neq$ DISTILLATION Reflux returns the condensate to the reaction flask. Distillation collects the condensed vapour in a separate receiver. Keep a reflux apparatus open to the atmosphere.

Worked explanation: why the product is not collected here

When 1-bromobutane is heated with aqueous sodium hydroxide, vapour rises into the vertical condenser, cools and returns to the flask. The purpose is to allow continued heating of the reacting mixture, not to collect butan-1-ol in a receiver.

CONDITIONS CHECK Aqueous hydroxide: open reflux apparatus. Ammonia route: heat with excess ethanolic NH_3 under pressure in suitable sealed equipment. Do not combine these apparatus descriptions.



TEST IT 12

a) 1-bromopropane is heated with aqueous KOH. Explain why reflux is useful. [2 marks]

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b) State where cooling water must enter the condenser and explain why. [2 marks]

.....

c) State one difference between reflux and distillation in what happens to the condensate. [1 mark]

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✓ **DONE WHEN** I can explain the open condenser, water direction and return of condensate.



Worked checking example

FINAL MASTERY CHECK Can you define nucleophile, locate $C\delta+$, start arrows at lone pairs or bonds, use all three reagent sets, count the extra nitrile carbon and complete the second ammonia step?



a) 1-bromobutane is converted into pentanenitrile. Give the reagent and conditions. [2 marks]

13(b) Mechanism: 1-bromobutane + $\text{CN}^- \rightarrow$ pentanenitrile + bromide.

c) A student writes $\text{CH}_3\text{CH}_2\text{I} + \text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HI}$ as the overall equation in excess ammonia. Correct the equation. [2 marks]

d) A curly arrow is drawn from Cl towards the C–Cl bond to show bond breaking. State the correct origin and destination. [1 mark]

✓ **DONE WHEN** I can select, draw and check a complete substitution route without copying a worked molecule.

Answers for TEST IT 1 to 5

These are marking points for the original practice questions. Mechanism drawings show the reacting lone pairs; other non-bonding pairs are omitted for clarity. Equivalent correct orientations are acceptable.

TEST IT 1 | 4 marks

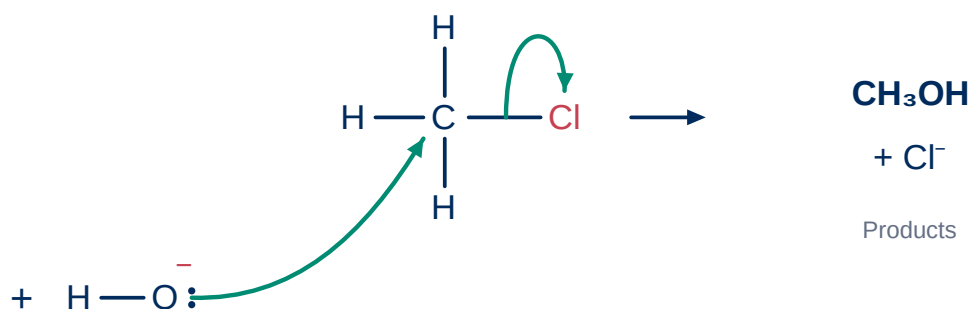
- a) 1-iodobutane; primary, because the C-I carbon is bonded to one other carbon.
 b) $\text{CH}_3\text{CHClCH}_2\text{CH}_3$; $\text{C}_4\text{H}_9\text{Cl}$.

TEST IT 2 | 4 marks

- a) Cl is more electronegative than C; the C-Cl bonding pair is drawn towards Cl, leaving C partially positive.
 b) An electron-pair donor. NH_3 has a lone pair on nitrogen available to form a bond.

TEST IT 3 | 4 marks

- a) Arrow from an O lone pair on OH^- to the carbon in CH_3Cl ; arrow from the C-Cl bond to Cl; products CH_3OH and Cl^- .



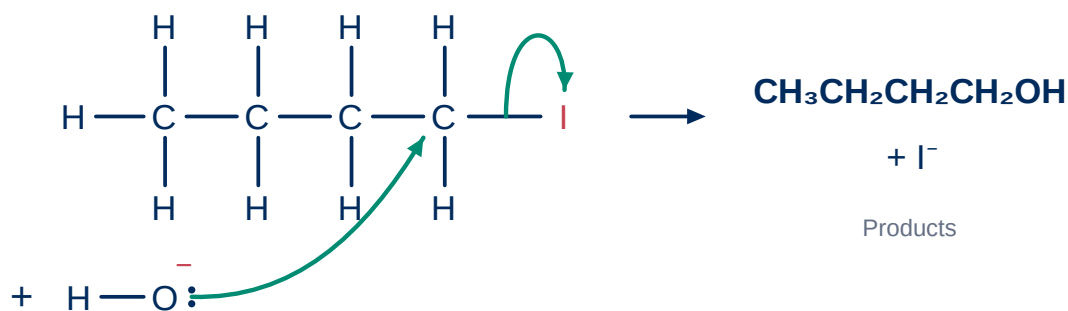
- b) Movement of a pair of electrons.

TEST IT 4 | 5 marks

- a) Aqueous NaOH or KOH; heat under reflux.
 b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} + \text{KOH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + \text{KCl}$.
 c) Three.

TEST IT 5 | 5 marks

- a) O lone pair on $\text{OH}^- \rightarrow$ carbon bonded to I; C-I bond $\rightarrow$ I. Products: $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ and I^- .



- b) Nucleophilic substitution.

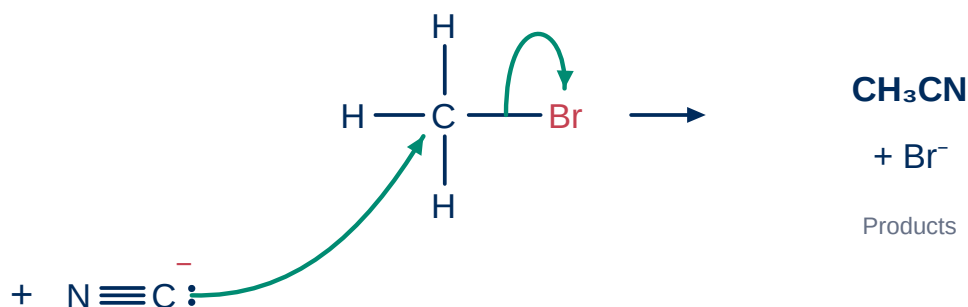
Answers for TEST IT 6 to 9

TEST IT 6 | 5 marks

- a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CN}$; pentanenitrile.
 b) KCN or NaCN; aqueous ethanol and heat under reflux.
 c) The carbon atom from CN^- becomes part of the organic product.

TEST IT 7 | 5 marks

- a) C lone pair in CN^- → carbon in CH_3Br ; C–Br bond → Br. Products CH_3CN (ethanenitrile) and Br^- ; the $\text{C}\equiv\text{N}$ triple bond is retained.



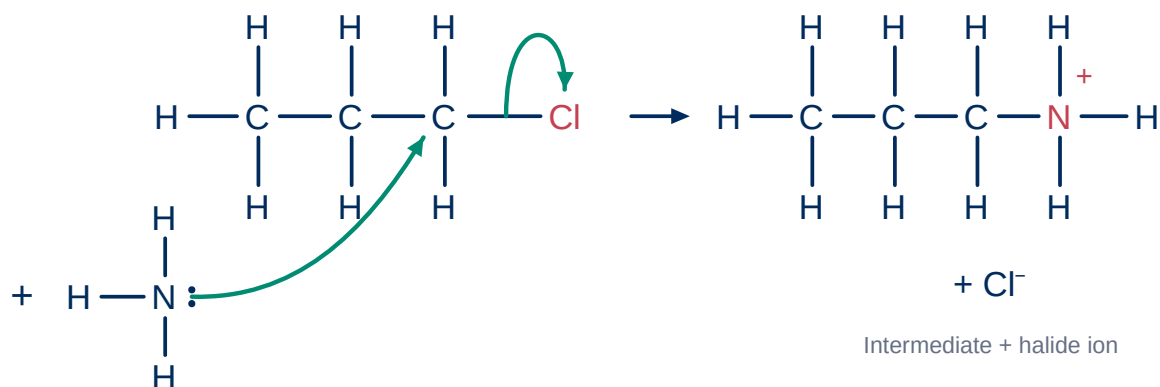
- b) $\text{C}_2\text{H}_5\text{N}$.

TEST IT 8 | 5 marks

- a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + 2\text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Br}$.
 b) Ethanol; heat under pressure in a sealed vessel.
 c) It favours reaction with NH_3 and reduces further substitution by the amine product.

TEST IT 9 | 5 marks

- a) N lone pair in NH_3 → carbon bonded to Cl; C–Cl bond → Cl. Products $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_3^+$ and Cl^- .

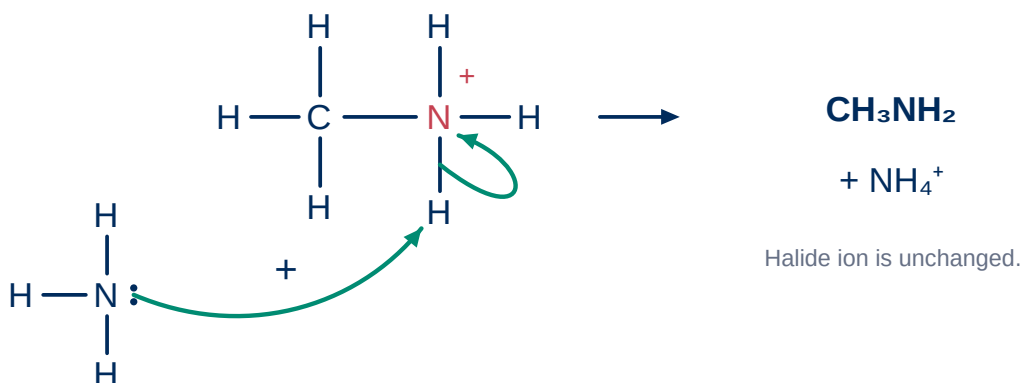


- b) Nitrogen has used its lone pair to form a fourth covalent bond and carries a formal +1 charge.

Answers for TEST IT 10 to 13

TEST IT 10 | 5 marks

a) Lone pair on the second NH_3 nitrogen $\rightarrow$ H on CH_3NH_3^+ ; that N–H bond $\rightarrow$ positive N. Products CH_3NH_2 and NH_4^+ .



b) Base (proton acceptor).

TEST IT 11 | 5 marks

a) Excess NH_3 in ethanol; heat under pressure in a sealed vessel.

b) $\text{CH}_3\text{CH}_2\text{OH}$.

c) CH_3CN . Cyanide makes a nitrile and adds one carbon; aqueous hydroxide is needed for methanol.

TEST IT 12 | 5 marks

a) It allows the mixture to be heated; the condenser returns volatile material to the flask, preventing its loss.

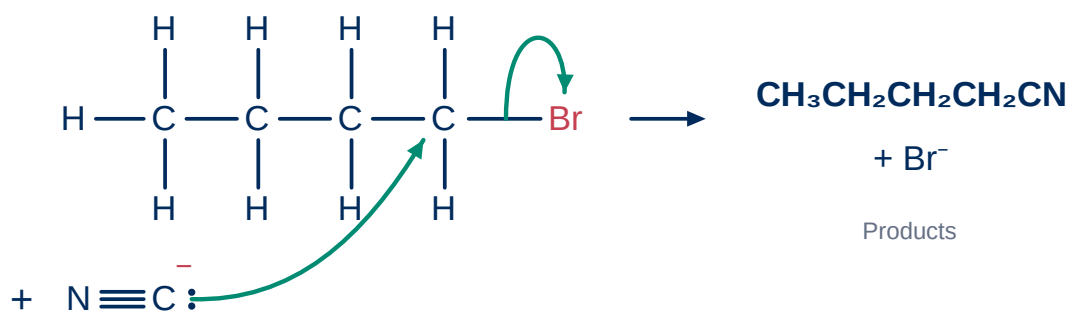
b) At the bottom; this keeps the water jacket full for effective cooling.

c) Reflux returns it to the same reaction flask; distillation collects it in a separate receiver.

TEST IT 13 | 9 marks

a) KCN or NaCN in aqueous ethanol; heat under reflux.

b) C lone pair on CN^- $\rightarrow$ C carrying Br; C–Br bond $\rightarrow$ Br. Products $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CN}$ and Br^- .



c) $\text{CH}_3\text{CH}_2\text{I} + 2\text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{NH}_4\text{I}$.

d) From the C–Cl bond to the Cl atom.

Specification and checking sources

AQA 7405, 3.3.3.1, nucleophilic substitution. Bond enthalpy/rate comparisons within that section, 3.3.3.2 elimination and 3.3.3.3 ozone depletion are reserved for Haloalkanes II.

aqa.org.uk/subjects/chemistry/a-level/chemistry-7405/specification/subject-content/organic-chemistry

Reagent, solvent and arrow conventions checked against AQA 7405/2 June 2019 mark scheme, Q01 and organic-mechanism guidance: filestore.aqa.org.uk/sample-papers-and-mark-schemes/2019/june/AQA-74052-W-MS-JUN19.PDF