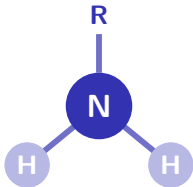


Nitrogen Compounds

A-Level Chemistry ■ Topic 19

A-Level Chemistry



What we will cover

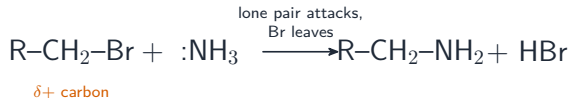
- 1 Making a primary amine
- 2 Two ways cyanide adds a carbon
- 3 Nitrile routes



amines build nylon



Making a primary amine



An **amine** has an -NH_2 group.
Heat a **halogenoalkane** with NH_3 in ethanol.

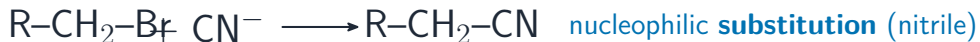
The lone pair on N attacks the $\delta+$ carbon and pushes out the halogen – a **nucleophilic substitution**. Use **excess** NH_3 .

Two ways cyanide adds a carbon

■ $\text{KCN} + \text{halogenoalkane} \rightarrow \text{a nitrile}$ (substitution)

■ $\text{HCN} + \text{carbonyl} \rightarrow \text{a hydroxynitrile}$ (addition)

Both **add one carbon** to the chain.

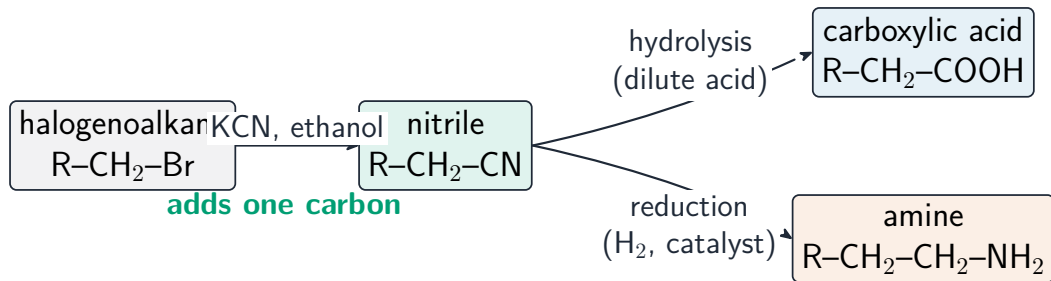


Nitrile routes

A **nitrile** is a useful hub:

- **hydrolysis** → a **carboxylic acid**
- **reduction** → an amine (a longer chain)

Nitrile routes, in detail



A **nitrile** is a useful hub – it leads two ways:

hydrolysis $\rightarrow$ a **carboxylic acid**.

reduction $\rightarrow$ an amine, one carbon longer than you started.

The two things a nitrile can become

hydrolysis

with dilute acid and heat, $\text{RCN} \rightarrow \text{RCOOH}$ – a **carboxylic acid** with the same number of carbons

reduction

with hydrogen and a catalyst (or LiAlH_4), $\text{RCN} \rightarrow \text{RCH}_2\text{NH}_2$ – an **amine**

why it matters

both routes **keep** the extra carbon the cyanide added

nucleophilic addition

how the cyanide got there: CN^- adds to an **aldehyde** or **ketone** to give a hydroxynitrile

hydrogen cyanide

the source of CN^- , used with KCN in ethanol

Count the carbons first. Bromoethane has 2 and propanoic acid has 3, so the route must add one – which is exactly what the cyanide step does.

Exam tips

- **Amines are bases** (the N lone pair accepts H^+); aliphatic amines are stronger bases than ammonia.
- Making amines: **reduce a nitrile**, or react a halogenoalkane with excess ammonia.
- **KCN adds one carbon** (halogenoalkane $\rightarrow$ nitrile) – track the carbon count carefully in synthesis routes.
- State reagents and conditions precisely for each conversion.



Worked example – why is an amine basic?

Explain why ethylamine is a stronger base than ammonia.

- A base **donates its lone pair** to H^+ , so the more available the pair, the stronger the base.
- In $\text{CH}_3\text{CH}_2\text{NH}_2$ the ethyl group is **electron-releasing** (positive inductive effect).
- It pushes electron density **onto** N, making the lone pair more available.
- $\Rightarrow$ **ethylamine** > **ammonia**.

Anything pushing electrons **onto** N strengthens the base; anything pulling them **away** (a benzene ring) weakens it.

Topic 19 – key takeaways

1

Amines

halogenoalkane + NH_3 ;
nucleophilic substitution

2

Nitriles

KCN substitutes; HCN adds –
both add a carbon

3

Hydrolysis

nitrile $\rightarrow$ carboxylic acid

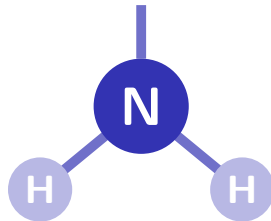
4

Reduction

nitrile $\rightarrow$ amine; amines build
nylon

Check yourself

- 1 What attacks the carbon when NH_3 makes an amine?
- 2 Which reagent turns a halogenoalkane into a nitrile?
- 3 Hydrolysing a nitrile gives which functional group?
- 4 What does reducing a nitrile give?



Answers 1. the lone pair on nitrogen 2. KCN 3. a carboxylic acid ($-\text{COOH}$) 4. an amine