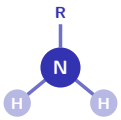
Nitrogen Compounds

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

1 Amines and nitriles

Making a primary amine

$$\underset{\delta+\text{ carbon}}{\text{R–CH}_2\text{–Br}} + :\text{NH}_3 \xrightarrow[\text{Br leaves}]{\text{lone pair attacks,}} \text{R–CH}_2\text{–NH}_2 + \text{HBr}$$

An **amine** 胺 has an $-\text{NH}_2$ group. Heat a **halogenoalkane** 卤代烷 with NH_3 in ethanol.

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

Two ways cyanide adds a carbon

- KCN + halogenoalkane → a **nitrile** 腈 (substitution)
- HCN + carbonyl → a **hydroxynitrile** 羟基腈 (addition)

Both add one carbon to the chain.

$$\text{R–CH}_2\text{–Br} + \text{CN}^- \longrightarrow \text{R–CH}_2\text{–CN}$$ nucleophilic **substitution** (nitrile)

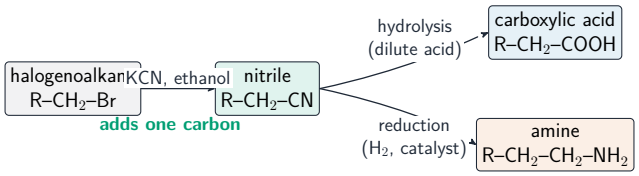
$$\text{R}_2\text{C=O} + \text{HCN} \longrightarrow \text{R}_2\text{C(OH)(CN)}$$ nucleophilic **addition** (hydroxynitrile)

Nitrile routes

A **nitrile** 腈 is a useful hub:

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

Nitrile routes, in detail



A **nitrile** 腈 is a useful hub – it leads two ways:
hydrolysis 水解 → a **carboxylic acid** 羧酸.
reduction 还原 → an amine, one carbon longer than you started.

The two things a nitrile can become

hydrolysis	with dilute acid and heat, RCN → RCOOH – a carboxylic acid with the same number of carbons
reduction 还原	with hydrogen and a catalyst (or $LiAlH_4$), RCN → RCH_2NH_2 – an amine
why it matters	both routes keep the extra carbon the cyanide added
nucleophilic addition 亲核加成	how the cyanide got there: CN^- adds to an **aldehyde** 醛 or **ketone** 酮 to give a hydroxynitrile
hydrogen cyanide 氰化氢	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 → nitrile) – track the carbon count carefully in synthesis routes.
- State reagents and conditions precisely for each conversion.

2 Recap

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 $CH_3CH_2NH_2$ the ethyl group is **electron-releasing** 推电子的 (positive inductive effect).
- It pushes electron density onto N, making the lone pair more available.
- ⇒ ethylamine > ammonia.

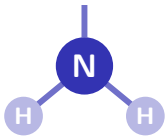
Anything pushing electrons onto N strengthens the base; anything pulling them away (a benzene ring) weakens it.

Topic 19 – key takeaways

1. **Amines**
   halogenoalkane + NH_3; nucleophilic substitution
2. **Nitriles**
   KCN substitutes; HCN adds – both add a carbon
3. **Hydrolysis**
   nitrile → carboxylic acid
4. **Reduction**
   nitrile → 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 ($-COOH$) **4.** an amine