

Nitrogen & Sulfur

A-Level Chemistry ■ Topic 12

A-Level Chemistry



Nitrogen & Sulfur

What we will cover

- 1 Why nitrogen is unreactive
- 2 Ammonia & the ammonium ion
- 3 Oxides of nitrogen
- 4 Smog & acid rain



nitrogen oxides cause smog

1 Nitrogen

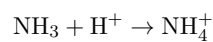
Why nitrogen is unreactive

N_2 has a **triple bond** (bond energy $\approx 945 \text{ kJ mol}^{-1}$) and a non-polar molecule. Breaking $\text{N}\equiv\text{N}$ needs a lot of energy, so nitrogen is inert at room temperature.

The Haber process forces it: high T , high p , and an iron catalyst.

Ammonia and the ammonium ion

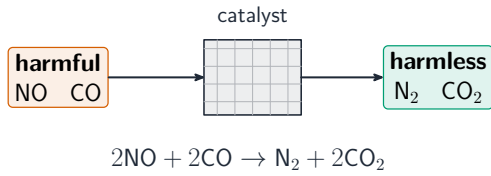
NH_3 is a weak base: the nitrogen lone pair accepts H^+ to give the **ammonium** 铵 ion NH_4^+ .



Test: damp red litmus turns blue. With HCl you get white NH_4Cl smoke.

2 Pollution

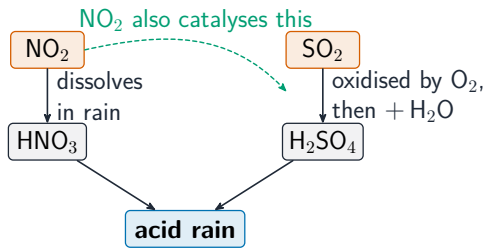
Oxides of nitrogen



NO_x 氮氧化物 comes from lightning and hot **engines** 内燃机 ($\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$).

A **catalytic converter** 催化转化器 lets them react away: $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$.

Smog and acid rain



- NO_x + hydrocarbons in sunlight → **photochemical smog** 光化学烟雾
- NO₂ forms nitric acid & catalyses SO₂ → SO₃ → **acid rain** 酸雨

3

Recap

Worked example – the lone pair on nitrogen

Explain why ammonia acts as a base, and why NO from a car engine is a pollutant.

- N in NH_3 has a **lone pair**, so it accepts a proton: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$.
- The lone pair forms a **dative bond** 配位键 to H^+ – that is what a Brønsted base does.
- In an engine the spark is hot enough for $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$.
- NO oxidises to NO_2 , which **catalyses acid rain** and makes photochemical smog.

The lone pair is the whole story: it makes NH_3 a **base**, a **ligand** and a **nu-cleophile** – one feature, three exam topics.

Topic 12 – key takeaways

1 Nitrogen

strong triple bond; non-polar; unreactive

2 Ammonia

lone pair accepts H^+ ; coordinate bond

3 NO_x

from engines; cleaned by catalytic converters

4 Pollution

photochemical smog & acid rain

Check yourself

- 1 Why is N_2 so unreactive?
- 2 What kind of bond forms when NH_3 gains H^+ ?
- 3 What does a catalytic converter turn NO and CO into?
- 4 Name a pollution problem caused by NO_x .



Answers 1. strong triple bond & non-polar 2. a coordinate bond 3. N_2 and CO_2
4. smog / acid rain