

12.1 Nitrogen and sulfur

Name: _____ Class: _____ Date: _____

Total: 12 marks

Objective

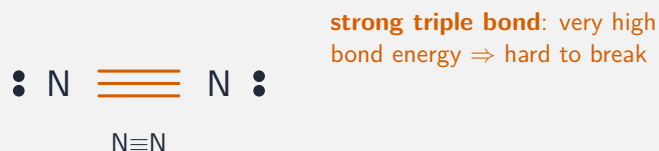
Build the skills to answer exam questions on **nitrogen and sulfur** —the unreactivity of nitrogen, the **basicity** 碱性 of **ammonia** 氨, oxides of nitrogen, and **acid rain** 酸雨.

You must be able to:

- explain the lack of reactivity of nitrogen
- explain the basicity of ammonia and the formation of the ammonium ion
- describe the sources, catalytic removal, and role in acid rain of nitrogen oxides

1 Worked examples

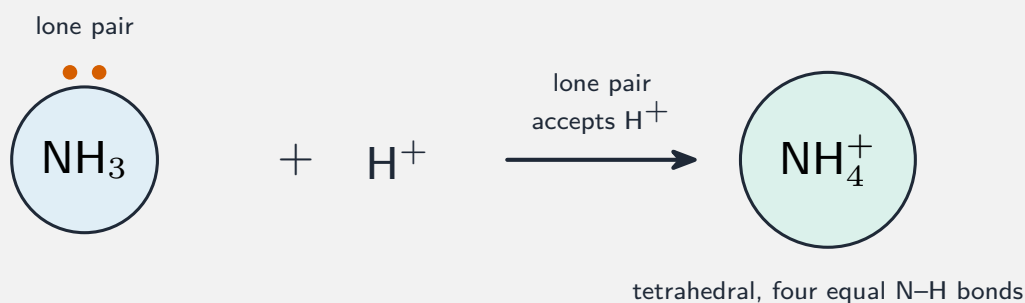
■ Unreactive nitrogen



symmetrical molecule $\Rightarrow$ no polarity $\Rightarrow$ nothing pulls it into a reaction

N is unreactive: a very strong triple bond (high bond energy) and a symmetrical, non-polar molecule

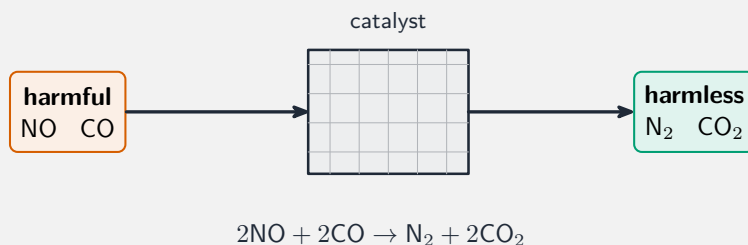
■ Ammonia as a base



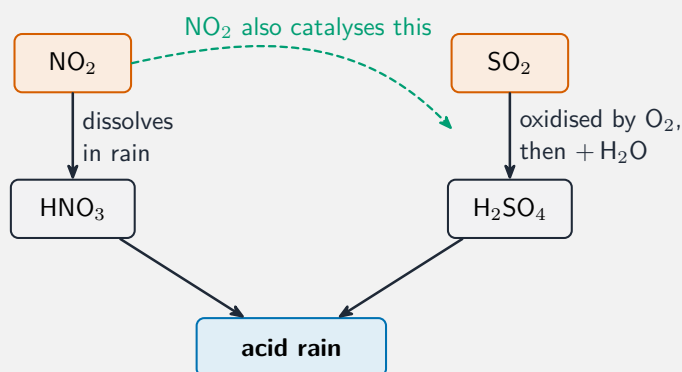
Ammonia is a base because the lone pair on N accepts a proton: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

The new N–H bond is a **coordinate bond** (both electrons from N). Warming an ammonium salt with a base displaces ammonia: $\text{NH}_4\text{Cl} + \text{NaOH} \rightarrow \text{NaCl} + \text{NH}_3 + \text{H}_2\text{O}$.

■ Nitrogen oxides and acid rain



A catalytic converter: $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$



NO forms nitric acid directly and catalyses the oxidation of SO to sulfuric acid — both cause acid rain

2 Practice

2.1 State **two** reasons why nitrogen gas is unreactive.

[2]

2.2 Write the equation for ammonia acting as a base towards H .

[1]

3 Exam-style questions

3.1 Ammonia acts as a Brønsted–Lowry base because:

[1]

- A it donates a proton

- **B** the lone pair on nitrogen accepts a proton
 - **C** it is a gas
 - **D** it contains hydrogen
-

3.2 In a catalytic converter, nitrogen monoxide is removed by reacting with: [1]

- **A** oxygen
 - **B** carbon monoxide
 - **C** water
 - **D** sulfur dioxide
-

3.3 (a) Describe how nitrogen monoxide is formed inside a car engine, and write an equation. [2]

(b) Explain the **two** ways that oxides of nitrogen contribute to acid rain. [3]

3.4 Describe a chemical test for an ammonium salt. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **12.1 Nitrogen and sulfur** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/12 N25 —Q24 (nitrogen/ammonia)
- 9701/14 N25 —Q23 (oxides of nitrogen)

Solutions

2.1 the N N triple bond is very strong (high bond energy); the molecule is non-polar / symmetrical.



3.1 B. The lone pair on nitrogen accepts a proton.



3.3 (a) the high temperature in the engine makes nitrogen and oxygen from the air react; $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$.

(b) directly: NO dissolves in rain to form nitric acid; as a catalyst: NO catalyses the oxidation of SO to SO₂, which forms sulfuric acid in the rain.

3.4 warm the salt with sodium hydroxide; ammonia gas is given off —sharp smell and damp red litmus turns blue.