Week 22

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

12. Nitrogen and sulfur

Starter Quiz · 课前小测

A-Level Chemistry Name: _____ Score: _____

1. Nitrogen gas is unreactive because it has:
   - ☐ a strong triple bond and a non-polar molecule
   - ☐ a weak single bond
   - ☐ a permanent dipole
   - ☐ an unpaired electron
2. Oxides of nitrogen (NO_x) are produced by:
   - ☐ lightning, and the high temperature inside car engines
   - ☐ photosynthesis
   - ☐ dissolving salt in water
   - ☐ burning hydrogen only
3. Ammonia acts as a base because:
   - ☐ the lone pair on nitrogen can accept a proton (H^+)
   - ☐ it donates a proton
   - ☐ it has no lone pair
   - ☐ it gains electrons
4. In a catalytic converter, NO and CO react to form:
   - ☐ nitrogen and carbon dioxide (harmless gases)
   - ☐ more NO
   - ☐ sulfur dioxide
   - ☐ ammonia
5. The bond formed when NH_3 accepts H^+ is a coordinate bond because:
   - ☐ both shared electrons came from the nitrogen atom
   - ☐ each atom gave one electron
   - ☐ electrons were transferred
   - ☐ no electrons are shared
6. Ammonia (NH_3) acts as a base because it can accept a _____.

_____

7. Oxides of nitrogen from car engines contribute to acid rain and photochemical smog.

   ☐ True ☐ False

8. How does NO_2 contribute to acid rain?

   ☐ it forms nitric acid directly and catalyses the oxidation of SO_2 to SO_3

   ☐ it neutralises acids

   ☐ it removes sulfur dioxide

   ☐ it has no effect

9. The test for an ammonium salt is to warm it with NaOH and look for:

   ☐ ammonia gas (sharp smell; damp red litmus turns blue)

   ☐ a white precipitate

   ☐ a colour change to yellow

   ☐ hydrogen gas

10. Photochemical smog forms when NO_x reacts in sunlight with unburned hydrocarbons to make:

    ☐ PAN (peroxyacetyl nitrate)

    ☐ ammonia

    ☐ pure oxygen

    ☐ water only

A-Level Chemistry

1. **a strong triple bond and a non-polar molecule**

   The N≡N triple bond is very strong, and the symmetrical molecule is non-polar — both make it unreactive.

2. **lightning, and the high temperature inside car engines**

   Lightning (natural) and the heat of internal combustion engines both make N_2 and O_2 combine into NO.

3. **the lone pair on nitrogen can accept a proton (H^+)**

   A Brønsted–Lowry base accepts a proton; ammonia's nitrogen lone pair does exactly that.

4. **nitrogen and carbon dioxide (harmless gases)**

   $2NO + 2CO \rightarrow N_2 + 2CO_2$; the harmful gases become harmless ones.

5. **both shared electrons came from the nitrogen atom**

   Nitrogen supplies both electrons of the new N–H bond, making it a coordinate (dative) bond.

6. **proton**

   $NH_3 + H^+ \rightarrow NH_4^+$.

7. **True**

   NO_x are atmospheric pollutants.

8. **it forms nitric acid directly and catalyses the oxidation of SO_2 to SO_3**

   NO_2 dissolves to form nitric acid, and it also speeds up $SO_2 \rightarrow SO_3$, which forms sulfuric acid.

9. **ammonia gas (sharp smell; damp red litmus turns blue)**

   A base displaces ammonia from the salt; the ammonia smells sharp and turns damp red litmus blue.

10. **PAN (peroxyacetyl nitrate)**

    In sunlight NO_x and hydrocarbons form PAN, a harmful part of the brown photochemical smog.

A-LEVEL CHEMISTRY • EXERCISE SHEET

12.1 Nitrogen and sulfur

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

KEY WORDS acid rain 酸雨 • bond energy 键能 • triple bond 三键 • basicity 碱性 • coordinate bond 配位键

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

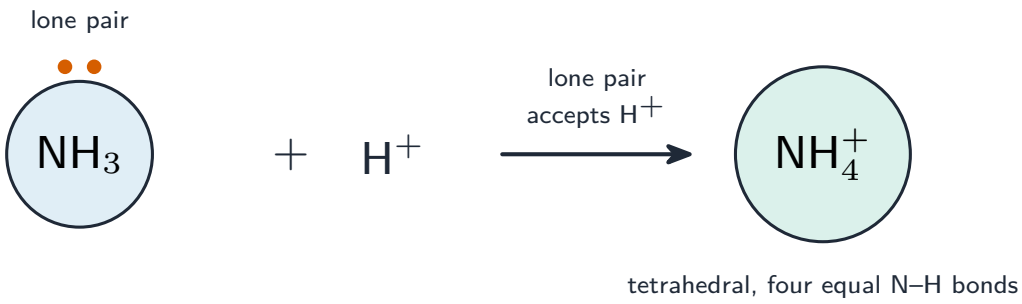
strong triple bond: very high bond energy ⇒ hard to break

N≡N

symmetrical molecule ⇒ no polarity ⇒ nothing pulls it into a reaction

N_2 is unreactive: a very strong triple bond (high bond energy) and a symmetrical, non-polar molecule

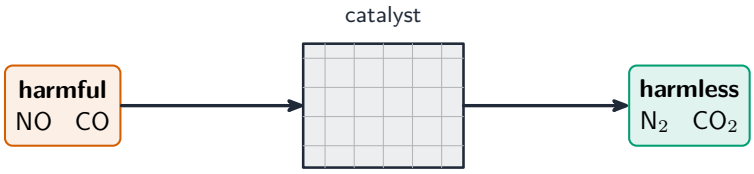
Ammonia as a base



Ammonia is a base because the lone pair on N accepts a proton: $NH_3 + H^+ \rightarrow NH_4^+$

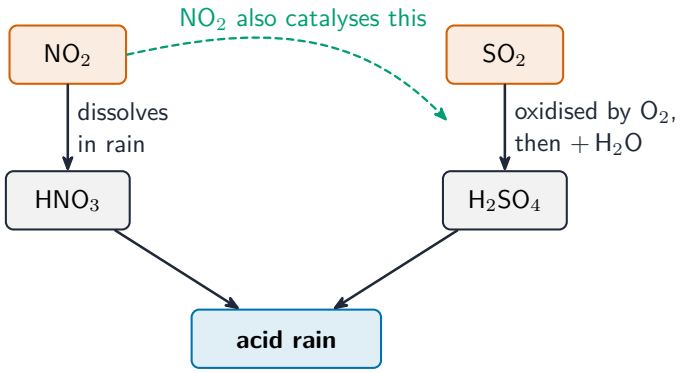
The new N–H bond is a **coordinate bond** (both electrons from N). Warming an ammonium salt with a base displaces ammonia: $NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$.

Nitrogen oxides and acid rain



$2NO + 2CO \rightarrow N_2 + 2CO_2$

A catalytic converter: $2NO + 2CO \rightarrow N_2 + 2CO_2$



NO_2 forms nitric acid directly and catalyses the oxidation of SO_2 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]

Solutions

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

2.2 $NH_3 + H^+ \rightarrow NH_4^+$.

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

3.2 B. $2NO + 2CO \rightarrow N_2 + 2CO_2$.

3.3 (a) the high temperature in the engine makes nitrogen and oxygen from the air react; $N_2 + O_2 \rightarrow 2NO$.
(b) directly: NO_2 dissolves in rain to form nitric acid; as a catalyst: NO_2 catalyses the oxidation of SO_2 to SO_3, 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.

16 Oxides of nitrogen, NO_x, are involved in formation of photochemical smog and acid rain.

Which oxides of nitrogen are involved in each of these processes?

	photochemical smog		acid rain	
	NO	NO_2	NO	NO_2
A	✓	✓	✓	✓
B	✗	✓	✗	✓
C	✓	✓	✗	✓
D	✗	✓	✓	✓

24 Four reaction mixtures are listed.

1 $(NH_4)_2SO_4(aq)$ and NaOH

2 $NH_4Cl(aq)$ and $Ba(OH)_2$

3 $NH_4Cl(aq)$ and Na_2O

4 $(NH_4)_3PO_4(aq)$ and HCl

Which reaction mixtures produce ammonia as a product?

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 3 and 4 only

23 The oxides of nitrogen, NO and NO_2, act as pollutants in the Earth's atmosphere in a number of different ways.

Three statements about the oxides of nitrogen are listed.

1 They react with oxygen and water vapour to form nitric acid, a constituent of acid rain.

2 They react with carbon monoxide to form photochemical smog.

3 They catalyse the oxidation of sulfur dioxide in the formation of sulfuric acid, another constituent of acid rain.

Which statements are correct?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

24 Which reagent, when mixed with ammonium sulfate and then heated, liberates ammonia?

A aqueous bromine

B dilute hydrochloric acid

C aqueous calcium hydroxide

D potassium dichromate(VI) in acidic solution