

Week 18

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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12. Nitrogen and sulfur

Starter Quiz · 课前小测

A-Level Chemistry

Name: _____ Score: _____

- 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
- Oxides of nitrogen (NO_x) are produced by:
 - ☐ lightning, and the high temperature inside car engines
 - ☐ photosynthesis
 - ☐ dissolving salt in water
 - ☐ burning hydrogen only
- 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
- In a catalytic converter, NO and CO react to form:
 - ☐ nitrogen and carbon dioxide (harmless gases)
 - ☐ more NO
 - ☐ sulfur dioxide
 - ☐ ammonia
- 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
- 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 NO₂ contribute to acid rain?

- ☐ it forms nitric acid directly and catalyses the oxidation of SO₂ to SO₃
- ☐ 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

12. Nitrogen and sulfur

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 N₂ and O₂ 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 → N₂ + 2CO₂; 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

NH₃ + H⁺ → NH₄⁺.

7. True

NO_x are atmospheric pollutants.

8. it forms nitric acid directly and catalyses the oxidation of SO₂ to SO₃

NO₂ dissolves to form nitric acid, and it also speeds up SO₂ → SO₃, 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.

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

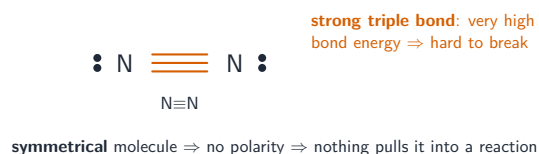
Build the skills to answer exam questions on **nitrogen and sulfur** — the unreactivity of nitrogen, the **basicity** 碱性 of **ammonia** 氨, oxides of nitrogen, and **acid rain** 酸雨.

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

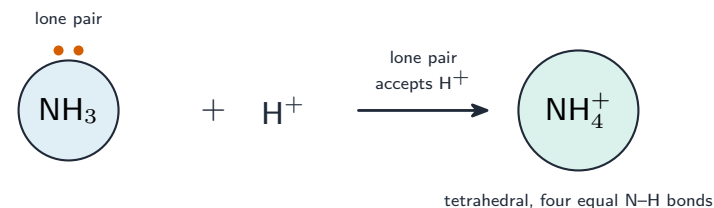
1 Worked examples

■ Unreactive nitrogen



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

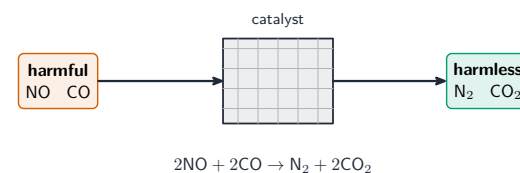
■ Ammonia as a base



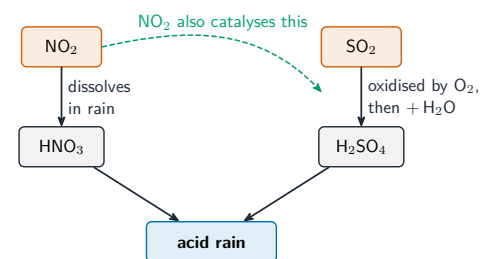
Ammonia is a base because the lone pair on N accepts a proton: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

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_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 $\text{N}\equiv\text{N}$ 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_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	x	✓	x	✓
C	✓	✓	x	✓
D	x	✓	✓	✓

24 Four reaction mixtures are listed.

- 1 $(\text{NH}_4)_2\text{SO}_4(\text{aq})$ and NaOH
- 2 $\text{NH}_4\text{Cl}(\text{aq})$ and $\text{Ba}(\text{OH})_2$
- 3 $\text{NH}_4\text{Cl}(\text{aq})$ and Na_2O
- 4 $(\text{NH}_4)_3\text{PO}_4(\text{aq})$ 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