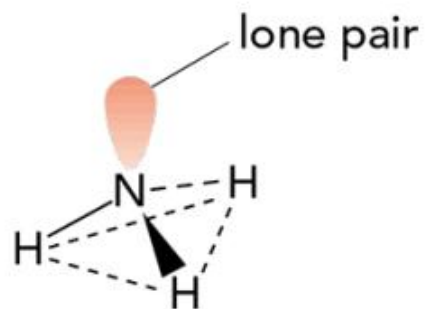
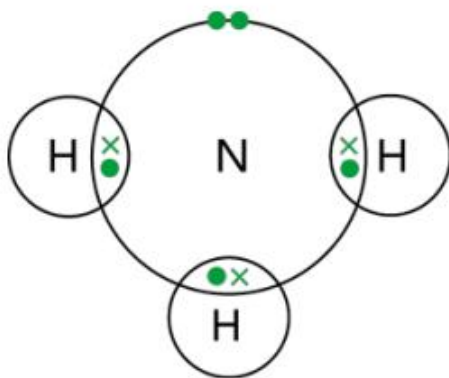
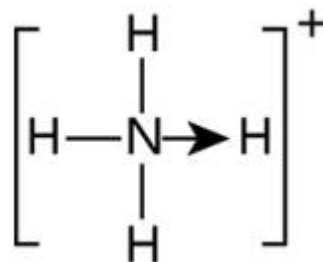
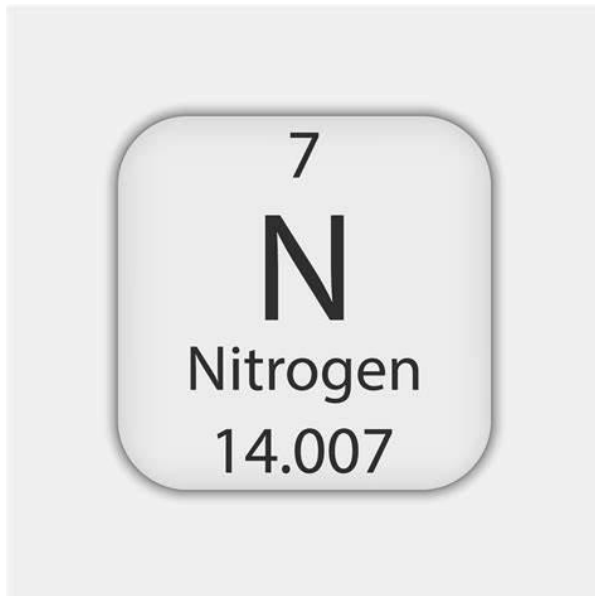


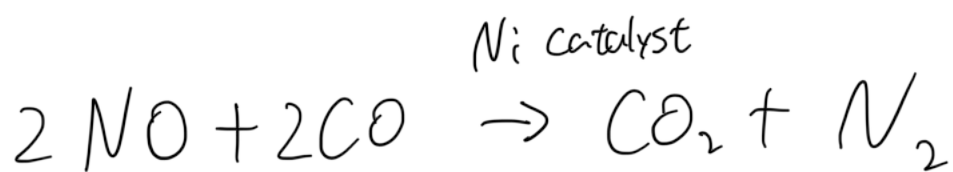
Nitrogen and sulfur

review

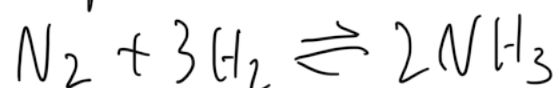


1. Nitrogen gas

The electronic configuration of a nitrogen atom is 1s² 2s² 2p³. Its atoms need to gain three electrons to achieve the noble gas configuration of neon. Nitrogen atoms do this by forming a triple covalent bond between two N atoms



Haber process



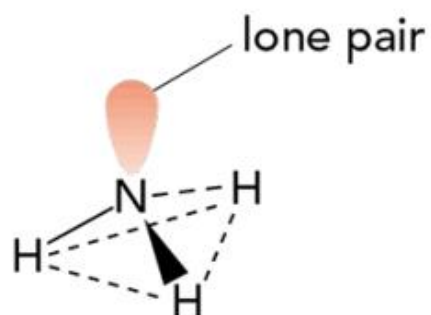
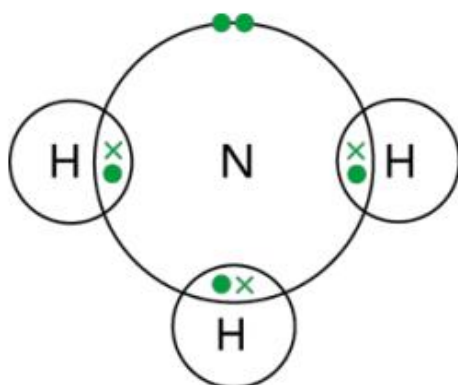
This sequence of reactions in the atmosphere forms part of the natural nitrogen cycle. In this way, nitrogen from unreactive, insoluble nitrogen gas can get into the soil in a soluble form that plants can absorb. The plants can then use the nitrate ions, NO_3^- , from the dilute nitric acid to make proteins. These proteins are essential for healthy growth of the plants.

2. Ammonia and ammonium compounds

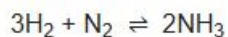
Molecule shape:

Bond angle:

Haber process



The Haber process is used in industry to form ammonia from hydrogen and nitrogen.



Which statements about the activation energy for this process are correct?

1. The activation energy for the forward reaction is the same as the activation energy for the reverse reaction.
2. The activation energy for the reverse reaction is decreased by the addition of iron.
3. The activation energy is the minimum energy that colliding particles must possess in order to react.

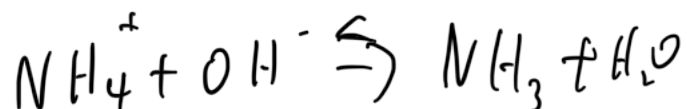
- A. 1, 2 and 3 are correct
B. 1 and 2 only are correct
C. 2 and 3 only are correct
D. 1 only is correct

3. Basicity of ammonia

Ammonia exists as simple covalent molecules, NH_3 . Ammonia can react with suitable reagents to form products containing ammonium ions, NH_4^+ . Ammonia can also react with suitable reagents to form products containing amide ions, NH_2^- .

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

- A. ammonia molecules and amide ions
- ☒ B. ammonia molecules and ammonium ions
- C. ammonia molecules only
- D. ammonium ions only



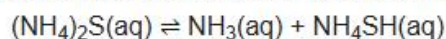
Reaction with Water

In this reaction, ammonia reacts with water, a process in which it accepts a proton from a water molecule, resulting in the formation of ammonium ions and hydroxide ions.

This reaction is an excellent demonstration of the dual role of water, which acts as an acid (proton donor) in this context.

The equilibrium of this reaction lies to the left under standard conditions, indicating that ammonia does not completely react with water, a characteristic of [weak bases](#).

Ammonia gas, NH_3 , and hydrogen sulfide gas, H_2S , react together to form the salt ammonium sulfide, $(\text{NH}_4)_2\text{S}$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.



The addition of $\text{NaOH}(\text{aq})$ to this solution produces a gas, X.

The addition of $\text{HCl}(\text{aq})$ to a separate portion of this solution produces a gas, Y.

X and Y could represent different gases or identical gases.

What are the identities of X and Y?

	X	Y
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

\rightarrow weak acid

Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product.

How are the carbonate ions behaving during this reaction?

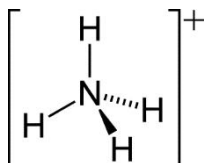
- A. Brønsted-Lowry acid
- B. Brønsted-Lowry base
- C. oxidising agent
- D. reducing agent

4. Structure of the Ammonium Ion

The ammonium ion, NH_4^+ , adopts a [redacted] This structure consists of a central nitrogen atom surrounded symmetrically by four hydrogen atoms.

The tetrahedral shape is due to the [redacted] hybridisation of the nitrogen atom's orbitals. This hybridisation occurs when one s and three p orbitals combine to form four equivalent sp^3 hybrid orbitals.

The positive charge of the ammonium ion is distributed evenly across the molecule, contributing to its stability.



Molecule shape:

Bond angle:

Ammonia can undergo an acid–base reaction with hydrogen chloride to form ammonium chloride.

Which statement is correct?

- A. The ammonium ion is basic.
- B. The hydrogen atom from HCl donates a lone pair of electrons to the nitrogen atom.
- C. The H-N-H bond angle in ammonia is the same as the H-N-H bond angle in the ammonium ion.
- D. The H-N-H bond angle in the ammonium ion is the same as the H-C-H bond angle in methane.

6.90 g of an ammonium salt is heated with an excess of aqueous sodium hydroxide. The volume of ammonia produced, measured under room conditions, is 2.51 dm³.

Which ammonium salt is used?

- A. ammonium carbonate ($M_r = 96.0$)
- B. ammonium chloride ($M_r = 53.5$)
- C. ammonium nitrate ($M_r = 80.0$)
- D. ammonium sulfate ($M_r = 132.1$)

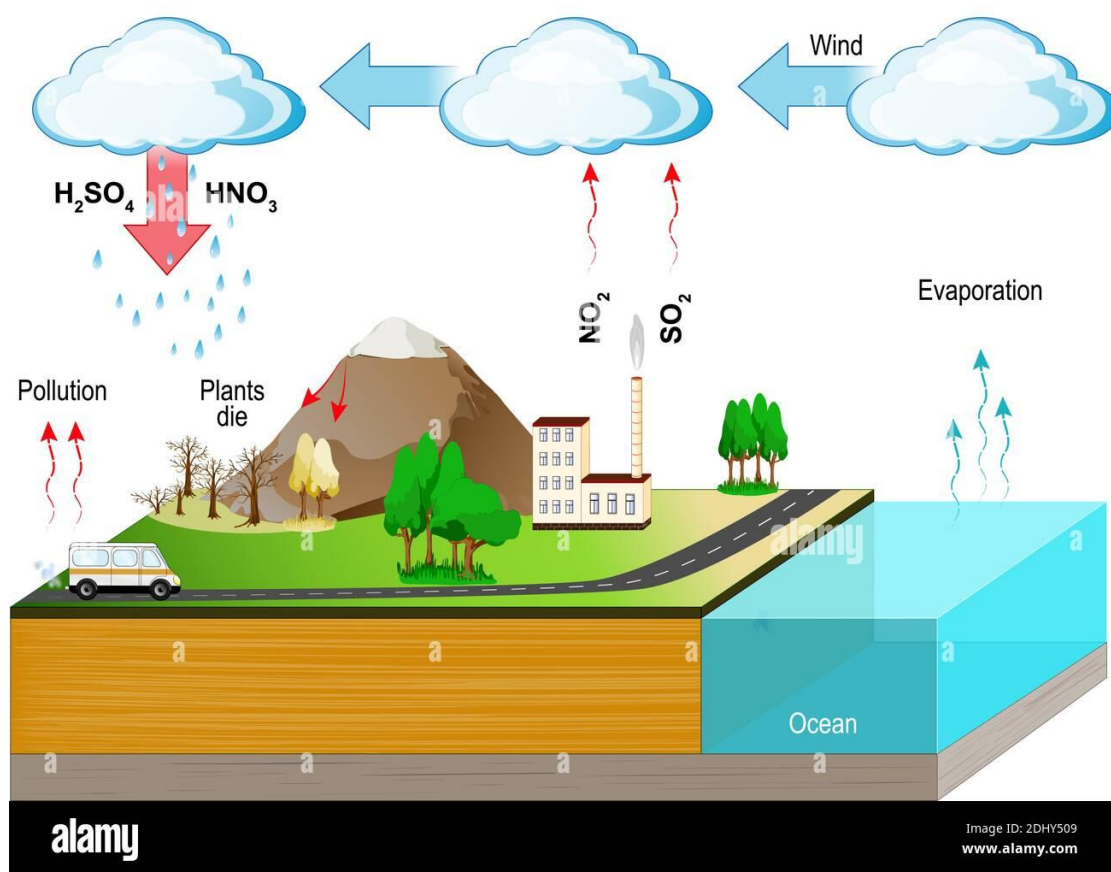
Which gases will dissolve in water causing a lowering of the pH?

- 1. ammonia
 - 2. sulfur dioxide
 - 3. nitrogen dioxide
- A. 1, 2 and 3 are correct
 - B. 1 and 2 only are correct
 - C. 2 and 3 only are correct
 - D. 1 only is correct

5. Nitrogen oxides in the atmosphere

Acid rain

Acid rain



Which reaction gives a product that is an atmospheric pollutant causing acid rain?

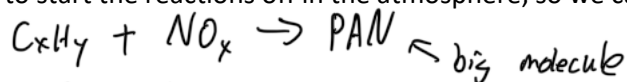
- A. $3\text{Mg(s)} + \text{SO}_2\text{(g)} \rightarrow \text{MgS(s)} + 2\text{MgO(s)}$
- B. $(\text{NH}_4)_2\text{SO}_4\text{(s)} + \text{Ca(OH)}_2\text{(s)} \rightarrow 2\text{NH}_3\text{(g)} + \text{CaSO}_4\text{(s)} + 2\text{H}_2\text{O(l)}$
- C. $2\text{MnO}_4^-\text{(aq)} + 5\text{SO}_2\text{(g)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{Mn}^{2+}\text{(aq)} + 4\text{H}^+\text{(aq)} + 5\text{SO}_4^{2-}\text{(aq)}$
- D. $2\text{FeSO}_4\text{(s)} \rightarrow \text{Fe}_2\text{O}_3\text{(s)} + \text{SO}_2\text{(g)} + \text{SO}_3\text{(g)}$

What would be produced when 60 g of nitrogen monoxide react with an excess of carbon monoxide in a catalytic converter?

- A. 12 g of carbon and 92 g of nitrogen dioxide
- B. 24 g of carbon and 92 g of nitrogen dioxide
- C. 88 g of carbon dioxide and 28 g of nitrogen
- D. 88 g of carbon dioxide and 56 g of nitrogen

Photochemical smog

Volatile organic compounds (VOCs), these are largely **unburnt** hydrocarbons from fuel, and their oxidised products. The VOCs can react in sunlight with oxides of nitrogen to make peroxyacetyl nitrate (also called **PAN**). Its chemical formula can be written as $\text{CH}_3\text{CO}_3\text{NO}_2$. Sunlight provides the energy needed to start the reactions off in the atmosphere, so we call them **photochemical reactions**.



* —

16 Feb acidic

Which problem can result if too much NH_4NO_3 is applied to crops by farmers?

- A. Not all the NH_4NO_3 is used by plants and the excess makes the soil alkaline.
- B. Rain washes some of the NH_4NO_3 into rivers where it forms a precipitate.
- ☒ C. Some of the NH_4NO_3 dissolves in groundwater which may eventually be used for drinking.
- D. Ammonia is produced; this lowers the pH of the soil.

NH_4^+ always dissolve

What is an environmental consequence of the uncontrolled use of nitrate fertilisers?

- A. acid rain
- ☒ B. low oxygen levels in streams
- C. ozone depletion
- D. the greenhouse effect

↓
promotes algae
in water

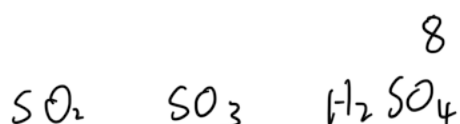
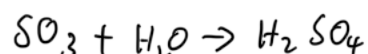
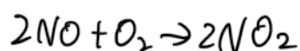
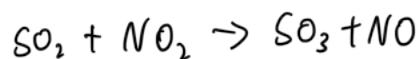
Nitrogen dioxide gas is produced when petrol is burned in car engines.

Which acids are made in the atmosphere as a result of this release of nitrogen dioxide into the air?

- 1. H_2SO_3
- 2. H_2SO_4 ✓
- 3. HNO_3 ✓

- A. 1, 2 and 3 are correct
- B. 1 and 2 are correct
- ☒ C. 2 and 3 are correct
- D. 1 only is correct

e weak



When burned, sulfur forms a gaseous product X which can be oxidised to produce a gas Y.

Gas Y reacts with water to produce a product Z.

Which row correctly shows the oxidation states of sulfur in X, Y and Z?

	X	Y	Z
A	-2	+4	+4
B	-2	+4	+6
C	+4	+6	+4
<input checked="" type="radio"/> D	+4	+6	+6

Most modern cars are fitted with catalytic converters in the exhaust system.

Which three gases are removed by a catalytic converter?

- ☒ A. carbon monoxide, hydrocarbons, nitrogen oxides
- ☐ B. carbon monoxide, carbon dioxide, nitrogen oxides
- ☐ C. carbon monoxide, nitrogen oxides, sulfur dioxide
- ☐ D. hydrocarbons, nitrogen oxides, sulfur dioxide

Which statements correctly describe an oxide of nitrogen acting as an atmospheric pollutant?

- ☒ 1. Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide which contributes to acid rain.
 - ☒ 2. Nitrogen dioxide reacts with sulfur dioxide to form sulfur trioxide which reacts with water to form sulfuric acid.
 - ☒ 3. Nitrogen oxides react with unburnt hydrocarbons in sunlight to form other pollutants.
- ☒ A. 1, 2 and 3 are correct
 - ☐ B. 1 and 2 only are correct
 - ☐ C. 2 and 3 only are correct
 - ☐ D. 1 only is correct

Reducing the effects of nitrogen oxides

The nitrogen oxides are reduced to form harmless nitrogen gas, which is released from the vehicle's exhaust pipe.

NO, NO₂, CO and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines.

When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

	NO	NO ₂	CO	unburnt hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced



Nitrogen oxides are removed from the exhaust gases of internal combustion engines by the action of a catalyst in a catalytic converter.

Which row is correct?

	change in oxidation number of nitrogen	type of catalyst
A	decrease	heterogeneous
B	decrease	homogeneous
C	increase	heterogeneous
D	increase	homogeneous

In the atmosphere, which transformations can involve sulfur dioxide as either a reagent or a catalyst?

- 1. NO_2 to NO
- 2. NO to NO_2
- 3. CO to CO_2
- A. 1, 2 and 3 are correct
- B. 1 and 2 only are correct
- C. 2 and 3 only are correct
- ☒ D. 1 only is correct

Sulfur dioxide is an atmospheric pollutant.

What might result from the release of sulfur dioxide gas into the atmosphere?

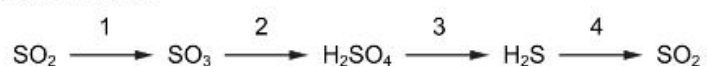
- 1. reduction of NO_2 to NO ✓
- 2. depletion of aquatic life
- 3. corrosion of limestone statues CaCO_3
- ☒ A. 1, 2 and 3 are correct
- B. 1 and 2 only are correct
- ~~C. 2 and 3 only are correct~~
- D. 1 only is correct

The rate of chemical reactions can be increased by the addition of a suitable catalyst.

For which reactions can a heterogeneous catalyst be used?

- 1. $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
- 2. $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- 3. $2\text{NO} + 2\text{CO} \rightleftharpoons \text{N}_2 + 2\text{CO}_2$
- ☒ A. 1, 2 and 3 are correct
- B. 1 and 2 only are correct
- C. 2 and 3 only are correct
- D. 1 only is correct

A reaction sequence is shown.



In each stage of this sequence the sulfur is oxidised, reduced or neither oxidised nor reduced.

Which row is correct?

	1	2	3	4
A	neither	oxidised	reduced	reduced
B	oxidised	neither	reduced	reduced
C	oxidised	neither	reduced	oxidised
D	oxidised	oxidised	reduced	oxidised

Eutrophication(富营养化)

Nitrate fertilisers leach into rivers and lakes after rain.

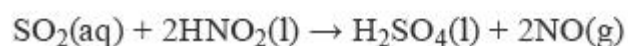
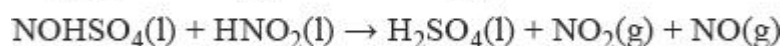
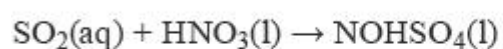
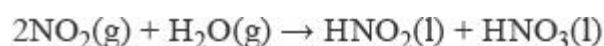
Water plants grow more than usual.

They block sunlight and kill plants underneath.

Bacteria/fungi decompose remains using the O_2 .

Fish and other creatures die from oxygen starvation.

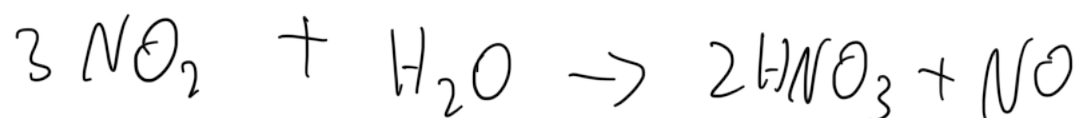
nitrates promotes grow of



6.sulfur

Sulfur		
O.N.	e.g.	name
-2	H ₂ S	sulfide
0	S ₈	
+2	SCl ₂	
+4	SF ₄ , H ₂ SO ₃	sulfurous
	SO ₃ ²⁻	sulfite
+6	SF ₆ , H ₂ SO ₄	sulfuric
	SO ₄ ²⁻	sulfate

6. Summary



$$-3 \times 34 + 286 + 2 \times 173 + 91.1$$

