

The Haber process

4.10.4.1 · Using resources · revision notes

How ammonia is manufactured from nitrogen and hydrogen, and the conditions used. This is in GCSE Chemistry only, not in Combined Science. Expect recall of the conditions.

Key facts

- $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ (forward reaction exothermic)
- Conditions: iron catalyst, about 450 °C, about 200 atmospheres
- Catalyst: faster rate
- Nitrogen from the air; hydrogen from natural gas
- Cool → ammonia liquefies and is removed; unreacted N_2 and H_2 are recycled
- Ammonia is used to make nitrogen-based fertilisers

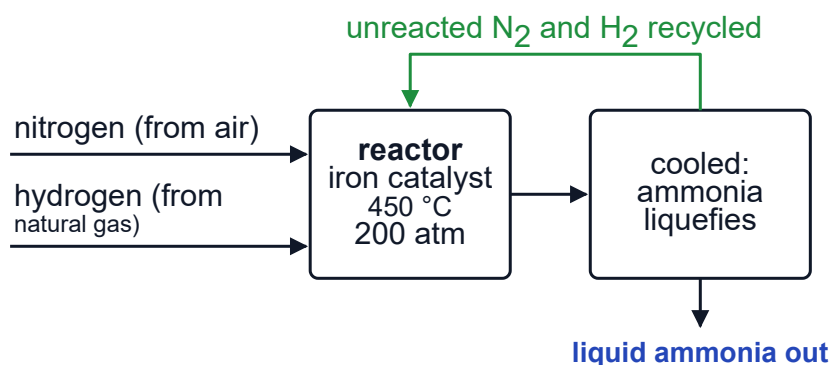
Notes

Making ammonia

- The **Haber process** manufactures **ammonia**, NH_3 , which can be used to produce nitrogen-based fertilisers.
- The raw materials are **nitrogen**, from the **air**, and **hydrogen**, from **natural gas** (methane).
- nitrogen + hydrogen $\rightleftharpoons$ ammonia, or $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
- The reaction is **reversible**, and the forward reaction is **exothermic**.

The process

- The purified gases are passed over an **iron catalyst** at a high temperature (about **450 °C**) and a high pressure (about **200 atmospheres**).
- Some of the nitrogen and hydrogen react to form ammonia. Because the reaction is reversible, some of the ammonia breaks down again into nitrogen and hydrogen.
- The gas mixture is **cooled**: the ammonia **liquefies** and is removed (ammonia has a much higher boiling point than nitrogen and hydrogen).
- The unreacted nitrogen and hydrogen are **recycled** back over the catalyst, so little is wasted.



$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$: ammonia is removed as a liquid; unreacted gases go round again.

How to answer each type of question

Recall the raw materials and conditions

1 to 4 marks

Grade 4

1. Nitrogen from the air; hydrogen from natural gas.
2. Give the conditions with units: about 450 °C and about 200 atmospheres.
3. The catalyst is iron.

Example. (a) Give the source of the hydrogen used in the Haber process. (1 mark)
(b) State the temperature and pressure used in the Haber process. (2 marks)
(c) Name the catalyst. (1 mark)

Model answer. (a) Natural gas / methane (1)
(b) About 450 °C (1); about 200 atmospheres (1)
(c) Iron (1)

Describe what happens to the gases after the reactor

2 to 3 marks

Grade 5

1. Say that the mixture is cooled.
2. Say that the ammonia liquefies and is removed.
3. Say that the unreacted nitrogen and hydrogen are recycled.

Example. The gas mixture leaving the reactor contains ammonia, nitrogen and hydrogen. Describe how the ammonia is separated from the mixture and what happens to the other gases. (3 marks)

Model answer. The mixture is cooled (1). The ammonia liquefies (condenses) and is removed (1). The unreacted nitrogen and hydrogen are recycled back over the catalyst (1).

Don't lose marks

- ✗ Saying the catalyst increases the yield. It only increases the rate.
- ✗ Swapping the sources: nitrogen comes from the air and hydrogen from natural gas.

More tips

Memory tricks

- The Haber numbers: iron, 450 °C, 200 atmospheres.
- A catalyst changes how fast, never how much.

Exam technique

- When a graph or table is given, quote values from it with units to support your answer.
- Give the conditions with 'about': about 450 °C and about 200 atmospheres.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State what the Haber process makes

Ammonia, which is used to make nitrogen-based fertilisers.

Grade 4

Give the sources of nitrogen and hydrogen

Nitrogen comes from the air; hydrogen comes from natural gas (methane).

Grade 4

Recall the conditions used

An iron catalyst, about 450 °C and about 200 atmospheres.

Grade 5

Describe how ammonia is separated and gases recycled

On cooling, ammonia liquefies and is removed; unreacted nitrogen and hydrogen are recycled.

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