

## The Haber Process

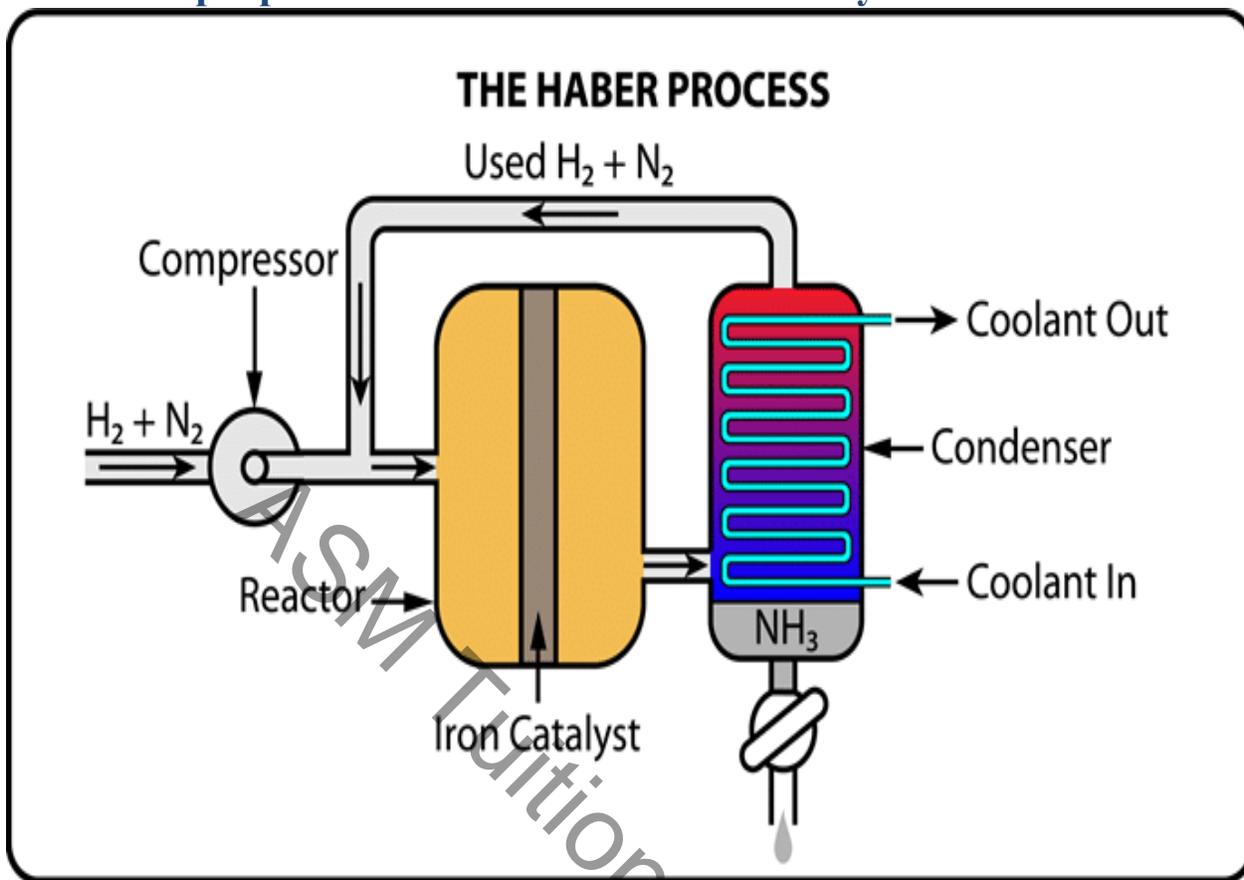
- In industry, the **Haber process** is used to manufacture **ammonia**. The ammonia can then be used to form nitrogen-based fertilisers.
- **Raw materials** are required to begin the Haber process. These raw materials will react to form ammonia.
- In forming ammonia, the raw materials used in the Haber process are **nitrogen** and **hydrogen**.
- Nitrogen is very abundant gas in **air**. Therefore, air is the primary source for nitrogen in the Haber process. Air is **fractionally distilled** to produce nitrogen as the gases (nitrogen and oxygen) in air have different boiling points and condense at different temperatures.
- Methane is a source of hydrogen. When **methane** reacts with steam, carbon dioxide and hydrogen are formed. This is a source for hydrogen in the Haber process.



## The Haber Process:

The Haber process consists of the following steps:

1. Nitrogen and hydrogen are pumped into a compressor through pipes.
2. The gases are compressed to around 200 atmospheres within the compressor.
3. The pressurised gases are pumped into a tank and passed over an iron catalyst at 450°C. In this tank, some of the nitrogen and hydrogen react to form ammonia.
  - Since this is a reversible reaction, some of the ammonia can break down back into nitrogen and hydrogen.
4. The ammonia is cooled, causing it to liquefy, and then it is removed.
5. Unreacted nitrogen and hydrogen gases are recycled and passed back over the catalyst, which forms more ammonia.



## Increasing the Yield of Ammonia

- ▶ To increase the yield of ammonia, the reaction required optimum conditions. This allows more ammonia to be produced at a lower cost.

1. Optimisation of a temperature
2. optimisation of pressure
3. Using an appropriate Catalyst

### 1. Optimising the temperature

- ▶ The forward reaction in the Haber process is exothermic. Lowering the temperature would increase the rate of ammonia production. However, a lower temperature also decreases the rate of reaction. Therefore, there's a trade-off: while lower temperatures favour ammonia production, they also slow down the reaction.

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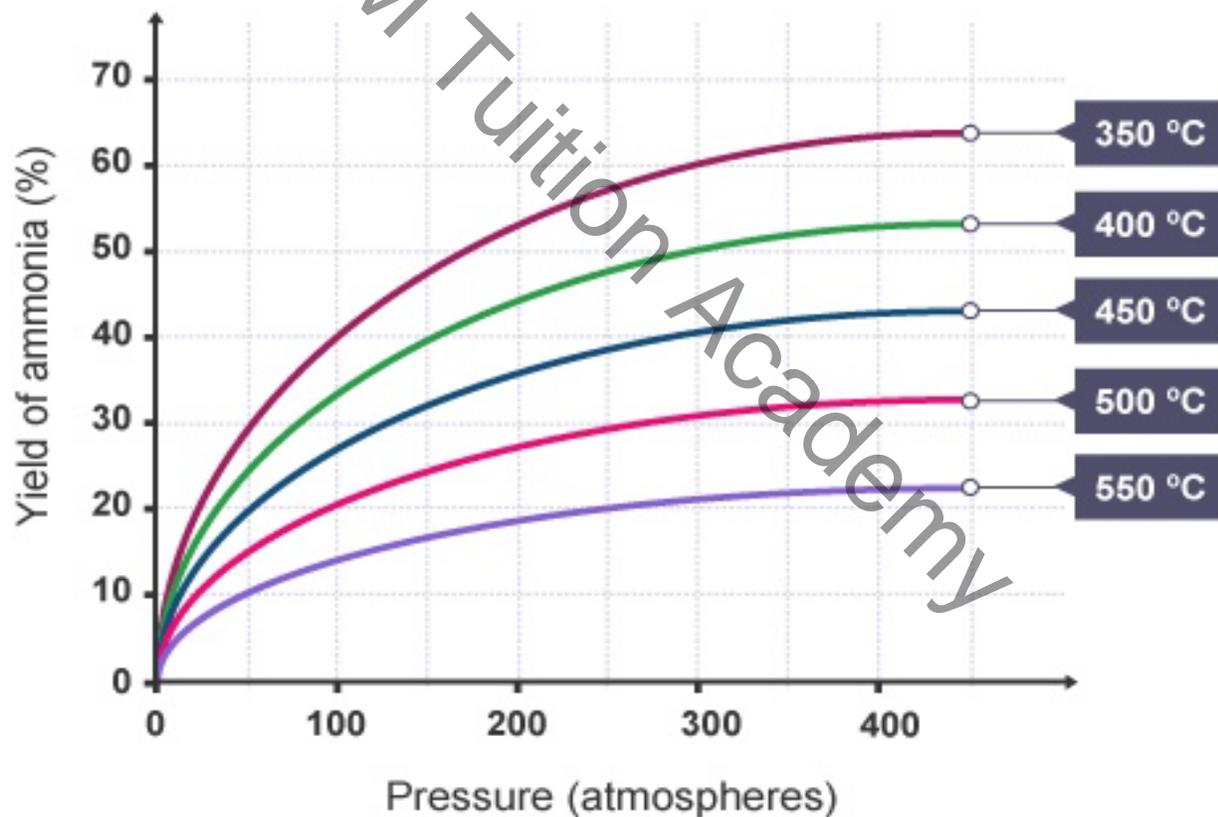
- At 450°C, a balance is achieved with a relatively fast rate of reaction and a high yield of ammonia.

## 2. Optimising the pressure

- A high pressure shifts the position of equilibrium to the right. However, working with very high pressures can be expensive.
- To maintain a cost-effective production process, a pressure of 200 atmospheres is used.

## 3. Using a catalyst

- An iron catalyst increases the rate of the reaction, without being used up in the process. This contributes to a more efficient production of ammonia.



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