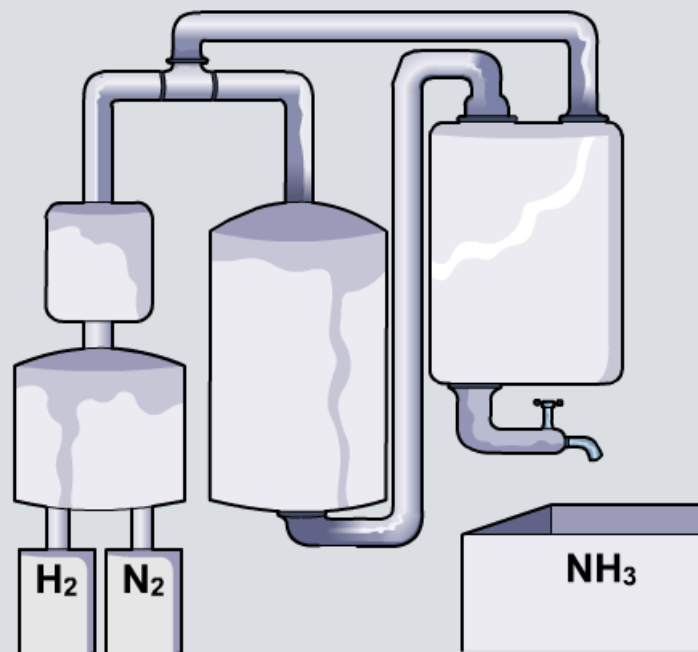


The Haber Process

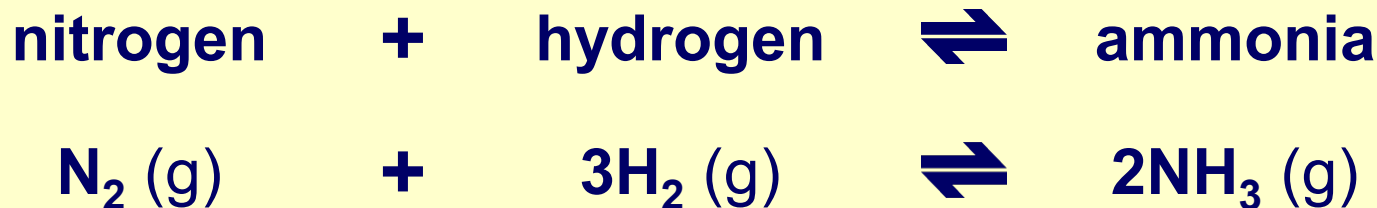


What is ammonia?

Ammonia is an important compound in the manufacture of fertilizer and other chemicals such as cleaning fluids and floor waxes.

It is made industrially by reacting nitrogen with hydrogen in the **Haber process**. It is a reversible reaction, so it never goes to completion.

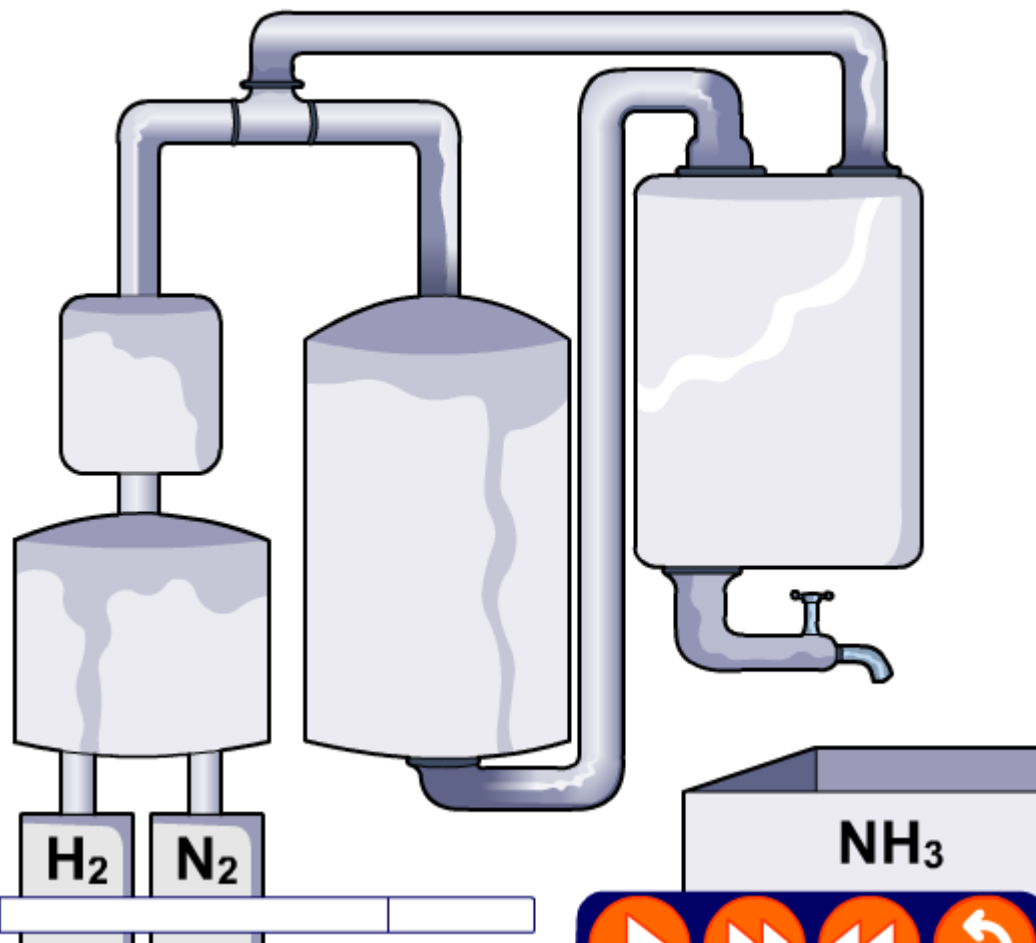
Why is this a problem for companies making ammonia?



How is ammonia produced in the Haber process?

The Haber process is the industrial reaction used to make **ammonia** (NH_3) from **hydrogen** (H_2) and **nitrogen** (N_2).

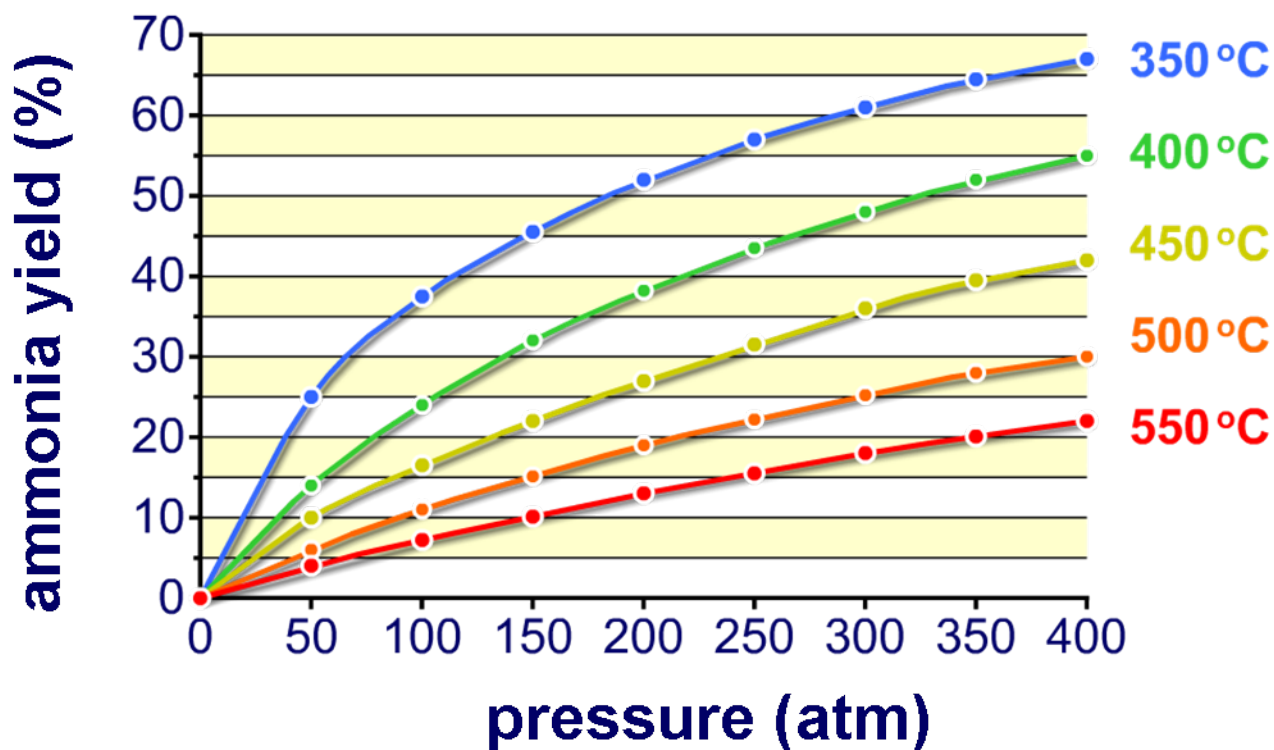
Click "**play**" to find out what happens.



What is yield?

The amount of product made in a reaction is called the **yield** and is usually expressed as a percentage.

The yield of ammonia produced by the Haber process depends on the **temperature** and **pressure** of the reaction.



What is the Haber compromise?

The highest yield of ammonia is theoretically produced by using a low temperature and a high pressure.

In practice, though, these conditions are not used. Why?

Lowering the temperature slows down the rate of reaction. This means it takes longer for ammonia to be produced.

Increasing the pressure means stronger, more expensive equipment is needed. This increases the cost of producing the ammonia.

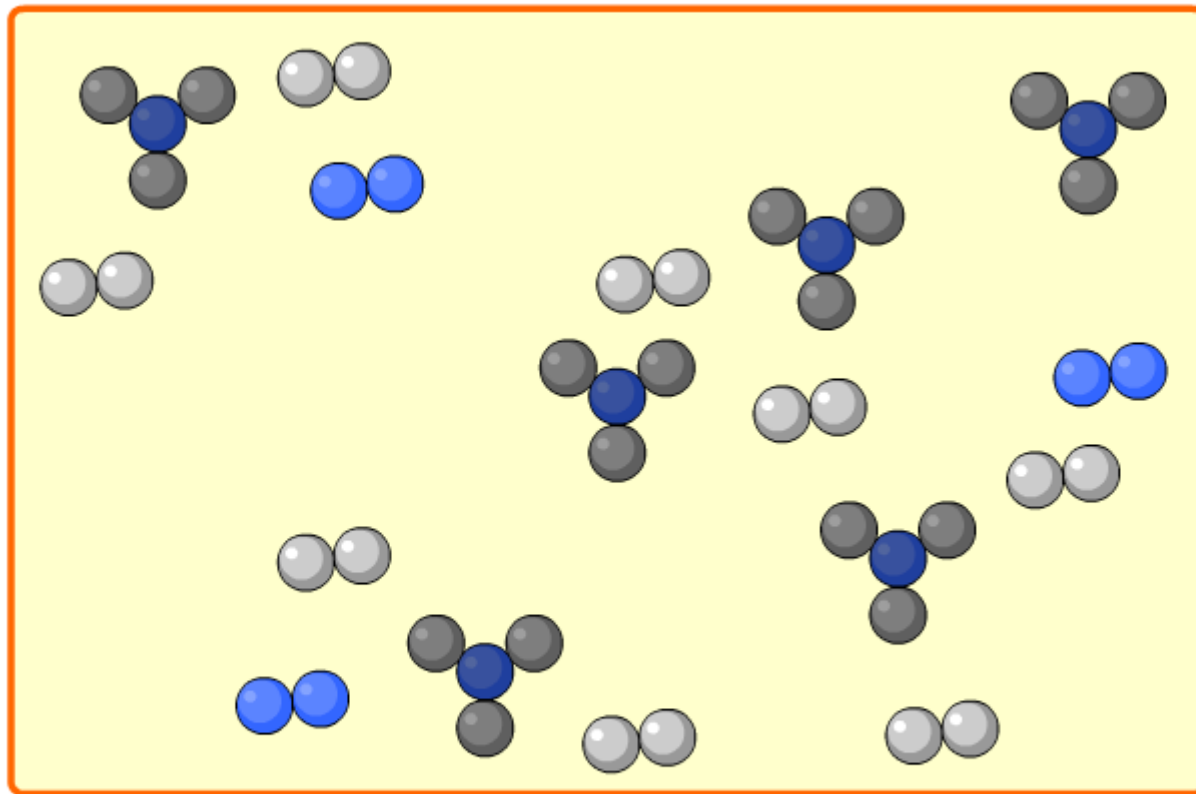
A compromise is reached to make an acceptable yield in a reasonable timeframe while keeping costs down.






Temperature, pressure and yield

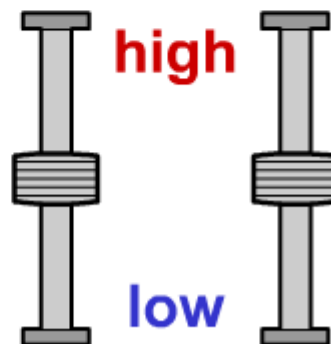


How do temperature and pressure affect the Haber process?

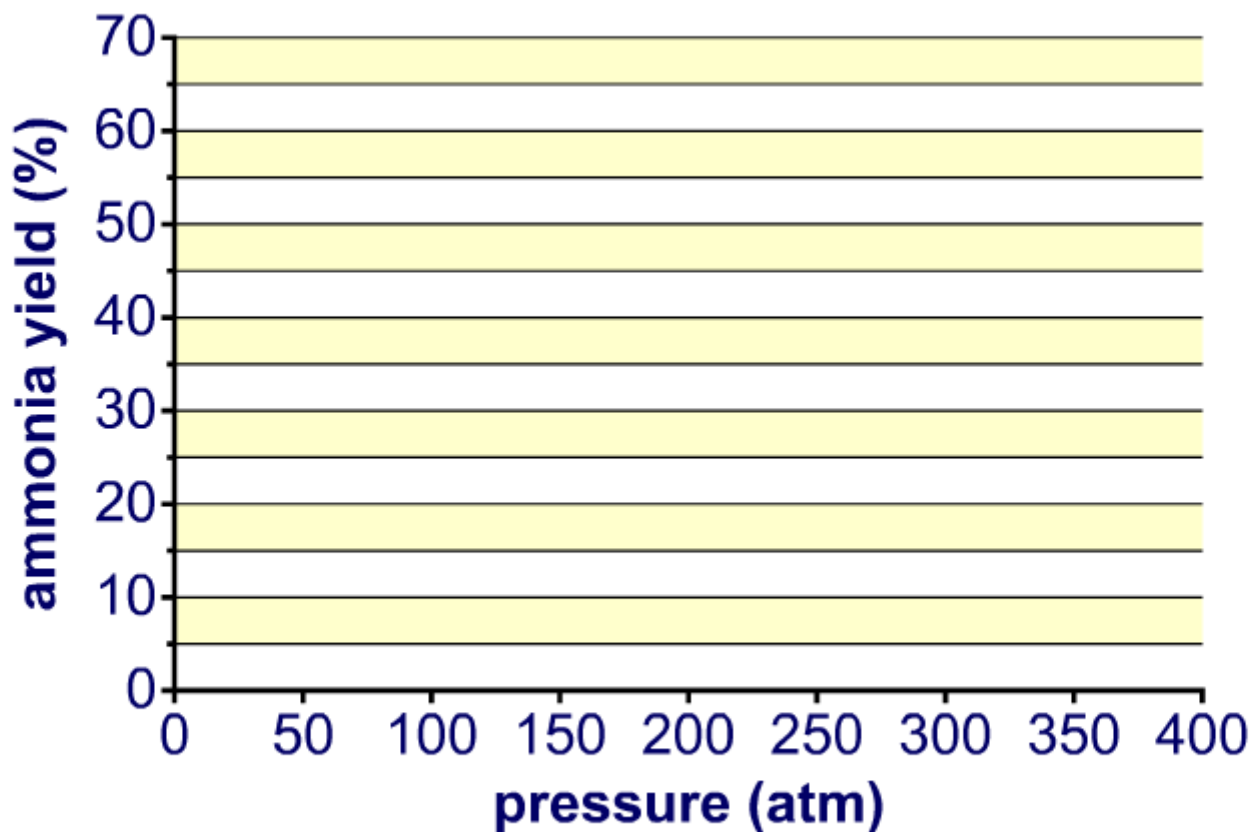


-  nitrogen
-  hydrogen
-  ammonia

temp. pressure



What conditions are used in the Haber process?



The Haber compromise

To produce a high yield of ammonia, but with a fast rate of reaction and without the need for overly expensive equipment, the Haber process is carried out at **450 °C** and **200 atmospheres**.

The most important factor in deciding what conditions to use is therefore not yield, but **total cost**.

What costs are involved in the industrial production of ammonia?

- raw materials
- energy
- equipment
- wages



What else can be done to maximize productivity in the manufacture of ammonia?

- An iron catalyst is used to increase the rate of reaction. It speeds up both the forward and backward reaction, so the position of equilibrium is not affected.
- The ammonia is cooled, liquefied and then removed as it is produced. This causes the equilibrium to shift to the right to produce more ammonia.
- Unreacted nitrogen and hydrogen are recycled and given another chance to react.





What are the missing words about the Haber process?

1a. The forward reaction in the Haber produces heat.

1b. It is therefore

2a. Lowering the temperature will cause the equilibrium to shift to the to try and oppose the change.

2b. This will the yield of ammonia.

3a. There are molecules to the left of the



solve





What is the order of stages in the Haber process?

- 1 The gases are heated to 450°C.
- 2 The gases are passed over an iron catalyst.
- 3 Unreacted nitrogen and hydrogen are recycled.
- 4 Ammonia gas is produced, then cooled to a liquid.
- 5 Hydrogen is mixed with nitrogen, obtained from air.
- 6 Steam is reacted with methane to make hydrogen.
- 7 Liquid ammonia is pumped off to be sold.
- 8 The gases are compressed to 200 atmospheres.



solve

