

The Haber process

Alisha Kakar: The Haber process is all about compromise.

But, what is it?

The Haber process is the industrial chemical process that makes ammonia.

An important material used in the manufacture of fertilisers.

It's made by reacting nitrogen and hydrogen together.

It's a reversible reaction, which means it can go both ways.

Let's see how it works.

Scientists balance yield, which is the mass of product made in a chemical reaction with the rate of reaction, safety and cost.

Nitrogen reacts with hydrogen to make ammonia, which is the forwards reaction.

Ammonia can break back down into its original elements, which is the backwards reaction.

At dynamic equilibrium, both reactions happen at the same rate in a closed system.

So nothing seems to change even though it's all still reacting.

Scientists can change conditions like temperature or pressure, which increases or decreases the yield.

This graph shows how changes in pressure affect the yield of ammonia in the Haber process.

As the pressure increases, so does the yield of ammonia at high pressure.

At high pressure, the equilibrium shifts to the side with fewer gas molecules in order to lower the pressure.

There are fewer gas molecules on the right side of the equation, so more ammonia forms.

We say that the equilibrium shifts to the right.

When it comes to temperature, ammonia formation is exothermic, which means it gives off heat.

So, increasing the temperature will shift the equilibrium to the left in the endothermic direction in order to reduce the temperature.

That means lowering the temperature gives a higher yield.

So why don't scientists just use high pressure and a lower temperature?

Well, there are trade offs.

Higher pressure can be more dangerous.

It requires stronger and more expensive equipment, as well as higher energy costs.

Lower temperatures slow the reaction and give the yields at a lower rate.

So scientists need to find a balance, a good yield, a fast enough rate, and equipment that's safe and affordable.

Therefore, a catalyst is used.

Catalysts speed up the rate of reaction without being used up or chemically changed.

This reduces the time taken to reach equilibrium, but it doesn't affect the yields.

That means a lower temperature can be used without slowing the reaction too much.

Manufacturers might cut costs further by recycling unreacted gases and reusing the heat that's released in order to power other parts of the production process.

Over to you with a challenge.

Using this equation, can you work out how increasing the pressure would affect the yield of ethanol at equilibrium?

Would the ethanol yield increase or decrease?

Pause the video while you have a think.

Increasing the pressure would increase the yield of ethanol.

This is because higher pressure favours the side with fewer gas molecules, and here, that's ethanol.

The key things to remember about the Haber process are:

A higher pressure increases the yield, but creates safety concerns.

A lower temperature increases the yield, yet slows the rate of reaction.

Catalysts speed up the time taken to reach equilibrium, but don't change the yields.

The Haber process is all about finding the sweet spot between yield, rates, safety, and cost.