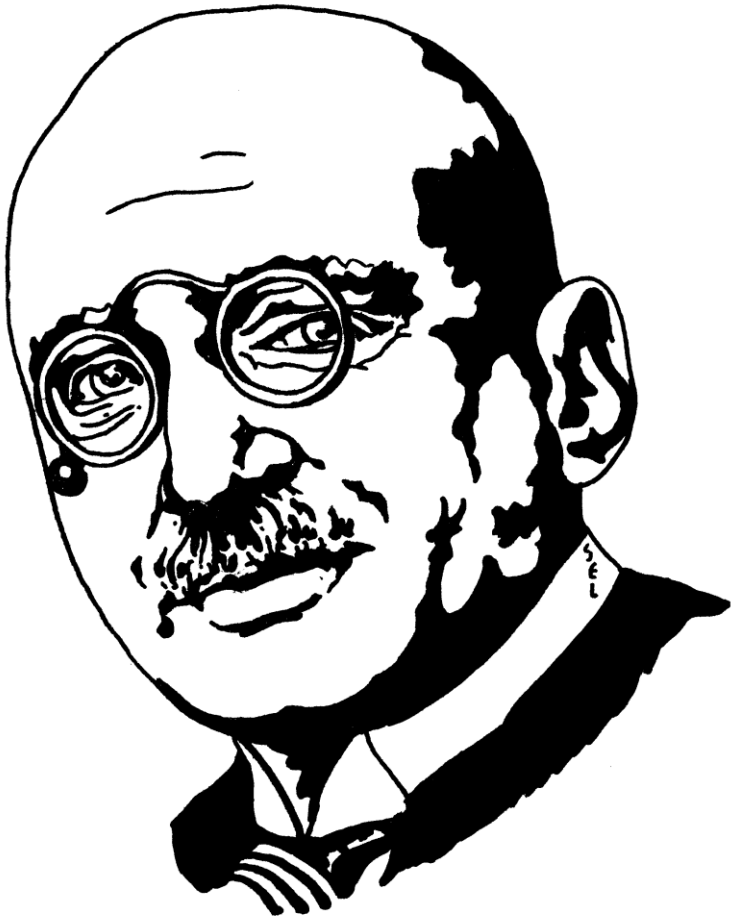
# The Haber Process



# What we will study today . . .

1. A little bit about Fritz Haber
2. How ammonia is made industrially
3. The role of a catalyst
4. The uses of ammonia

# What we will do . . .

1. Watch a video clip about Fritz Haber
2. Complete a short quiz
3. Hear an explanation of the Haber process
4. Watch a short video clip about the industrial process.
5. Learn a little about catalysts
6. Develop our scientific vocabulary
7. Try to win a million dollars

# Vocabulary

diatomic

catalyst

pressure

reactants

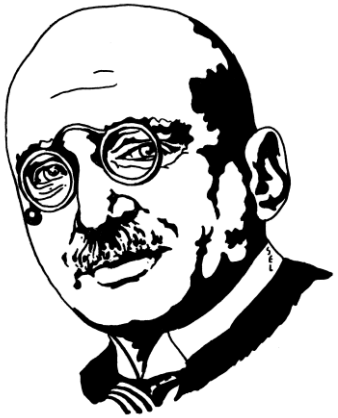
products

covalent bond

activation energy

reversible reaction

# Fritz Haber



- German born into a Jewish family
- Studied under Robert Bunsen at the University of Berlin.
- Famous for the production of ammonia
- Developed chemical warfare during WWI (chlorine and mustard gas)
- 1918 Nobel prize for Chemistry
- Developed Zyklon A which was developed by other scientist into Zyklon B.

For more information click here

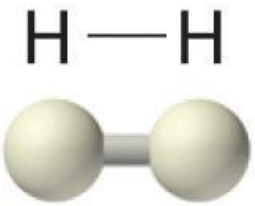

PLAY

# Fritz Haber

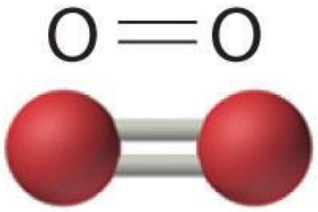
"A **scientist** belongs to **his country** in times of war and to all **mankind** in times of peace."

# How much do you remember?

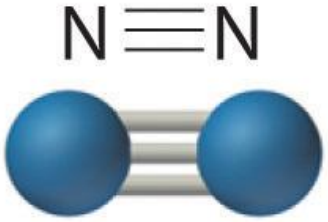
# Why is making ammonia so difficult?




Single bond




Double bond




Triple bond

**Triple bonds are difficult to break!**

# The solutions provided by science

## Part 1 – The raw materials

Ammonia is made by reacting nitrogen with hydrogen

$N_2 + 3H_2 \leftrightarrows 2NH_3$

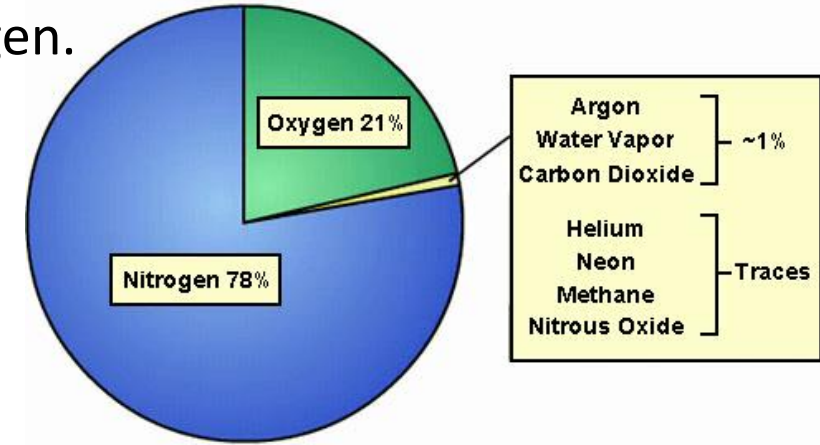
Hydrogen can be obtained by heating methane with steam:

$CH_4 + H_2O \rightarrow 3H_2 + CO$

Nitrogen can be obtained from air.

Burning hydrogen in air removes the oxygen.

$2H_2 + O_2 \rightarrow 2H_2O$



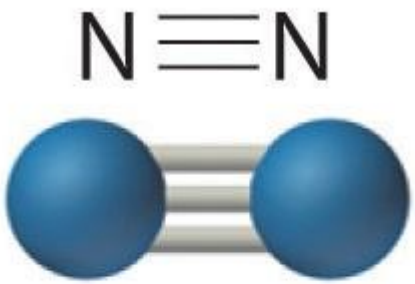
# The solutions provided by science

## Part 2 – Reacting nitrogen with hydrogen

$N_2 + 3H_2 \leftrightarrows 2NH_3$

- A high temperature
- A high pressure
- An iron catalyst

# Why a high temperature?




Triple bond

Triple bonds are difficult to break so high temperatures are needed to break the nitrogen atoms apart in order to react with hydrogen.

# Why high pressure?

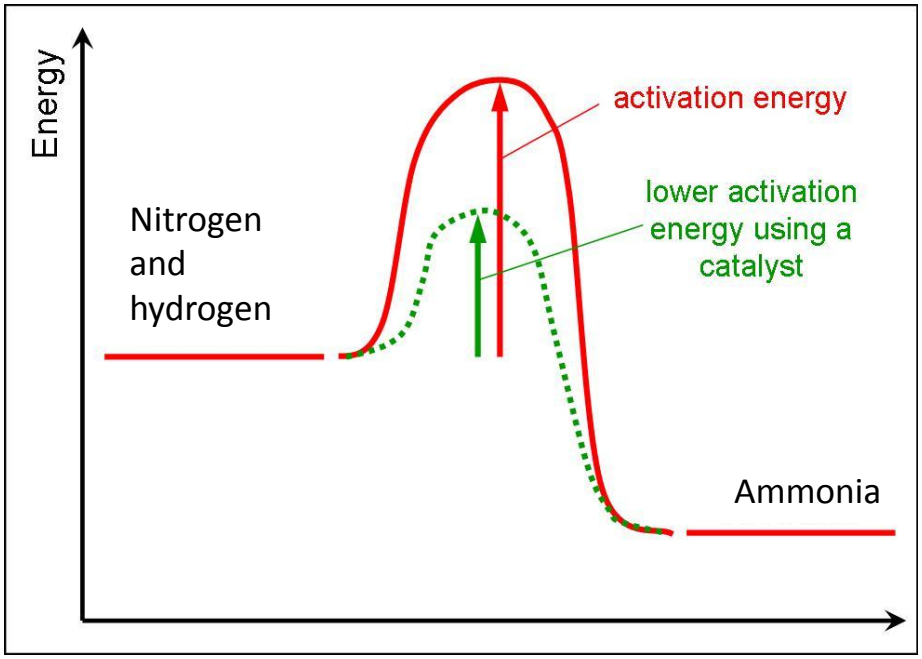
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The reaction is reversible! This is a problem!

$1dm^3$ of nitrogen reacts with $3dm^3$ of hydrogen to produce $2dm^3$ of ammonia.

The reactants have a larger volume than the product (ammonia) so high pressure moves the point of equilibrium towards the right.

# Why use a catalyst?



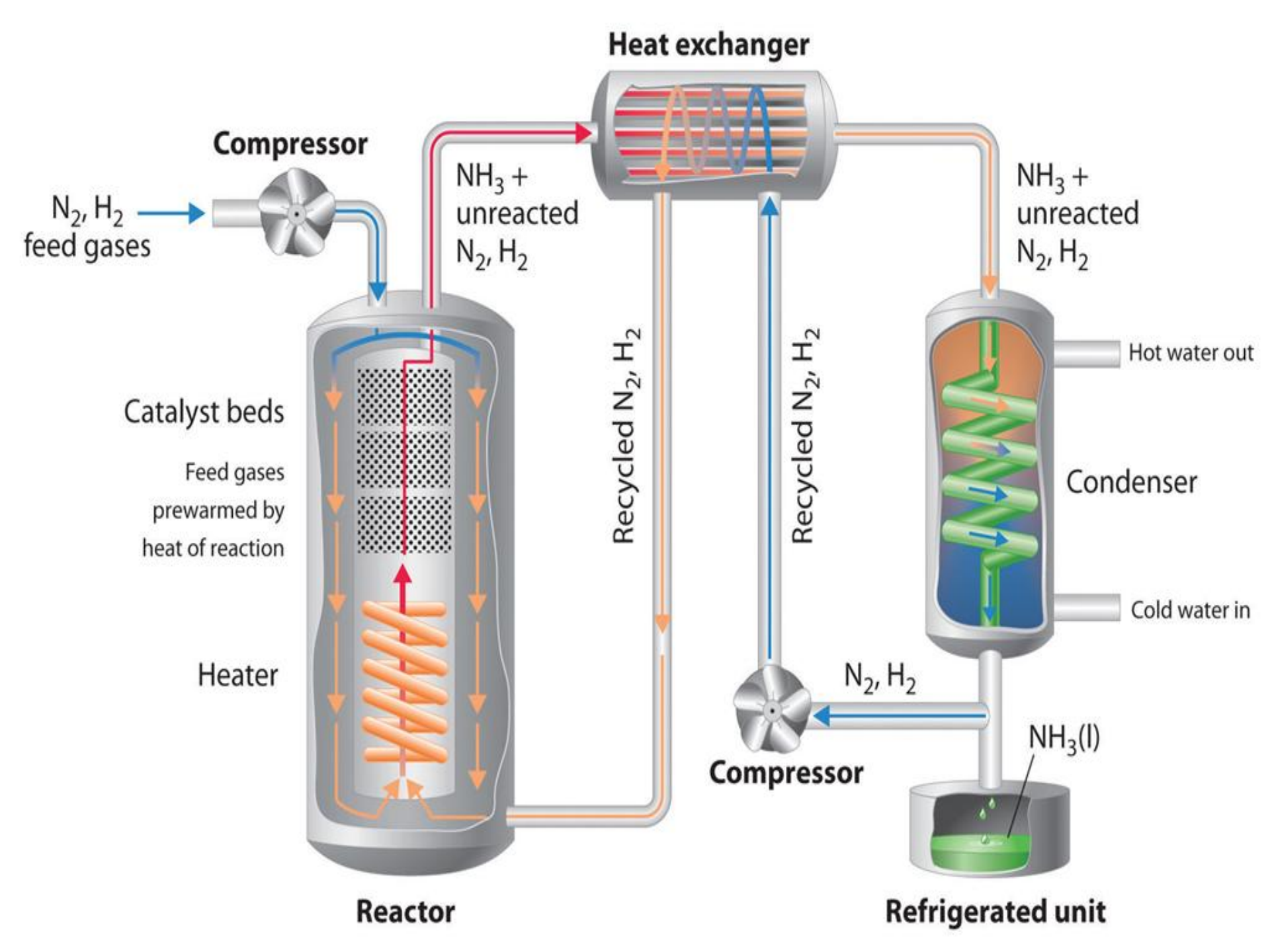

Fritz Haber used osmium as a catalyst. Why was the catalyst changed to iron?

❖ Activation energy is the energy to get a reaction going. Reaction diagrams usually look like a hill. It is the energy needed to climb up to the top of that hill, just like rolling a ball or a tire up a hill, you use energy to get it up there. That's activation energy.

❖ By lowering the activation energy, the reaction takes place at a faster rate (it takes less time to roll a tyre up Castle Crag than Scafell Pike!)

# The Haber Process on an industrial scale

1. Haber used an apparatus was small enough to be placed on a laboratory bench and produced 125ml of ammonia per hour. This is insufficient to produce explosives to win a war or produce fertilisers in sufficient amounts!
2. By 1914, German chemical engineer Carl Bosch had assisted Haber in converting the method into an industrial process.


Heat exchanger
Compressor
$N_2$, $H_2$ feed gases
$NH_3$ + unreacted $N_2$, $H_2$
$NH_3$ + unreacted $N_2$, $H_2$
Recycled $N_2$, $H_2$
Recycled $N_2$, $H_2$
Hot water out
Catalyst beds
Feed gases prewarmed by heat of reaction
Condenser
Cold water in
Heater
$N_2$, $H_2$
$NH_3$(l)
Compressor
Reactor
Refrigerated unit


PLAY

# Manufacturing costs

Different factors affect the cost of making a new substance.

Factors that increase cost include:

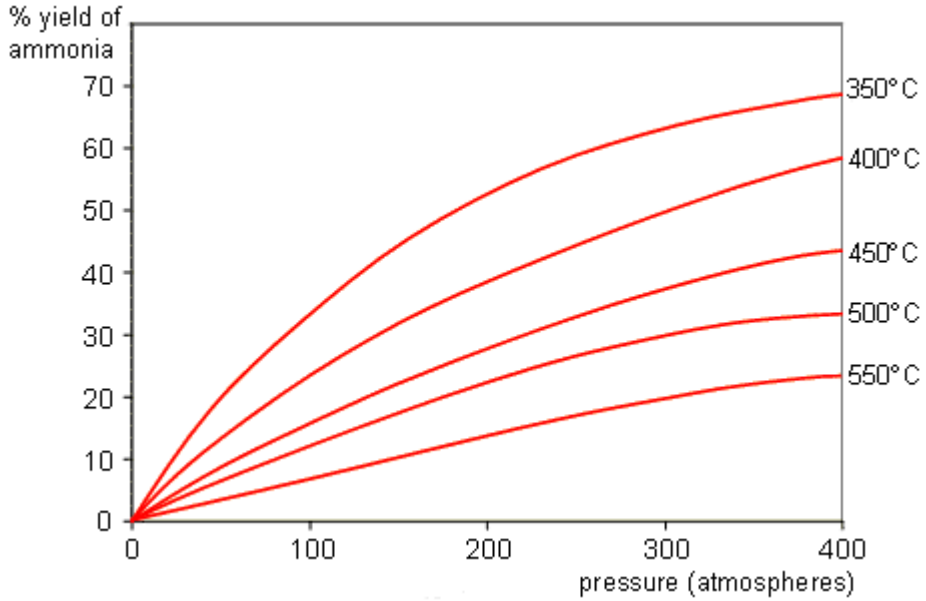
- high pressures (they increase the cost of the equipment)
- high temperatures (they increase the energy costs).

Factors that decrease manufacturing costs

- catalysts (they increase the rate of reaction)
- recycling unreacted starting materials
- automating equipment (because fewer people need to be employed, cutting the wage bill)

# Percentage Yield

The percentage yield is the mass of product that is actually made, compared to the total possible mass of product.




1. What is the effect of increasing the pressure on the percentage yield?
2. What is the effect of increasing the temperature on percentage yield?

# Vocabulary

diatomic

catalyst

pressure

fertiliser

products

covalent bond

reactants

activation energy

reversible reaction

# Exam blooper!

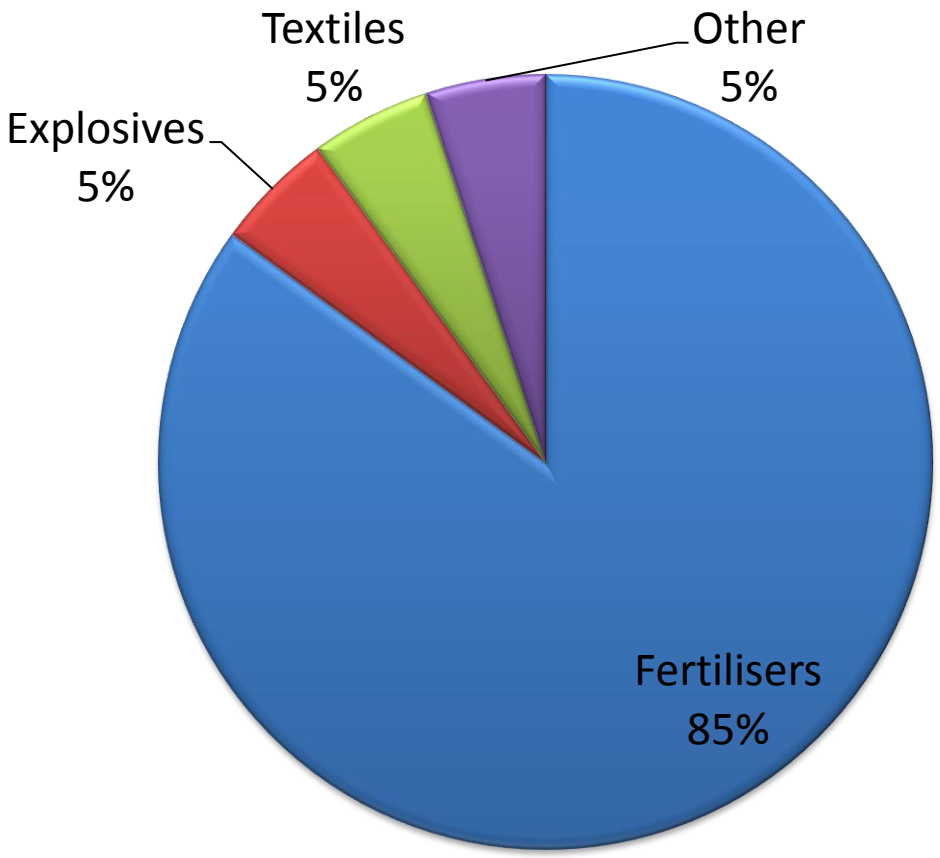
Question:

Where would you put an ammonia plant?

Student answer:

In the desert where there is lots of sunshine.

# Uses of ammonia




WHO WANTS TO BE A
MILLIONAIRE
WHO WANTS TO BE A