KS4
USEFUL PRODUCTS FROM THE AIR

Teacher's Notes

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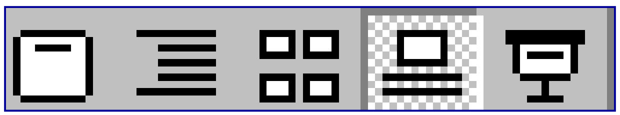
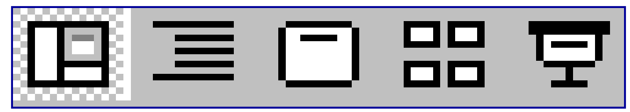


Notes Page View



Normal View

Flash Files

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What you will learn -

- The air is made up mostly of nitrogen and oxygen along with small amounts of other gases.
- Nitrogen is used in the manufacture of ammonia in a reversible reaction.
- It is possible to select the conditions of a reversible reaction so that we get the maximum yield of product.
- Ammonia can be oxidised to nitric acid and this is used to make nitrate fertilisers.
- Inappropriate use of fertilisers can lead to water pollution problems.

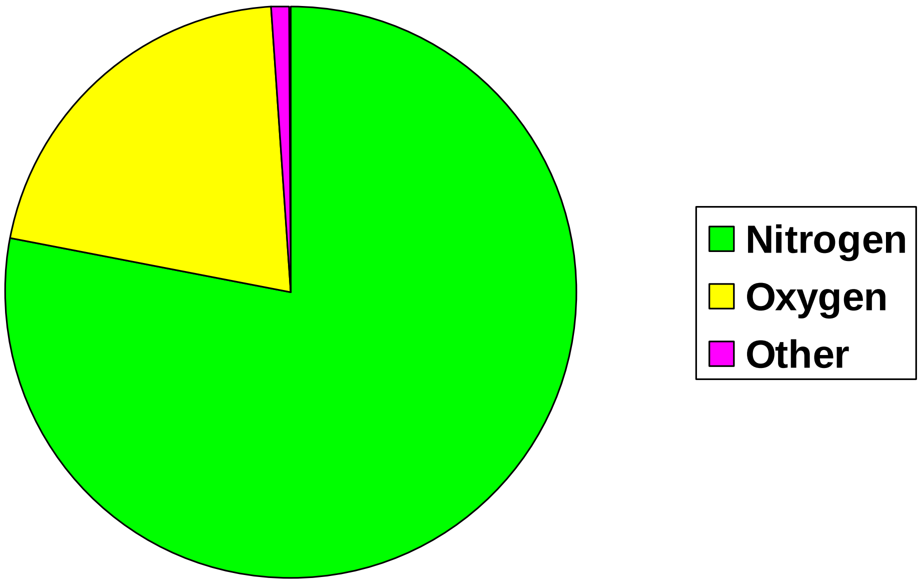
The composition of air

Air is made up of four main gases. Brainstorm with those around you and see if you can write down these four main gases.

Once you think you have the four gases order them so that the one that is the most abundant is at the top of the list and the one that is the least abundant is at the bottom of the list.

The composition of air

- Around 78% of the air is nitrogen.
- About 21% is oxygen.
- The remaining 1% is mostly argon (0.93%), with carbon dioxide (.04%) and varying amounts of water vapour.



Separating the gases in air

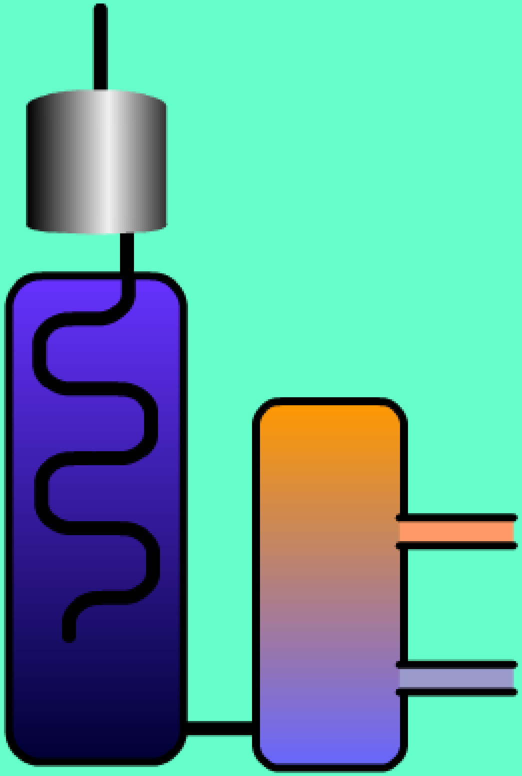
* Air is cooled until it becomes a liquid.

* The liquid is then allowed to warm up.

* Liquid nitrogen changes back into a gas first.

* The liquid oxygen boils at a slightly higher temperature.

* This process is a low temperature distillation.



Activity

Separating gases

Here are the boiling points of the three main gases in air.

Nitrogen - 196ºC

Oxygen - 183ºC

Argon - 186ºC

When air is distilled:

1. Which gas will boil first?
2. Which gas will there be most of?
3. Which gas will there be least of?

Nitrogen

Nitrogen

Argon

Oxygen and Combustion

- Oxygen is a highly reactive gas.
- It is involved in the majority of combustion (burning) reactions that take place.
- Much of our energy comes from the reaction of fossil fuels or renewable fuels with oxygen.

Combustion

Write word equations for the following combustion reactions:

1. Carbon + oxygen ⇨ Carbon dioxide
2. Hydrogen + oxygen ⇨ Water
3. Methane (CH4) + oxygen ⇨

Carbon dioxide + Water

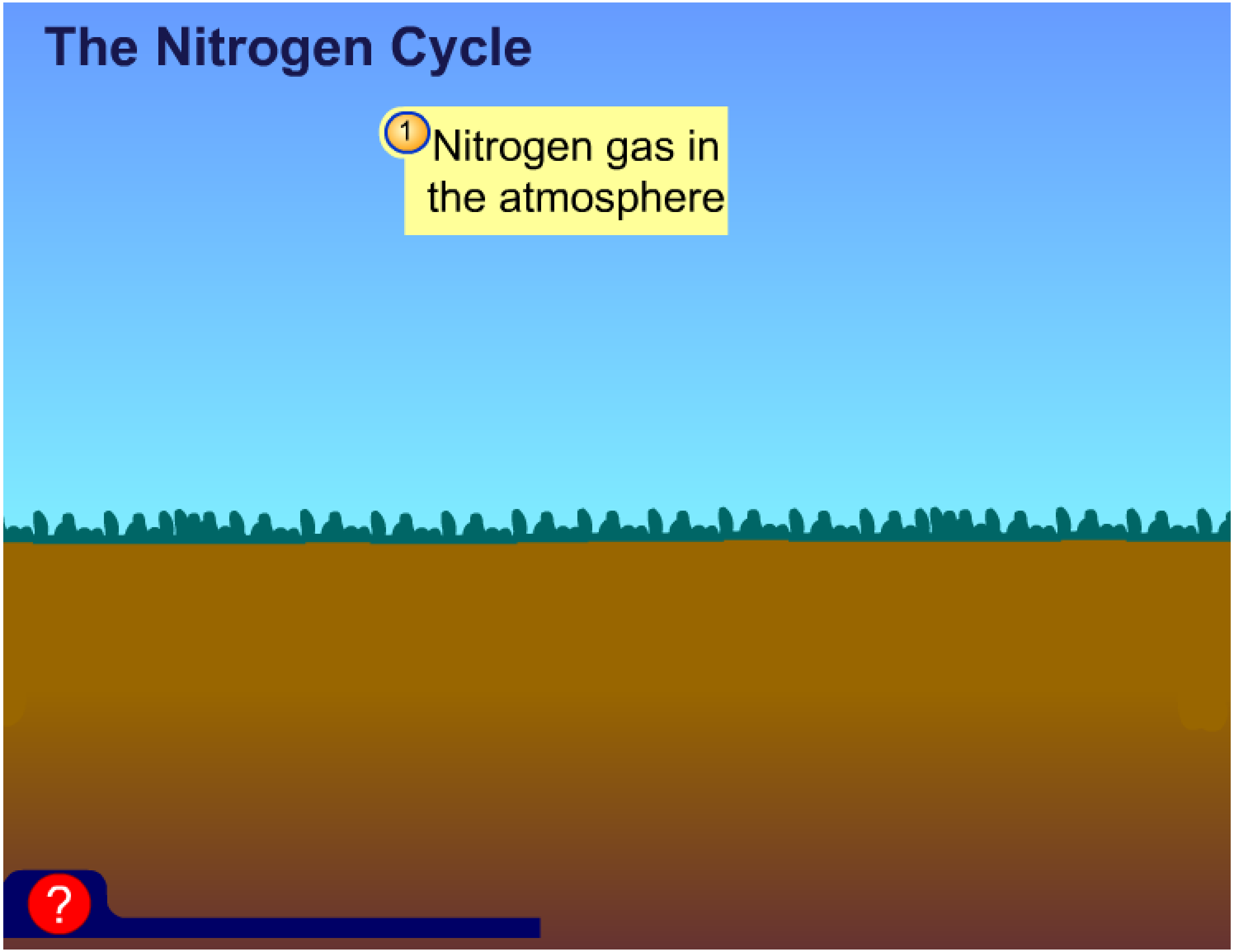
The Nitrogen Cycle: 1

- Nitrogen is used by plants when they manufacture proteins.
- However, nitrogen itself is too un-reactive for plants to be able to use directly. They have to use nitrogen compounds such as nitrates.
- There are natural processes, such as thunderstorms and the combined action of bacteria with certain plants, that convert nitrogen gas into the necessary nitrates.

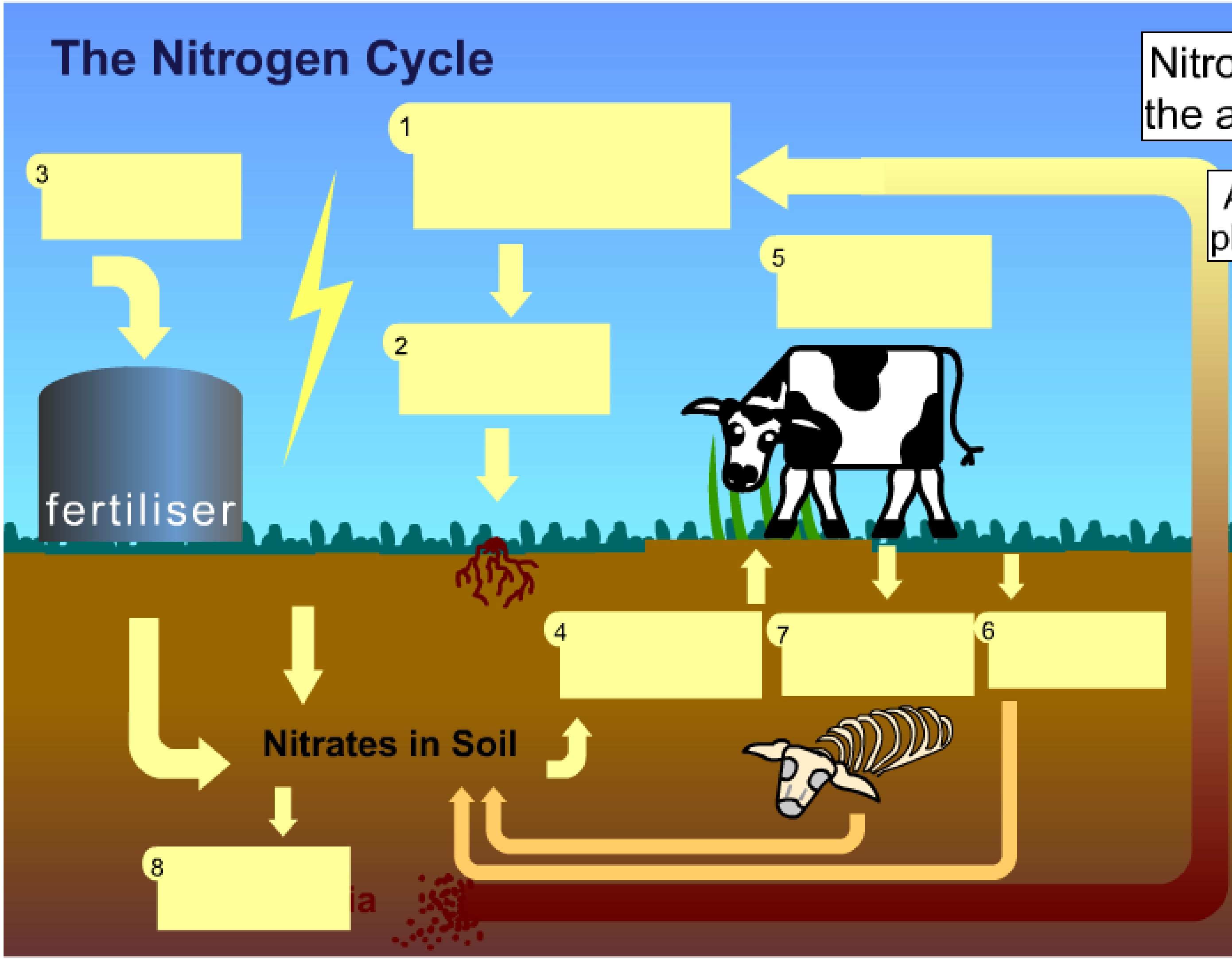
The Nitrogen Cycle: 2

- Intensive farming tends to remove nitrates from the soil faster than they are replaced by natural processes.
- In past centuries farmers used to leave fields fallow (unplanted) for nitrate levels to recover.
- Nowadays farmers often use fertilisers to "top-up" the nitrate content of the soil. These nitrates are manufactured from nitrogen using the Haber process. (See later.)

The Nitrogen Cycle



The Nitrogen Cycle



Nitrogen gas in the atmosphere

Absorbed by plants & crops

Fixation by legumes

Decay of dead animals

Bacteria

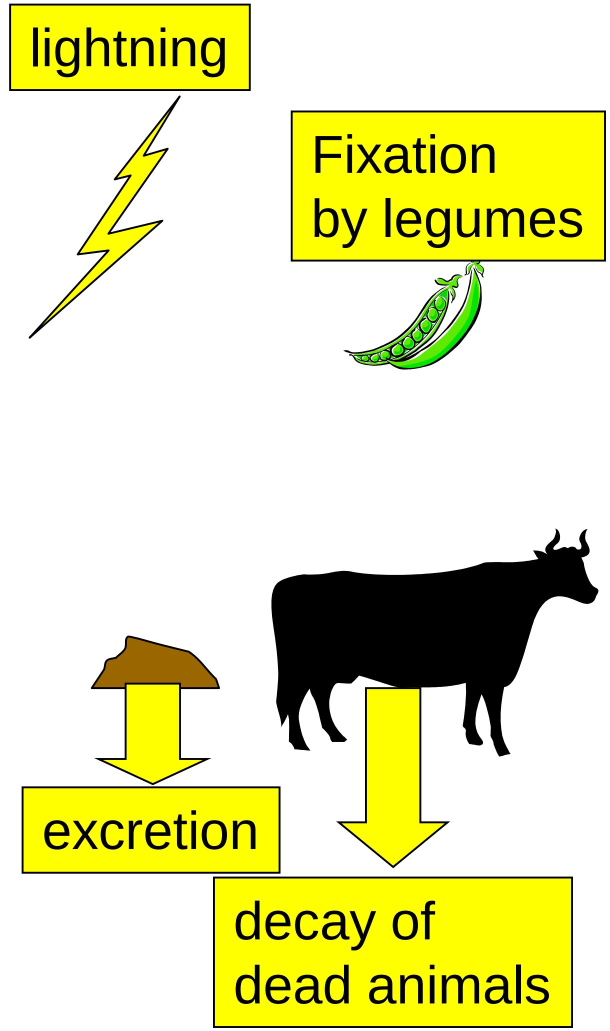
The Haber process

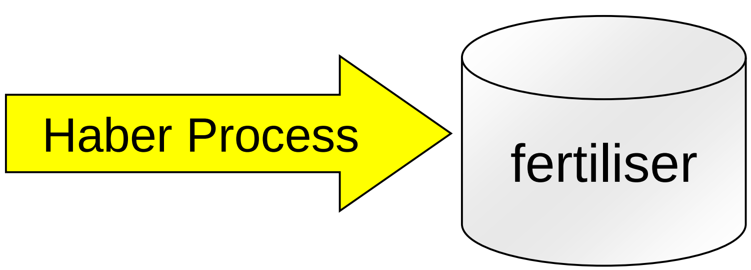
Conversion to animal protein

Excretion

The Nitrogen Cycle

1. Write down three natural processes which lead to an increase in the nitrate content of the soil.
2. Write down one man-made process used to increase the nitrogen content of the soil.





The Haber Process 1

- Nitrogen is a very unreactive gas which tends to react slowly if at all.
- Changing the element nitrogen into compounds that plants can absorb involves reacting the nitrogen with hydrogen to form ammonia.

nitrogen + hydrogen ⇨ ammonia

$N_2 + 3H_2 \Rightarrow 2\,NH_3$

The Haber Process 1

Can you suggest ways of speeding up the reaction of nitrogen with hydrogen?

1. Use a catalyst
2. Use a high temperature
3. Compress the gases

The actual conditions used are:

1. An iron catalyst
2. A temperature of 450ºC
3. A pressure of 200 atmospheres

The Haber Process 3

- Even under these conditions only part of the nitrogen and hydrogen react to form ammonia and if the temperature is raised too high the ammonia increasingly decomposes back into the reactants. The reaction is said to be reversible.

$$\text{nitrogen} + \text{hydrogen} \rightarrow \text{ammonia}$$

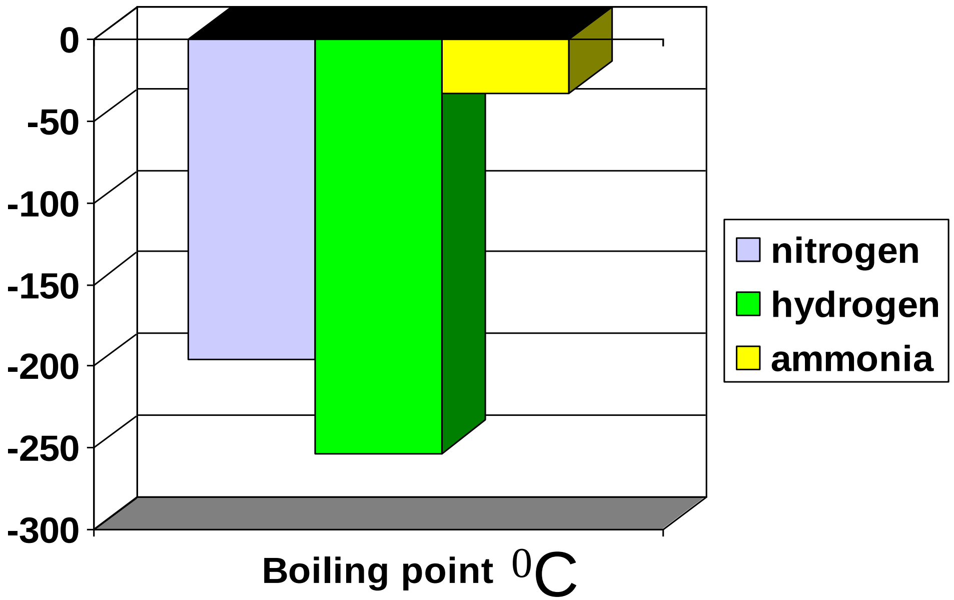
- Getting the best rate of conversion into ammonia involves very careful choice of reaction conditions.

The Haber Process

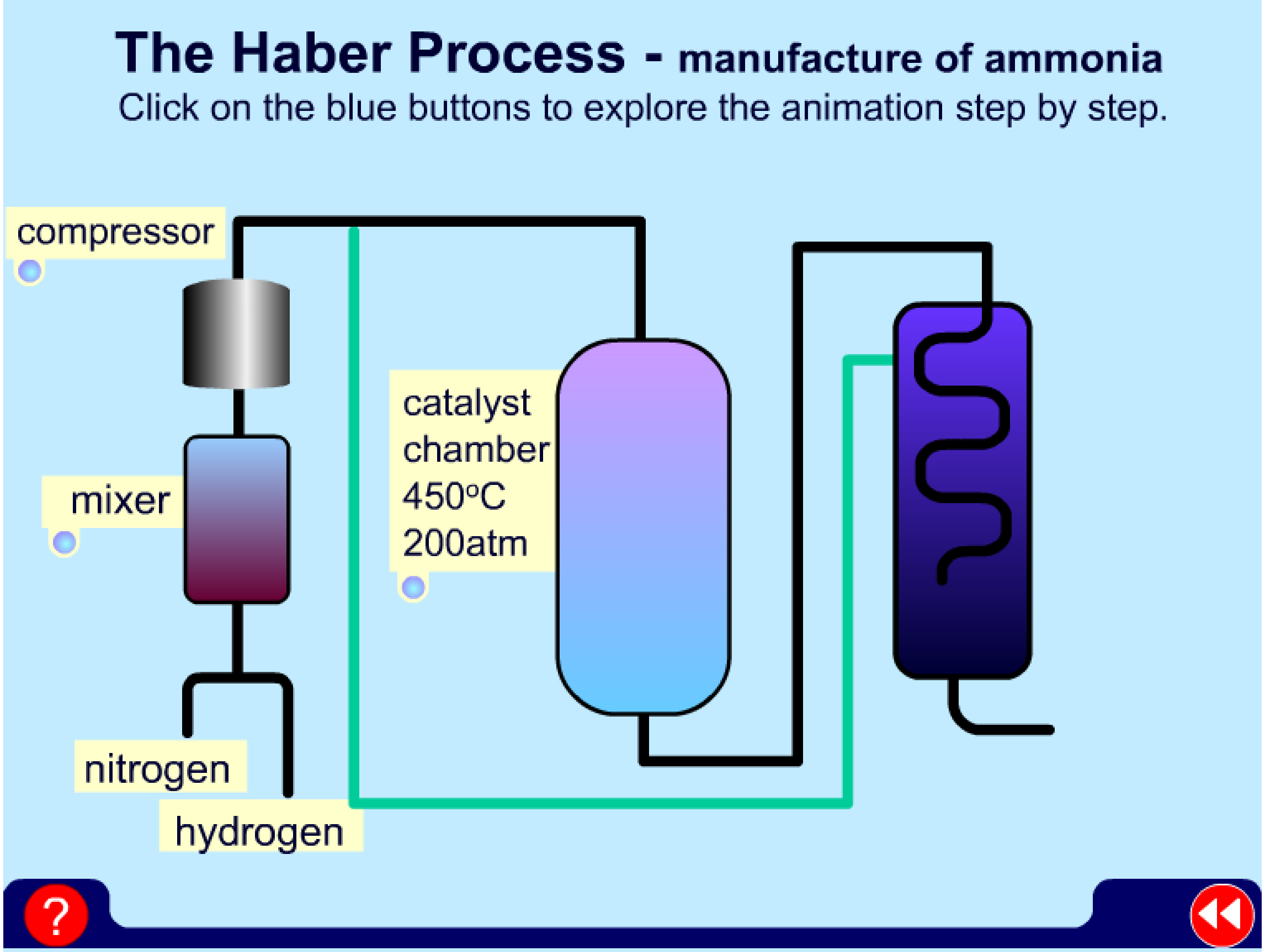
- The Haber process gives a mixture of reactants and products.
- Here are the boiling points of the substances involved.

1. Which one most easily turns into a liquid?

2. How might ammonia be separated from unreacted nitrogen & hydrogen?



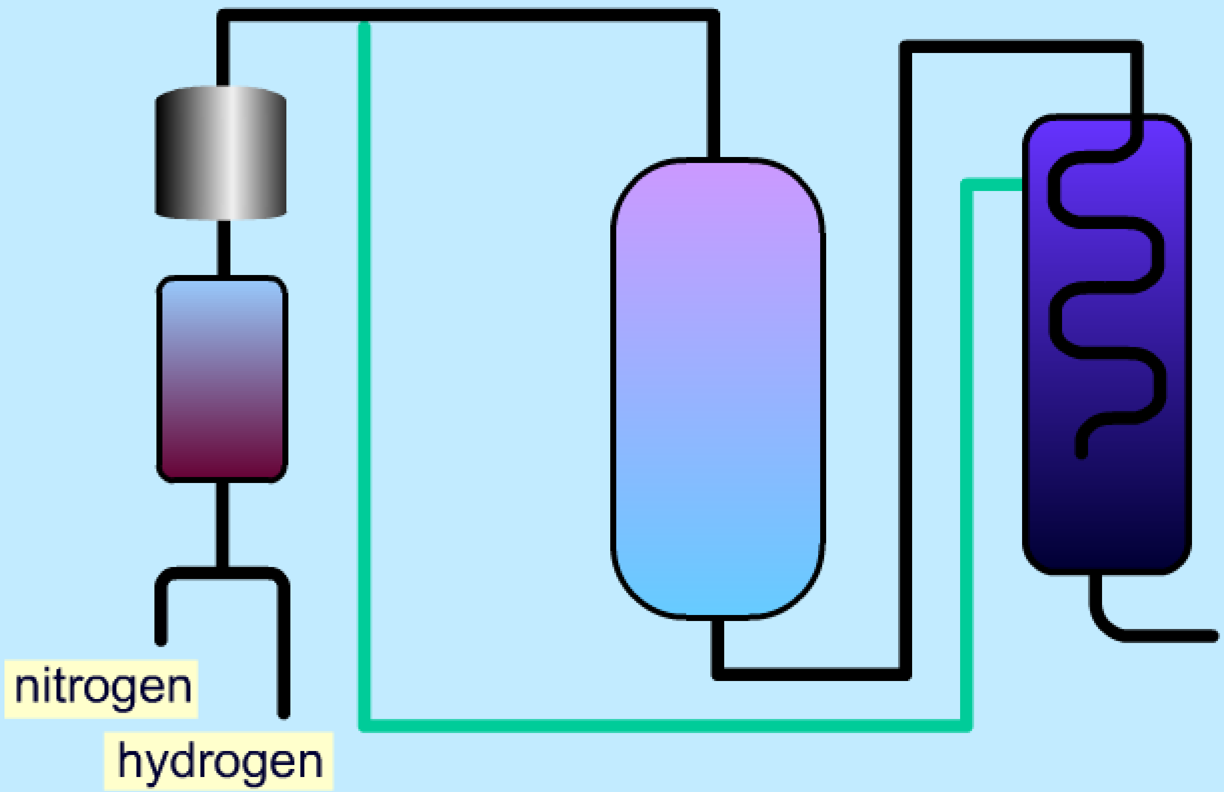
The Haber Process



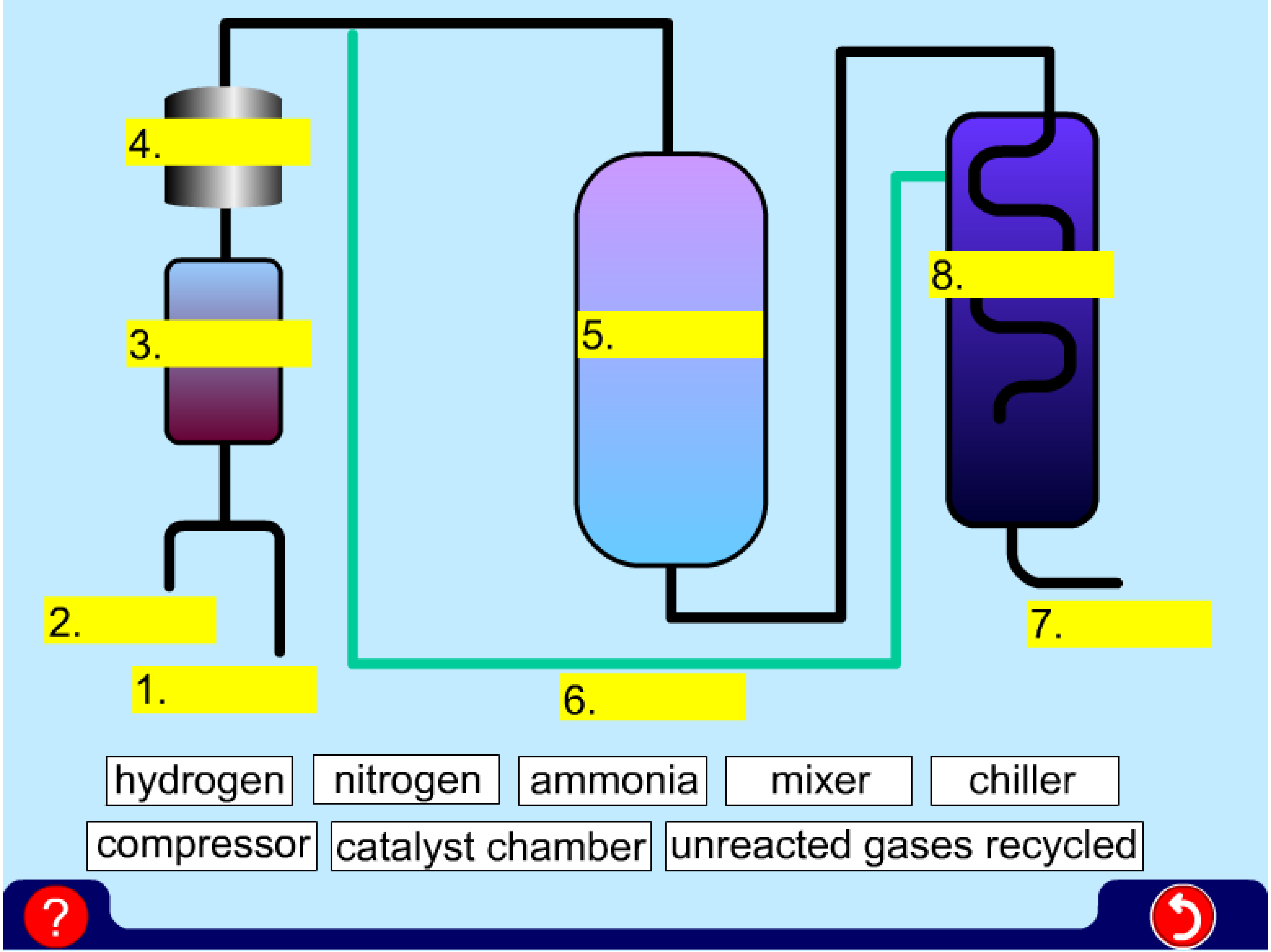
The Haber Process

The Haber Process - manufacture of ammonia

Click on the play sequence button to explore the animation as a whole.

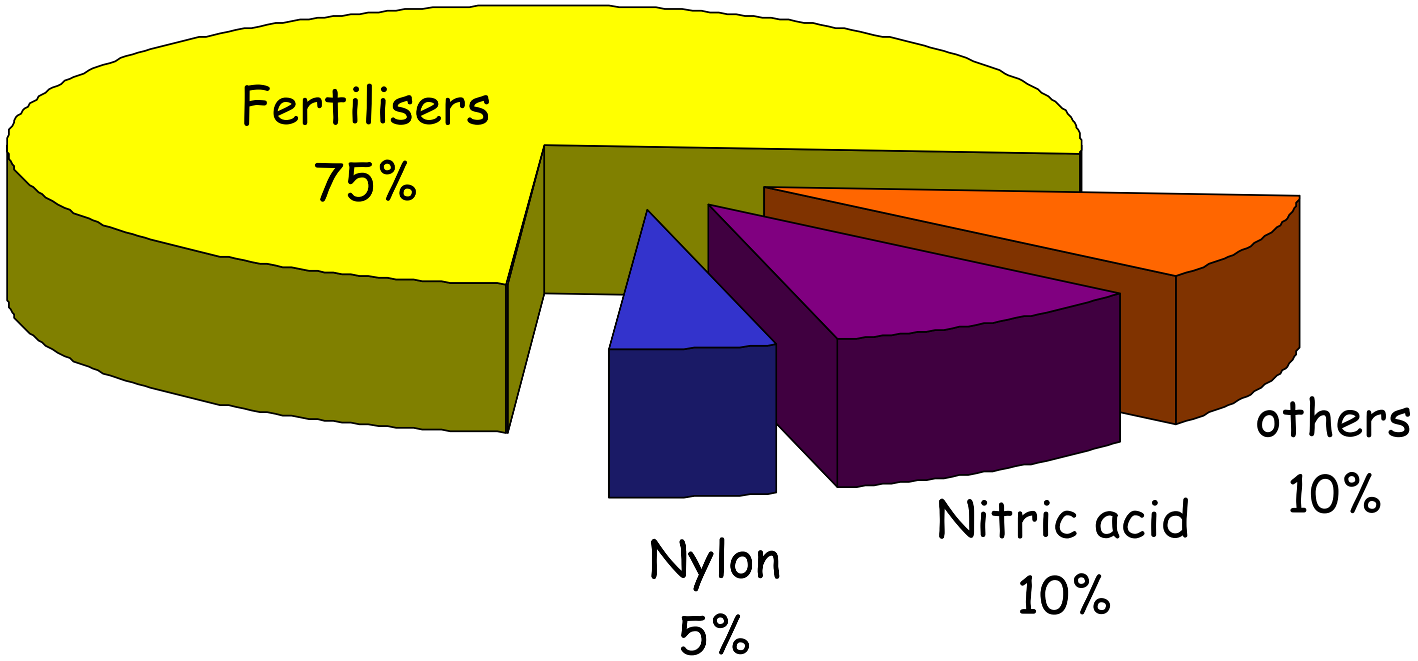


The Haber Process



Uses of Ammonia

The majority of ammonia is used for the manufacture of fertilisers, but there are other uses.



Fertiliser manufacture

- Ammonia is sometimes pumped directly into the soil as a fertiliser but because it is a gas much of it may escape.

- More usually some of the ammonia is reacted with oxygen to form nitric acid

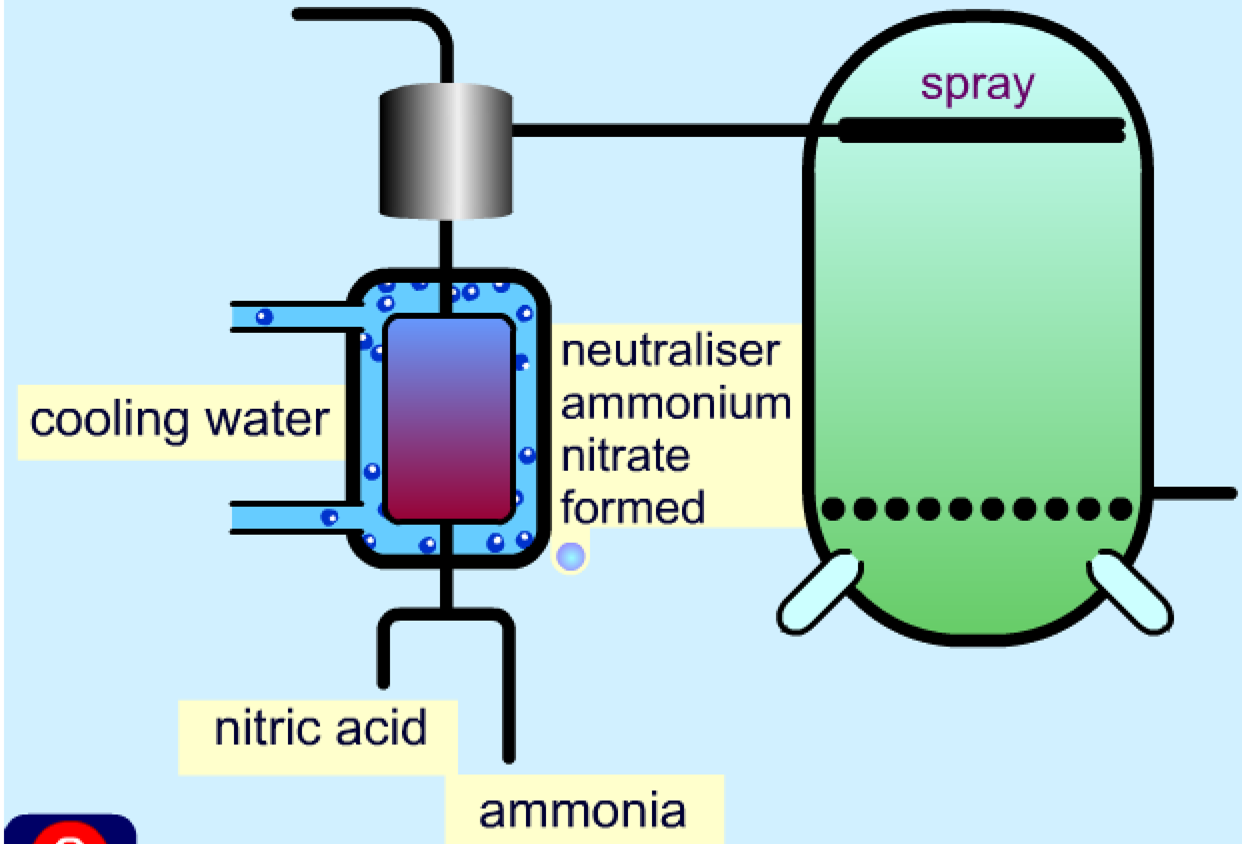
  $NH_3 + 2O_2 \Rightarrow HNO_3 + H_2O$

- This nitric acid is then reacted with more ammonia to give solid ammonium nitrate

  $HNO_3 + NH_3 \Rightarrow NH_4NO_3$

Ammonium Nitrate Production

Click on the blue buttons to explore the animation step by step.



Ammonium Nitrate Production

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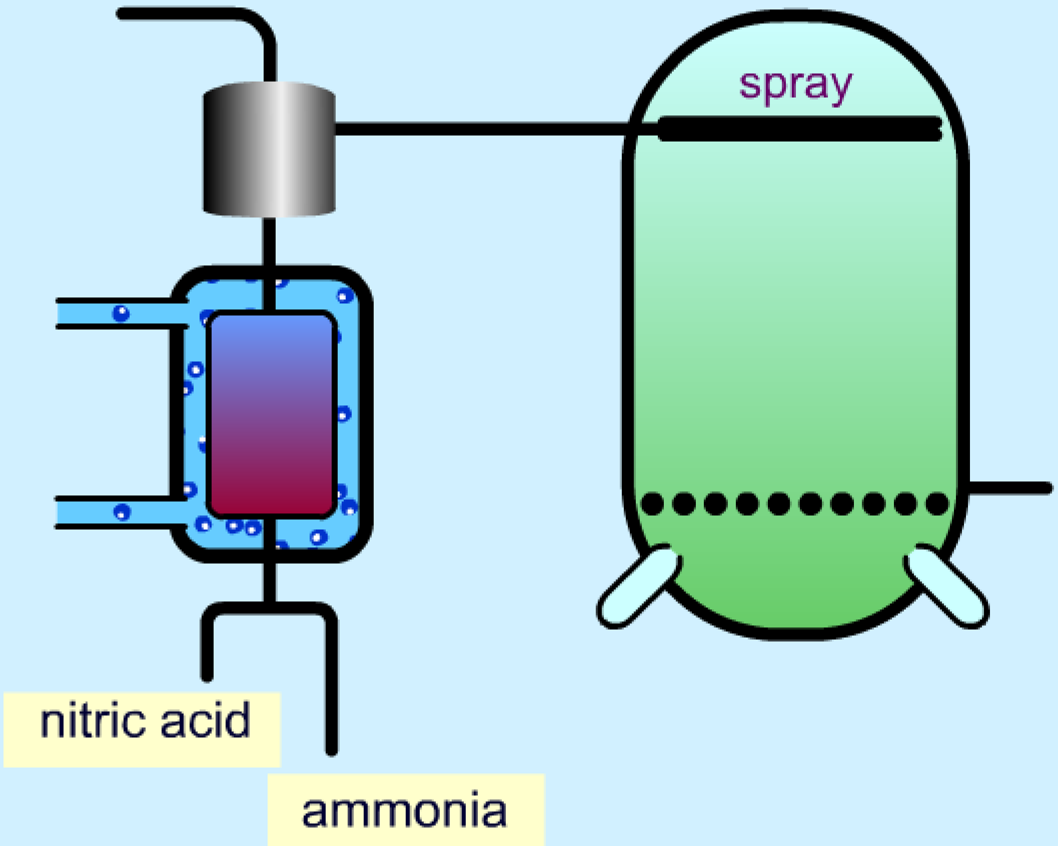
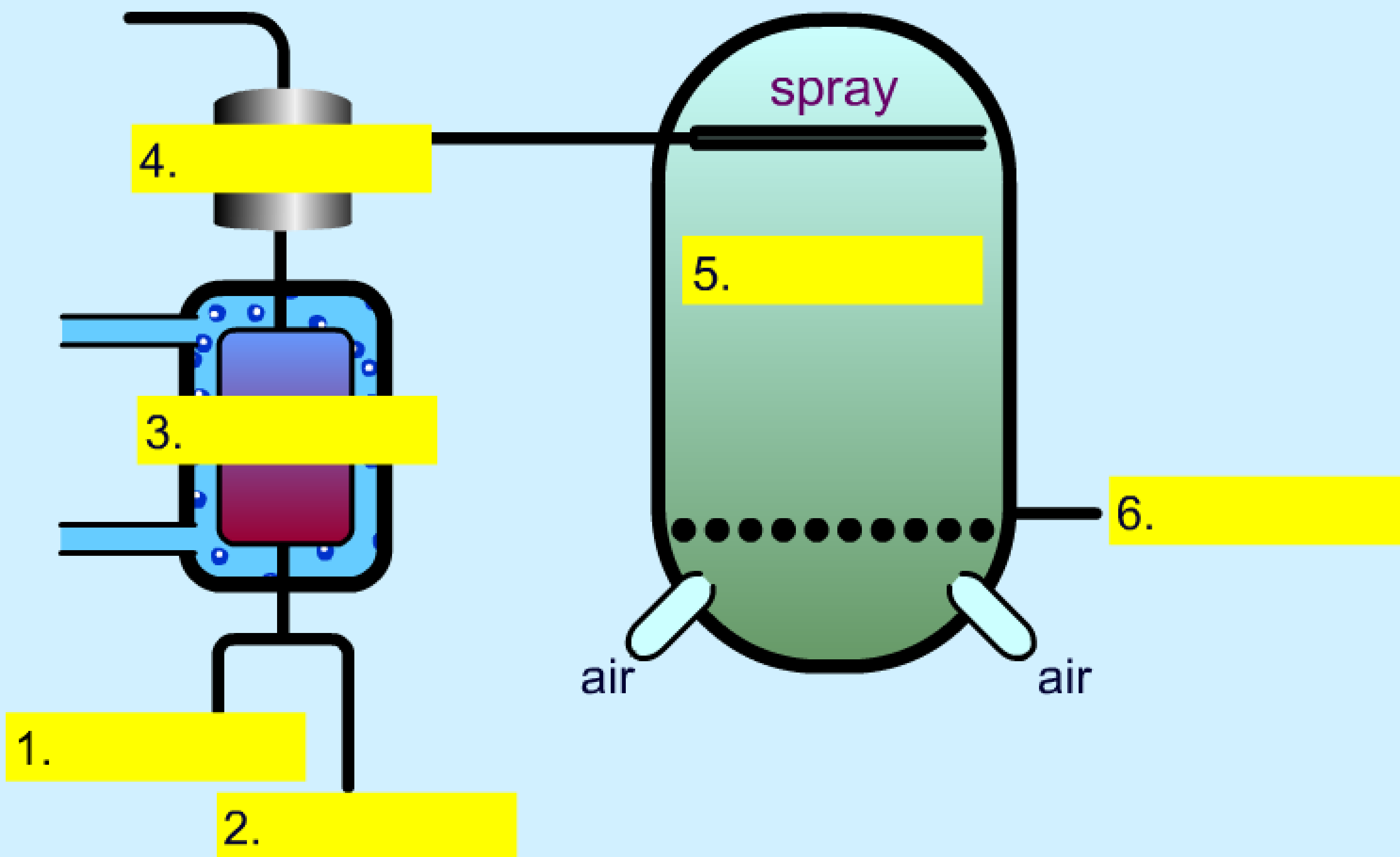




nitric acid	forms granules	evaporate	granules out
	neutralise	ammonia	

The effects of fertiliser

In a group of 3 or 4 write the words ‘The effects of fertiliser’ in the middle of a piece of A3 paper.

Around the outside write down all of the effects – good and bad - that fertilisers can have on the environment.

Effect of artificial fertilisers on farming

Fertilisers

They have made naturally infertile soils, suitable for agriculture. This has been significant in poorer parts of the World.

They eliminate the need to allow fields to lie fallow and for crop rotation. This enhances the productivity of the land.

They increase the yield of the crops produced.
This has allowed more land to be set aside for nature conservation and recreation.

The environment and fertilisers

fertilisers applied to farm land

if

too much used, at the wrong time of year, during wet weather,

excess

washed into rivers and lakes

causes

Excessive growth of aquatic plants.
The bacteria which live on dead plants thrive and use up the oxygen in the water.
The lack of oxygen causes death of fish.
This is called **eutrophication**.

excess

contaminates underground drinking water supplies

causes

Harm to infants - called ‘blue baby’ syndrome

Growmore is a NPK fertiliser (7-7-7) containing about 7% nitrogen, 7% phosphorous and 7% potassium.

NPK fertilisers

Nitrogen (N)- needed for proteins in leaves and stalks.

Phosphorous (P) - speeds up growth of the roots and helps fruit to ripen.

Potassium (K) - speeds up seed growth and improves resistance to disease.

A problem for Farmer Giles

Farmer Giles has been accused of raising nitrate levels in local water by using too much fertiliser.

Here are some suggestions from other locals.

Are they good or bad?

1. Split the fertiliser over 3 applications instead of just one.
2. Use a more soluble fertiliser so that it gets into the plants more easily.
3. Check the weather forecast and avoid applying it before rain is due.
4. Grow a quick crop of legumes instead of using a nitrogen containing fertiliser.
5. Use fertiliser with larger particle size.

Answers

1. Three applications instead of just one – good
   Plants get time to take in each application.
2. More soluble fertiliser – bad

   It will dissolve in rain and wash into local drains.
3. Avoid applying it before rain is due – good

   This means it won't dissolve in the rain and wash into drains.
4. Grow a quick crop of legumes – good

   But depends on timings of crops, etc.
5. Use fertiliser with larger particle size – good

   Using the same amount of fertiliser with larger particles is likely to lead to a slower dissolving into the ground, giving plants more time to absorb it.

Summary crossword

Across:

1 Acid formed by oxidation of ammonia

8 Alkali metal present in NPK fertilisers

9 metal used as a catalyst in the Haber process

Down:

2 Reaction that can go backwards

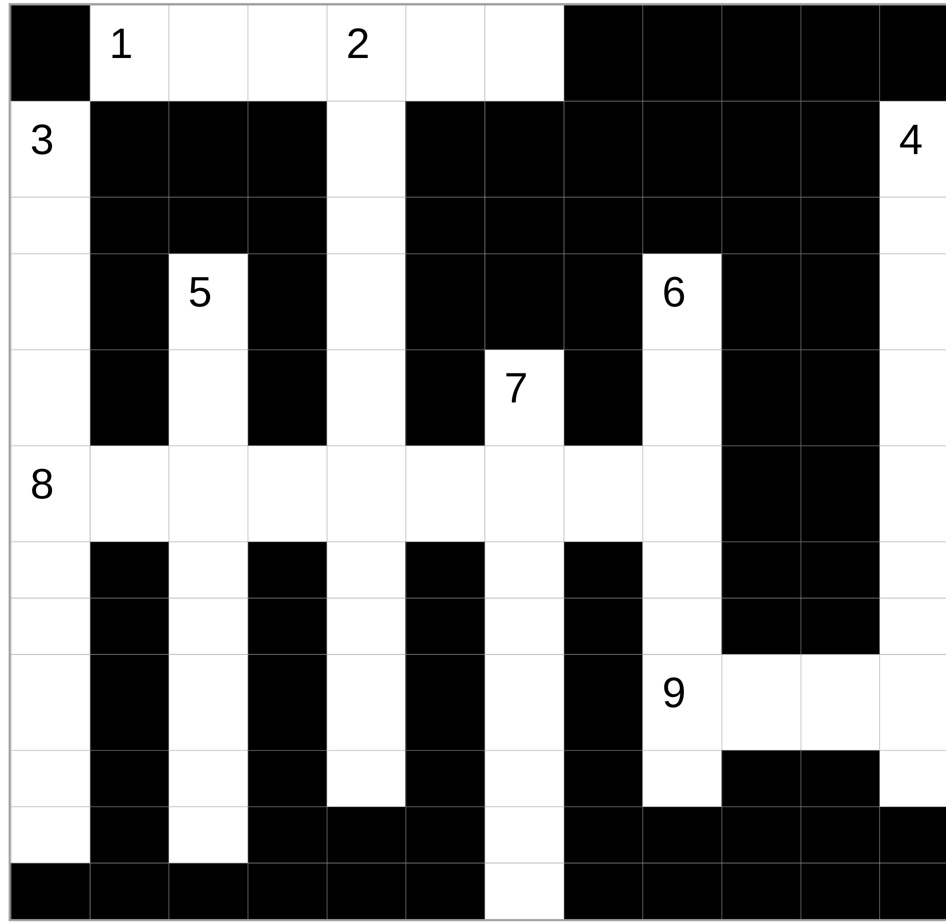
3 Element essential for growth of roots

4 Causes nitrates to be formed from the gases in air.

5 About 4/5 of air are made of this gas.

6 Formed in the Haber Process

7 Nitrogen compounds present in good soil



Crossword answers

Across:

1 Acid formed by oxidation of ammonia. - nitric
8 Alkali metal present in NPK fertilisers. - potassium (K)
9 metal used as a catalyst in the Haber process. iron

Down:

2 Reaction that can go backwards. - reversible
3 Element essential for growth of roots. - phosphorus
4 Forms nitrates from the gases in air. - lightning
5 About 4/5 of air are made of this gas. - nitrogen
6 Formed in the Haber Process - ammonia
7 Nitrogen compounds present in good soil - nitrates

1. Which word equation is correct?

A. Carbon + oxygen ⇨ carbon dioxide + water

B. Hydrogen + oxygen ⇨ carbon dioxide

C. Magnesium + oxygen ⇨ magnesium oxide

D. Methane + oxygen ⇨ carbon dioxide

2. Which process results in reduction in nitrate levels in the soil?

A. Lightning
B. Growth of legumes
C. Animal excretion
D. Growth of leaves

3. Which substances are raw materials for the Haber Process?

A. Oxygen and hydrogen

B. Oxygen and nitrogen

C. $\boxed{\text{Nitrogen and hydrogen}}$

D. Nitrogen and oxygen

4. What are the conditions used in the Haber Process?

A. Iron catalyst, 200 atm pressure, around 450^oC

B. Nickel catalyst, 200 atm pressure, around 450^oC

C. Iron catalyst, 450 atm pressure, around 200^oC

D. Nickel catalyst, 450 atm pressure, around 200^oC

5. In the Haber process how is ammonia separated from unchanged reactants?

A. Filtering it
B. Distilling it
C. Using chromatography
D. Liquefying it

6. Ammonia is made into solid (granular) fertiliser.

   What is the sequence of stages in this process?

A. Neutralise, evaporate, granulate
B. Granulate, neutralise, evaporate,
C. Evaporate, neutralise, granulate
D. Neutralise, granulate, evaporate,

7. One of the most common fertilisers is known to farmers as NPK.

   This contains:

A. Potassium, calcium, nitrogen
B. Potassium, phosphorus, nitrogen
C. Nitrogen, potassium, krypton
D. Nitrogen, phosphorus, krypton

8. Phosphorus is an essential plant nutrient to ensure

A. healthy leaves.
B. healthy stalks.
C. healthy roots.
D. healthy flowers.

9. Which of these might ***NOT*** be caused by excessive use of nitrogen containing fertiliser?

A. Blue baby syndrome
B. Excessive growth of aquatic plants
C. Dead fish
D. $\boxed{\text{Increased oxygen levels in rivers}}$