



- State the elements in NPK fertilisers
- Describe how the compounds and NPK fertilisers are produced
- Compare the industrial production of fertilisers with their production in a lab

Keyword	Definition
Batch process	A method of manufacture in which a substance is made in separate stages rather than continuously. Eg making a bottle of bleach at a time.
Continuous process	A method of manufacture in which a substance is made continuously. Eg making a continuous stream of bleach.
Fertiliser	Water soluble compounds added to soils to replace the minerals used by plants.
Yield	The amount of useful product you can get from something
Refining	The removal of impurities or unwanted elements from a substance.
Equilibrium	When the forwards and backwards reactions of a reversible reaction are occurring at the same rate. In a closed system the concentration of each compound would be constant.

Production of ammonia sulfate	Small scale (lab)	Large scale (industrial)
Starting materials	Ammonia solution and dilute sulfuric acid	Raw materials of ammonia and sulfuric acid
Stages	<ul style="list-style-type: none"> • Titration – methyl orange indicator, ammonia solution in flask, sulfuric acid in burette (see 'Acids' KO for method) • Crystallisation 	Several stages
Type of process	Batch	Continuous

Fertilisers

- Nitrogen, phosphorus and potassium (N, P, K) are the three essential elements in fertilisers.
- Plants absorb these elements from the soil gradually reducing their concentration.
- Without enough of these elements a plants growth and life process are negatively affected.
- Fertilisers add (or increase the amount of) these elements to a soil increasing crop yields as plants can grow faster and larger.
- Ammonia based fertilisers have advantages over traditional fertilisers such as manure. The composition of ammonia based fertilisers can be carefully controlled as well as the amount produced.

Ammonia based fertilisers

- Ammonia is used to produce nitrogen containing compounds that are used as fertilisers.
- Reacting ammonia with different chemicals will produce different fertilising compounds.
- Reactions of ammonia with water and oxygen are used to produce nitric acid (HNO₃) which is then used to produce a fertiliser.
- nitric acid + ammonia → ammonium nitrate (a fertiliser)

$$\text{HNO}_{3(aq)} + \text{NH}_{3(aq)} \rightarrow \text{NH}_4\text{NO}_{3(aq)}$$
- sulfuric acid + ammonia → ammonium sulfate

$$\text{H}_2\text{SO}_{4(aq)} + \text{NH}_{3(aq)} \rightarrow (\text{NH}_4)_2\text{SO}_{4(aq)}$$

Conditions of industrial manufacturing – (HIGHER ONLY)

- The aim of chemical industrial manufacturing is to produce a substance at an acceptable yield and timeframe in an economically viable way (ie a profit can be made).
- Conditions (temperature, pressure, presence of a catalyst) are controlled to balance costs, yields and rates of production.
- Higher temperatures and pressures generally cost more to maintain due to higher energy demands.
- The cost of extraction and refining of raw materials also impacts the economic viability of a process.

Predicting rate of reaching equilibrium – (HIGHER ONLY)

- Increasing the temperature and pressure (or concentration) of reactants increase the rate at which equilibrium is reached.
- Depending on the reaction being carried out these conditions could result in a higher or lower yield.
- A catalyst will increase the rate reaction (and so equilibrium will be reached faster) without affecting the yield or equilibrium point of a reaction.

Conditions of the Haber process

- The Haber process is used to produce ammonia industrially
 - $$\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)} + \text{heat}$$
- Higher pressures favour the forward reaction (4 moles of gas : 2)
- Lower temperatures favour the forwards reaction (forwards is exothermic) but slow the rate of reaction.
- The pressure is maintained at ~200 atmospheres – an acceptable compromise between costs and yield.
- Temperature is maintained at ~450 °C – an acceptable compromise between yield and rate of reaction.
- An iron catalyst is used to reach equilibrium faster.

Which elements make up NPK fertilisers?

What is the chemical formula for ammonia?

What is the fertiliser made from ammonia and phosphoric acid called?

What is the fertiliser made from ammonia and sulphuric acid called?

Why do plants need nitrogen?

Why can potassium salts be used directly instead of being converted into another product?
