

Fertilisers

What are fertilisers

- ▶ Fertilisers provide mineral ions needed for healthy growth in plants. As plants grow, they absorb mineral ions from the water in the soil through their root hair cells.
- ▶ Over time, the concentration of these ions decreases, so farmers and gardeners add fertilisers to the soil.

Nitrogen, phosphorus and potassium

- ▶ Fertilisers are formulations which may contain nitrogen, phosphorus and potassium compounds to promote plant growth.
- ▶ Fertilisers that supply all three elements are often called NPK fertilisers, after the chemical symbols for these three elements.
- ▶ Fertiliser compounds must be soluble in water so they can be absorbed by the root hair cells:
 1. ammonium ions, NH_4^+ , and nitrate ions, NO_3^- , are sources of soluble nitrogen
 2. phosphate ions, PO_4^{3-} , are a source of soluble phosphorus
 3. all common potassium compounds dissolve in water to produce potassium ions, K^+
- ▶ The table shows some examples of fertilisers, their formula and the essential elements they provide:

Fertiliser	Formula	Essential element(s)
Ammonium nitrate	NH_4NO_3	Nitrogen
Ammonium sulfate	$(\text{NH}_4)_2\text{SO}_4$	Nitrogen
Ammonium phosphate	$(\text{NH}_4)_3\text{PO}_4$	Nitrogen, phosphorus
Potassium nitrate	KNO_3	Potassium, nitrogen

The importance of ammonia in making fertilisers

- Ammonia (NH_3) is an alkali and when it is involved in neutralisation reactions, it produces the ammonium ion (NH_4^+) which is present in lots of fertilisers.
- However, ammonia can also be oxidised to make nitric acid (HNO_3), which is the source of the nitrate ion (NO_3^-).
- Ammonia can be neutralised by nitric acid, to make the salt ammonium nitrate (NH_4NO_3). This can be represented by the following equation:



- When this reaction takes place in aqueous solution, the reaction is more correctly represented by the following equation:

Ammonium hydroxide + nitric acid \rightarrow ammonium nitrate + water



Production of Fertilisers

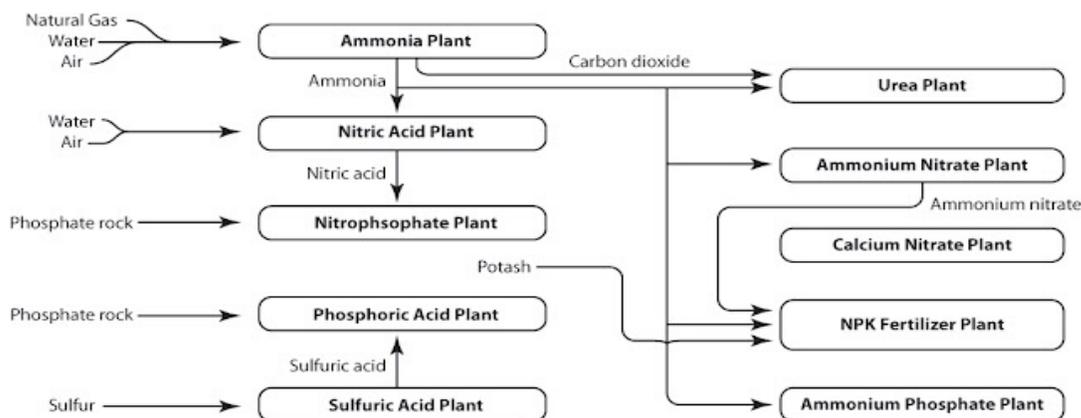
There are 2 methods

1. Industrial method
2. Laboratory method

Industrial production of Fertilisers

- The industrial routes to different fertilisers are shown in the flow diagram above. You can see what kinds of raw materials are required on the left of the chart and trace the kinds of fertilisers produced from them.

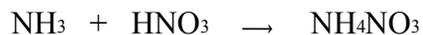
Nitrogen Fertilizer Production Routes



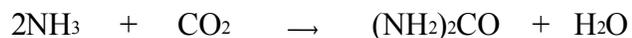
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- ▶ Some equations for the formation of fertilisers

① **Ammonium nitrate:**



② **Urea:**



③ **Ammonium phosphate:**



④ **Ammonium sulphate**



Production of fertilisers in laboratory:

- ▶ You can produce an ammonium fertilizer such as ammonium sulphate in the lab using the titration technique.



C10: Materials and Their properties

Procedure:

1. The dilute ammonia solution needs to be in a 250ml conical flask. Use a pipette to measure an accurate volume say 25ml.
2. Add a few drops of an acid base indicator such as methyl red to the ammonia.
3. Use a burette to add the dilute sulphuric acid to the ammonia solution until the end point has been reached and the methyl red is at its neutral orange colour. Methyl red turns yellow beyond the end point of the titration.
4. Record the volume of the ammonia used and the sulphuric acid used.
5. Repeat the titration adding the two volumes to each other again but **do not use the indicator**.
6. At the end point add a couple of extra drops of acid to ensure all the ammonia is neutralised.
7. The reaction should now be complete and you can take the final solution of ammonium sulphate and evaporate it slowly to obtain the colourless crystals of the ammonium salt.

Comparing the two methods

Factor	Industrial method	Laboratory method
Temperature	Different stages require temperatures between 60°C and 450°C	Room temperature for the neutralisation, then heating with a Bunsen burner to evaporate the water
Equipment and process	Very expensive chemical plant machinery, used in a continuous process	Cheap and versatile laboratory equipment, used in a batch process
Starting materials	Reactants are made from raw materials, eg sulfur, air, water	Reactants are purchased from a chemical supplier
Scale/yield	Huge quantities can be made quickly.	Small quantities are made slowly
Running costs	Automatic control mechanisms and machinery reduces the labour costs and running costs	The method is very labour-intensive, so running costs are high

Mining raw materials for fertilisers

- ▶ Minerals are extracted from the crust which can be used as fertilisers or as raw materials from which to make fertilisers.
 1. Potassium chloride and potassium sulfate can be used as fertilisers because they contain potassium ions.
 2. Phosphate rock cannot be used as a fertiliser because it is insoluble but it can be used to make fertilisers.

Phosphate rock contains phosphorus compounds. When it reacts with acids, useful soluble compounds are made:

Phosphate rock reacts with...	Compound(s) produced
Nitric acid	Calcium nitrate and phosphoric acid (which is neutralised with ammonia to make ammonium phosphate)
Sulfuric acid	Single superphosphate (a mixture of calcium sulfate and calcium phosphate)
Phosphoric acid	Triple superphosphate (calcium phosphate)