

FERTILIZERS

20 AUGUST 2013

Lesson Description

In this lesson we:

- Discuss the primary nutrients.
- Discuss the production of nitrogen containing fertilizers.
- Discuss the production of potassium and phosphorus containing fertilizers.
- Explain how to calculate the nutrient content in fertilizers using N:P:K ratios.
- Discuss the negative impact of nutrients on the environment.

Key Concepts

The Primary Nutrients

Plants need nutrients to grow healthily. Plants absorb these nutrients from the soil as salts dissolved in water. The primary nutrients needed for plant growth are Nitrogen, Phosphorus and Potassium (NPK). Nitrogen helps plants to have healthy stems and leaves. Plants use nitrogen produce proteins and vitamins. Plants make use of phosphorus for the development of roots and cell development. Phosphorus is used by plants to produce nucleic acids and proteins. Potassium helps the plants in the process of cell division and the uptake of nitrogen as a nutrient. Potassium assist the plants in the production of carbohydrates and during the processes of transpiration and respiration.

Once plants absorb the primary nutrients from the soil they need to be replaced. Farmers have used fertilisers to do this. Most fertiliser came from natural sources such as Guano (bird droppings) which is rich in Nitrogen and Phosphorus. Bone meal was also used as a naturally Phosphorus rich fertilizer. Animal manure and plant compost were also used as fertilizers as they contained small amounts of the primary nutrients.

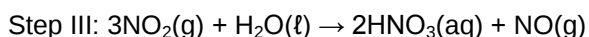
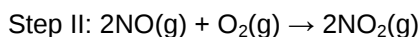
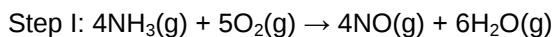
However, the rapid increase in human population over the last 100 years has led to an increase demand for food. Previously farmers provided for their families and neighbours. But now there is a need to improve farming method and produce much more food, by using more fertiliser. The demand for more fertilisers and better fertiliser has led to fertiliser being manufactured in chemical industries rather than using natural fertilisers.

Nitrogen containing Fertilizers

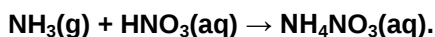
Nitrogen containing fertilizers are ammonium salts. These salts are mainly ammonium nitrates and ammonium sulphate. Plants absorb nitrogen containing fertilizers as nitrate or ammonium ions through the roots. The production of these salts is done through a number of processes:

1. Nitrogen is harvested from air which is 78% nitrogen per volume through fractional distillation. The air is liquefied and then heat up to allow gases to evaporate at different boiling points.
2. Nitrogen is the allowed to react with hydrogen through the Haber process to produce ammonia.

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3$$
3. Ammonia is reacted with oxygen to produce to produce nitrogen monoxide which is necessary for the production of Nitric Acid through the Ostwald process.

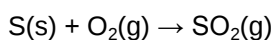


4. Ammonium nitrate is then produced by the reaction of ammonia and nitric acid as follows:

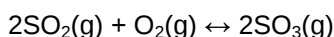


5. The production of ammonium sulphate involves the contact process where sulphuric acid is produced.

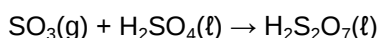
Step I: Sulphur burns in oxygen to form Sulphur Dioxide:



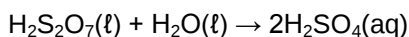
Step II: Sulphur dioxide reacts with oxygen in the presence of a contact catalyst being V_2O_5 or platinum. This is a reversible reaction so it can reach a state of chemical equilibrium if it is conducted in a closed system.



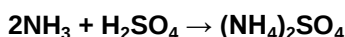
Step III: Sulphur trioxide is dissolved in sulphuric acid to form a highly concentrated form of the acid called oleum.



Step IV: The oleum is dissolved in water to produce sulphuric acid.



6. Ammonium sulphate is then produced as follows:



Phosphorus containing Fertilizers

The phosphorus containing fertilizers come from phosphate salts mined from places such as Phalaborwa in South Africa. The natural phosphate rock is insoluble in water and therefore not accessible to plants. The phosphate rock is then dissolved in sulphuric acid to form superphosphate that can be absorbed by plants.



Potassium containing Fertilizers

The potassium containing fertilizers used industrially in agriculture are potassium chloride, potassium sulphate and potassium nitrate. Potassium is not available in South Africa so it is imported from other countries.

NPK ratios and Percentage composition of primary nutrients

The nutrient quantities in fertilizer bags are determined by using the given ratios. For example, a bag of fertilizers can be marked as follows: 3:1:4 (26). The percentage composition of Nitrogen, Phosphorus and Potassium can then be calculated as follows:

$$\text{Total ratio} = 3 + 1 + 4 = 8$$

The (26) tell us that these nutrients make up 26% of any sample of this fertiliser

$$\%N = \frac{3}{8} \times 26 = 9.75\%$$

$$\%P = \frac{1}{8} \times 26 = 3.25\%$$

$$\%K = \frac{4}{8} \times 26 = 13\%$$

Environmental impact of artificial Fertilizers

The excessive use of artificial fertilizers leads to eutrophication. Rain leaches excessive fertilizers into rivers and dams causing the growth of algae to increase. When the algae dies and decomposes, it depletes the oxygen in the water. This leads to suffocation of aquatic animals such as fish and they eventually die. These areas are called dead zones.

Questions

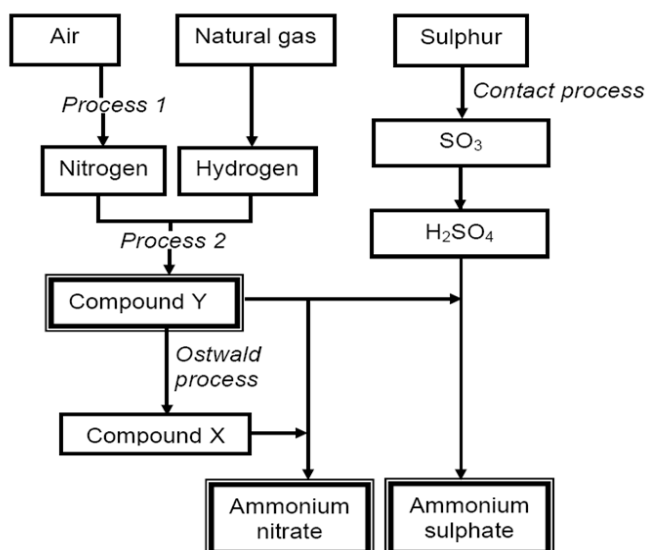
Question 1

What are the processes used to produce the following substances called?

- Nitrogen
- Ammonia
- Nitric acid
- Sulphuric acid

Question 2

Ammonia, ammonium nitrate and **ammonium sulphate** are three important nitrogen-containing fertilisers. The flow diagram below shows how these fertilisers are produced in industry.



Use the information in the flow diagram above and write down the following:

- a.) Name of Process 1
- b.) Balanced equation for Process 2
- c.) NAME or FORMULA of compound X
- d.) Balanced equation for the preparation of ammonium sulphate using sulphuric acid and compound Y
- e.) NAME or SYMBOL of the primary nutrient in ammonium sulphate
- f.) Write down ONE positive impact of fertilisers on humans.
- g.) Write down TWO negative impacts of the use of ammonium nitrate, as fertiliser, on humans.

Question 3

Fertilisers allow farmers to grow crops in the same soil year after year. However, environmental problems, such as eutrophication, are associated with the application of fertilisers.

- a.) State ONE PRECAUTION that a maize farmer can take to prevent eutrophication.
- b.) Nitric acid is an important reactant in the production of ammonium nitrate, a nitrogen-based fertiliser.
 - i. Write down the name of the industrial process for the production of nitric acid.
 - ii. Write down a balanced equation for the preparation of ammonium nitrate from nitric acid.