



Fertilisers and sustainability

Education in Chemistry

Sustainability in chemistry 2021

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
rsc.li/3sFPwsx

***'As the world population continues to grow, much more effort and innovation will be urgently needed in order to sustainably increase agricultural production.'*¹**

Sustainable agriculture means farming in ways that meet society's food needs for present and future generations. Simply put, it involves maintaining soil health, biodiversity and maximising crop yields. Fertilisers, both inorganic and organic, will play a part in successful sustainable food production.

This resource looks at the chemistry behind the use of urea as a fertiliser. Urea can be used as a nitrogen fertiliser manufactured in pellet form, or from an organic source with the addition of urine to the soil. In both cases the urea needs to be hydrolysed to give ammonia, which then needs to be converted into useful nitrogen compounds for healthy plant growth.

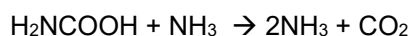
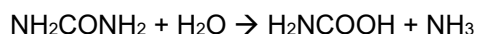
This resource supports the practical, **Rate of hydrolysis of urea**. Questions 1–3 assess your practical skill competencies. Question 4 tests your understanding of rates of reaction, order and mechanisms. The final set of questions asks you to apply your knowledge to look at the sustainability of fertiliser manufacture.

Questions on the practical

- Plan**
List the variables that need to be controlled when measuring reaction rates. How would you control those variables in this practical?
- Method: apparatus**
Justify your choice of apparatus for this practical.
- Method: hazards**
Using the CLEAPSS student Hazcards, or another appropriate source, assess the hazards associated with this practical and write a control measure to lower the risk for each hazard identified.
- Calculations and conclusions**
The rate at which you add the acid to neutralise the ammonia made, is a measure of the rate of hydrolysis of urea.
 - Plot a graph of the volume of $0.1 \text{ mol dm}^{-3} \text{ HCl(aq)}$ added/ cm^3 against time/minutes.
 - Using the graph, determine the initial rate of reaction. Add the correct units to your answer.
 - Using the graph, find 3 half-lives. Using these half-life values, deduce the order of reaction with respect to (wrt) urea.
 - The order wrt urea needs to be measured without any effect from the other reagents. Explain how the design of this reaction has helped.
 - This experiment was repeated with different concentrations of urea solution and the initial rate was calculated for each concentration. Using your answer to c), sketch a graph of concentration of urea against initial rate of reaction.

¹ UN Sustainable Development Goals Knowledge Platform <https://sustainabledevelopment.un.org/topics>

- f) Using the answer to c), identify the rate determining step in the mechanism below, and explain how you identified this step.



- g) Using your answer to f), write an expression for the rate equation for the hydrolysis of urea.

Fertiliser sustainability questions

Industrially made, inorganic soluble ammonium salts are an alternative to spreading organic manure (or urine) on fields as a fertiliser for food crops. They are bought as soluble pellets or crystals and can be added to the soil for immediate use. Urea can also be made as pellets in industrial quantities or added naturally as urine to crops. In both cases, it needs to be hydrolysed as shown in the **Rate of hydrolysis of urea** practical you have recently completed.

Seaweed is another organic fertiliser which can be added directly to the soil. Organic fertilisers also improve soil health.

1. List one advantage and one disadvantage of using: a) organic materials such as manure and seaweed and b) inorganic ammonium salts, as fertiliser.

You may need to look up information. Include a list of your sources.

2. a) Compare the Haber process with hydrolysis of urea and work out the atom economy for each. Why is atom economy important?



b) Efficient processes have high atom economies. State one way that the atom economy in the hydrolysis of urea might be increased.

3. Apart from atom economy, what other factors would you need to take into consideration if you wanted to compare the sustainability of an industrial process for making nitrogen-based fertilisers from ammonia, such as the Haber process, with the hydrolysis of urea?
4. Read [this article](https://bit.ly/3koJUzp) about the smelly seaweed on the beaches of Jersey in the Channel Islands (<https://bit.ly/3koJUzp>). The neighbouring island of Guernsey has the same seaweed species but does not suffer from a smelly seaweed problem. You are a scientist in the Jersey pollution laboratory. You have been asked to work out what the problem is and how to solve it.

Create a short half page report explaining what the problem is and suggesting how to solve it.