Rate of hydrolysis of urea

Student worksheet

Urea is not a fertiliser, but when it is hydrolysed in soil it produces ammonia and the nitrogen becomes available to plants. So the rate of urea hydrolysis is important.

The hydrolysis of urea results in the formation of two moles of ammonia and one of carbon dioxide, causing the pH of the mixture to rise as the reaction proceeds.

$$NH_2CONH_2 + H_2O \rightarrow CO_2 + 2NH_3$$

You can maintain the pH at a constant value by adding acid. The rate at which you have to add the acid is a measure of the rate of hydrolysis of urea.

A convenient source of urease is whole soya beans that you can buy from health food shops. They are extremely hard so you will have to use an electric coffee grinder or similar device to reduce them to powder.

Equipment and materials

- Electronic balance
- 25 cm^3 measuring cylinder
- 100 cm^3 conical flask
- Coffee grinder (or similar device)
- Buchner flask and funnel (or 50 cm^3 plastic syringe)
- 100 cm^3 beaker
- pH meter
- Magnetic stirrer
- Burette and burette clamp
- 2 cm^3 graduated pipette
- Dropping pipette (2)
- Cotton wool
- Whole soya beans
- 0.66 mol dm^{-3} urea solution
- 0.1 mol dm^{-3} hydrochloric acid
- 0.1 mol dm^{-3} sodium hydroxide solution

Method

Care: Wear eye protection. 0.1 mol dm^{-3} sodium hydroxide solution is an irritant.

1. Grind some whole soya beans to a powder using a coffee grinder or similar device.
2. Shake 2 g of the urease powder from the soya beans with about 20 cm^3 of deionised water in a 100 cm^3 conical flask for about a minute.
3. Filter the mixture by passing through damp cotton wool in a Buchner funnel or by passing through damp cotton wool in a 50 cm^3 or smaller plastic syringe. The resulting liquid may be cloudy. Use a measuring cylinder to put 10 cm^3 of the filtrate into a 100 cm^3 beaker.
4. Place the beaker on a magnetic stirrer and clamp a pH meter so that it dips into the solution without interfering with the stirrer bar. Add deionised water so the probe of the pH meter is covered. Adjust the pH of the solution to 6.5 by adding drops of 0.1 mol dm^{-3} hydrochloric acid or drops of 0.1 mol dm^{-3} sodium hydroxide solution.
5. Fill a burette with 0.1 mol dm^{-3} hydrochloric acid.
6. Use a 2 cm^3 graduated pipette to add 2.0 cm^3 of 0.66 mol dm^{-3} urea solution to the beaker and start a stop clock and the magnetic stirrer.
7. Monitor the pH of the urease extract/urea mixture by observing the pH meter. At convenient time intervals add acid from the burette to the beaker to bring the pH back to a value of 6.5.

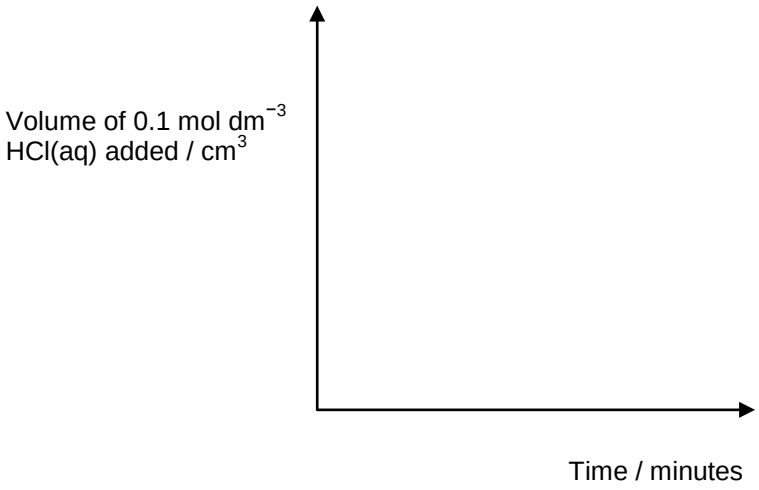
8. Record the time after adding urea to the urease extract and the total volume of acid added at the different times.

Time after urea was added to urease extract / minutes	Volume of 0.1 mol dm^{-3} HCl(aq) required to give pH 6.5 / cm^3	Total volume of 0.1 mol dm^{-3} HCl(aq) added / cm^3

Calculations and conclusions

The rate at which you add the acid is a measure of the rate of hydrolysis of urea.

1. Plot a graph of the volume of added acid against time.



2. Use the graph to determine the initial rate of reaction and the half lives of the reaction at different times.