Core practical 10: Rates of reaction

3.15 Core practical: Investigate the effect of changing the surface area of marble chips and of the concentration of hydrochloric acid on the rate of reaction between marble chips and dilute hydrochloric acid

Links to the specification content

3.9	describe experiments to investigate the effects of changes in surface area of a solid, concentration of a solution, temperature and the use of a catalyst on the rate of a reaction
3.10	describe the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas, temperature and the use of a catalyst on the rate of a reaction
3.11	explain the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas and temperature on the rate of a reaction in terms of particle collision theory

Introducing the practical

There are two investigations to carry out and they are likely to take a lesson each.

In investigation 1, students investigate the effect of changing the concentration of hydrochloric acid on the rate of reaction between hydrochloric acid and marble chips.

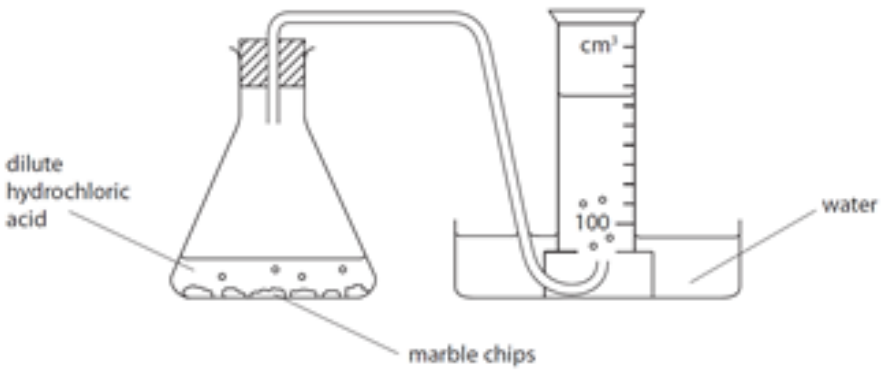
In investigation 2, students investigate the effect of changing the size of marble chips on the rate of reaction between hydrochloric acid and marble chips.

The volume of gas can be measured by collecting it in an upturned measuring cylinder over water or in a gas syringe. It would be helpful to demonstrate the method that the students do not use so they are familiar with both methods.

Students should plot appropriate graphs using their results, for example, volume of gas produced against time. They can then draw a tangent to the curve and calculate the gradient to determine the rate of reaction at a particular time.

Investigation 1

A typical set up for collection over water is shown in the diagram:



It is impossible to maintain an exactly constant surface area from one experiment to the next, but it can be partly controlled by taking the same mass of chips, the same number of the chips and similar size of chips in each case.

The exact concentrations of acid to use are best determined in advance by trial and error using the supply of marble chips at your disposal.

A good starting point would be 2mol/dm^3 and work downwards from there.

Investigation 2

In the investigation it is necessary to vary the surface area of the marble chips.

This can be done if you have access to marble chips of different size. Alternatively, you can start with large marble chips and hit them with a hammer (first wrap the chips in a towel) to produce smaller chips.

Once again, it is best to trial the experiments beforehand to determine the most effective concentration of hydrochloric acid to use. A concentration of 2mol/dm^3 often works well, providing times that are neither too long nor too short.

If the reaction in the first investigation has been followed by measuring the total volume of gas collected at set time intervals, it may be worthwhile to follow this reaction by measuring the time taken to collect a fixed volume of gas each time. The overall rate of reaction could then be calculated for each reaction by dividing the volume of gas collected by the time taken, giving typical units of say cm^3/s for the rate.

Additional investigations

1. Investigate the change in concentration of sodium thiosulfate on the rate of reaction between sodium thiosulfate and hydrochloric acid.
2. Investigate the effect of temperature of the rate of reaction between sodium thiosulfate and hydrochloric acid.

Rates of reaction

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What is the balanced equation for the reaction?
- What are the state symbols for the reactants and products?
- What is the best practical method to determine the rate of this reaction and why?
- What are two different methods of collecting and measuring the volume of gas produced?
- What is the biggest procedural error in this experiment?
- How could you reduce this procedural error?
- How do you decrease the size of the marble chips?
- What specific safety precaution should you take when decreasing the size of the marble chips?
- How does this affect the surface area of the marble chips?
- What effect does this have on the rate of reaction?
- How can you explain this effect from graphs of volume of gas plotted against time for two different sizes of marble chips?
- How can you calculate the rate of reaction from these graphs?
- What needs to be kept the same when you repeat the first experiment but use different size marble chips?
- How could you decrease the concentration of the hydrochloric acid?
- What effect will decreasing the concentration of hydrochloric acid have on the rate of reaction?
- How do you explain this effect in terms of particles and collisions?

Skills that are covered in the practical:

- Use appropriate apparatus to make and record measurements of mass, volume of solutions, time, temperature and volume of gas
- Use appropriate apparatus and techniques for monitoring chemical reactions, for example, a gas syringe or collecting gas over water in an upturned measuring cylinder
- Make and record observations and measurements of rate of reaction when a gas is produced
- Safe use and handling of hydrochloric acid and marble chips

Maths skills:

1A Use expressions in decimal form (eg when calculating gradients)

1B Use ratios (in balanced equations)

2A Use an appropriate number of significant figures (when calculating rate)

4A Translate information between graphical and numeric form

4C Plot two continuous variables from experimental data

4D Draw and use the slope of a tangent to a curve as a measure of rate of reaction