

MEASURING RATE

The rate of a chemical reaction can be found by measuring the quantity of a reactant used or the quantity of product formed over time:

$$\text{mean rate of reaction} = \frac{\text{quantity of reactant used}}{\text{time taken}}$$

$$\text{mean rate of reaction} = \frac{\text{quantity of product formed}}{\text{time taken}}$$

The quantity of reactant or product can be measured by the mass in grams or by a volume in cm³. Units of rate of reaction may be given as g/s or cm³/s.

INTERPRETING GRAPHS

Mean (average) rate of a reaction can be calculated from supplied data or from graphs- the steeper the gradient on the graph, the faster the rate of reaction

eg. if a reaction makes 40 cm³ gas in 60 seconds

$$\text{mean rate} = 40 \text{ cm}^3 \div 60 \text{ s} = 0.67 \text{ cm}^3/\text{s}$$



From the graphs shown here, reaction A is faster as the curve (and its gradient) is steeper. There is a greater increase in the amount of product over a shorter period of time.

RATE OF REACTION

For a reaction to take place, particles must collide, and they must collide with the required **ACTIVATION ENERGY**. This is the minimum energy needed for a reaction to take place.

Factors Affecting Rate (always explain using collision theory)

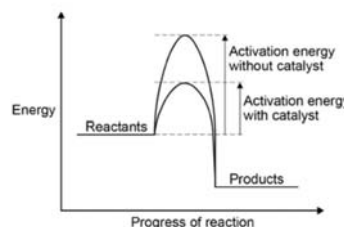
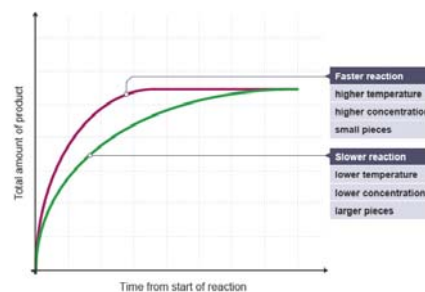
1. **Concentration** - more concentrated, more particles, more collisions

2. **Pressure** - more pressure (gases), particles closer together, more collisions

3. **Temperature** - higher temp, particles have more energy, particles move faster, more collisions (and harder ones - more likely to have activation energy)

4. **Surface Area** - smaller pieces, more surface area, more exposed particles, more collisions

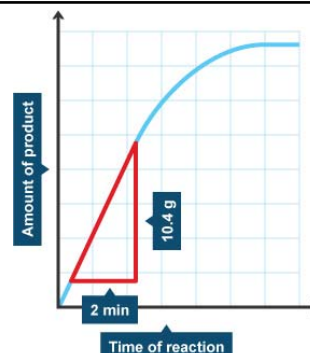
5. **Catalyst** - lowers activation energy, E_a , more collisions now have E_a



Extension Can you calculate the gradient of a tangent to the curve on these graphs as a measure of rate of reaction at a specific time

Gradient here would be:

$$10.4 \text{ g} \div 120 \text{ s} = 0.087 \text{ g/s} \quad (2 \text{ mins})$$



MAKE SURE YOU CAN:

Describe practically how to measure rate (see practical sheet on 'measuring rate')

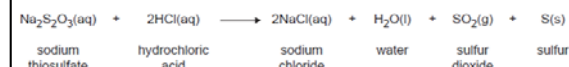
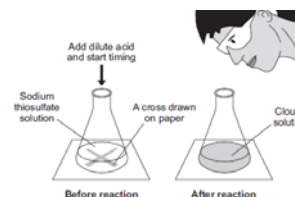
Calculate rate of reaction from supplied data or graphs

Explain, in terms of particles and collisions, how concentration, temperature, pressure, surface area and a catalyst affect rate of reaction, and why reactions slow down (*as particles get used up, so less collisions occur*)

Extension draw tangents and calculate rate from the gradient of the line/curve on a graph

TYPICAL EXAM QUESTION

Reaction takes place as shown here and is timed until the cross beneath the conical flask can no longer be seen.

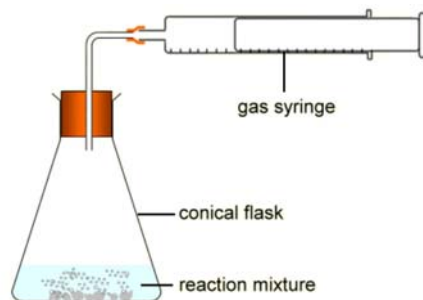
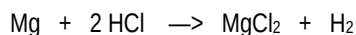


The student is investigating the effect of temperature on rate. Give two variables the student must control to make the investigation a fair test. *Any 2 from: vol thiosulfate, vol acid, conc of thiosulfate, conc. acid*

State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction. Explain this effect in terms of particles and collisions. *Rate increases, particles have more energy, move faster, more successful collisions (with E_a)*

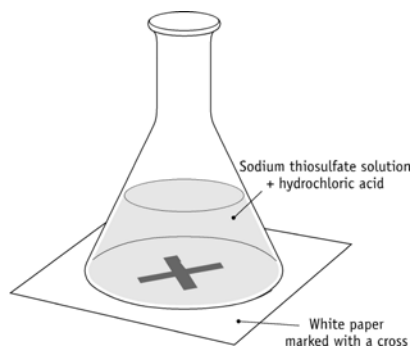
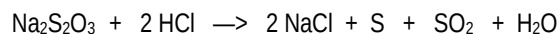
The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds. Calculate the rate of the reaction, stating the correct units. $0.32 \text{ g} / 64 \text{ s} = 0.005 \text{ g/s}$

Method 1 eg. Magnesium reacting with hydrochloric acid to make magnesium chloride and hydrogen, H₂



The **gas syringe** measures the volume of gas produced accurately. A **stopwatch** would also be needed to time the reaction. The volume of gas is recorded at regular timed intervals, eg. every 10 seconds.

Method 2 eg. a reaction between sodium thiosulfate and hydrochloric acid, that produces a cloudy precipitate of sulphur (S)



Reaction is timed from when the chemicals are mixed, until the point at which the cross is no longer visible below the conical flask. The faster the reaction, the less time it takes.

Rates of Reaction (PRACTICAL)

There are two main ways to investigate the rate of reaction.

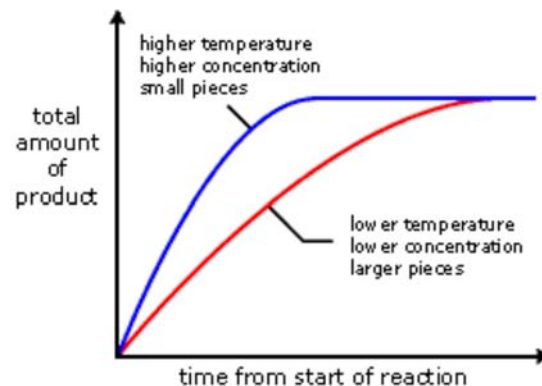
- 1) Measure how quickly a gas is being produced
- 2) How quickly a reaction gets to a fixed point (colour change)

In each case it is important to identify the independent, dependent and control variables.

To investigate the **effect of concentration of acid in method 1**

- Independent variable is concentration of acid
- Dependent variable is volume of gas
- Control variables would be volume of acid, mass of magnesium, surface area of magnesium, temperature

The results might be used to plot a graph:



The steeper the graph, the faster the reaction is going. It gradually slows down as particles get used up. This means less successful collisions are happening. The reaction stops when one of the reactants (the limiting factor) gets used up and the graph goes flat.

If investigating the **effect of temperature** using method 2, could you list the independent, dependent and 3 or 4 control variables?

MAKE SURE YOU CAN:

Describe the method needed to measure the rate for a particular reaction (if a gas is being made use method 1, if a colour change is happening use method 2), describing clearly what you will change (**independent**), how you will change it, what you will measure (**dependent**) and what you will keep the same to make it a fair test (**control variables**)

Talk about safety precautions, eg. dilute acids can be irritant or corrosive (wear goggles)

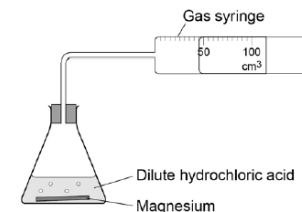
Name the apparatus used correctly

Explain why the independent variable affects the rate, using particles and collisions in your answer

Extension - use gradients on graph to determine rate

TYPICAL EXAM QUESTION

A student investigated the rate of reaction between magnesium and hydrochloric acid using the apparatus below to collect the gas produced.



Outline a plan to investigate how the rate of reaction changed when the concentration of the hydrochloric acid was changed.

- Describe how you would do the investigation and the measurements you would make
- Describe how you would make it a fair test

You do not need to write about safety precautions 6 marks