Summary Sheet Year 9 Rate of Reaction

Measuring Rate

Remember that reactants → products

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

$$\text{rate} = \frac{\text{change (in cm}^3\text{ or g)}}{\text{time (s)}}$$

The amount can be measured by the change in mass in grams or by a volume in cm^3.

Units of rate of reaction may be given as **g/s** (change in mass divided by time) or **cm^3/s** (change in volume divided by time)

Eg.1 If $25cm^3$ of gas is made in 10 seconds, rate = $25cm^3/10s$ = **2.5 cm^3/s**

Eg.2 If 7g of metal dissolves in 1 minute 20 seconds (convert to 80 seconds), rate = 7g/80s = **0.0875 g/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 cm^3 gas in 60 seconds

mean rate = 40 cm^3 ÷ 60 s = **0.67 cm^3/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.

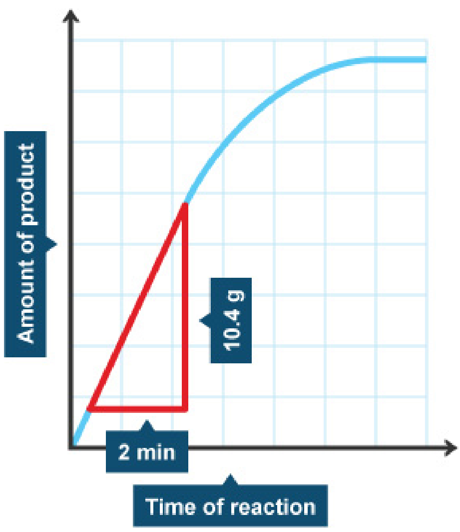
Extension – Using gradients to find rate

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?

Remember that 2 minutes = 120 seconds

Gradient here would be:

10.4 g ÷ 120 s = **0.087 g/s**



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Collision Theory

Rate of reaction can be explained using the idea of **particles** and **collisions**.

For a reaction to take place:

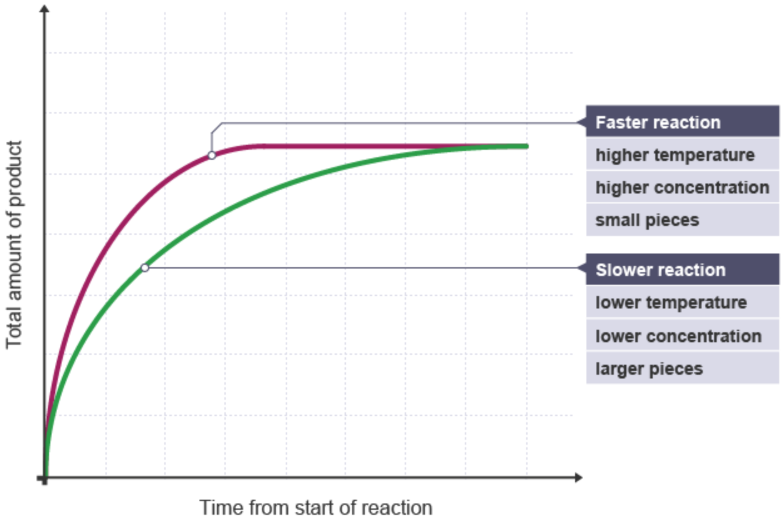
- particles must collide
- and they must collide with the required **ACTIVATION ENERGY (E_a)**

The activation energy, E_a, is the **minimum energy** needed for a reaction to take place.
The **more frequent collisions** between particles taking place, the **faster** the reaction.

Reactions are always fastest at the beginning, when there are more reactant particles present, so more frequent collisions occur.

Reactions always slow down as particles get used up.

<u>**FACTORS AFFECTING RATE**</u> (always explain using collision theory)



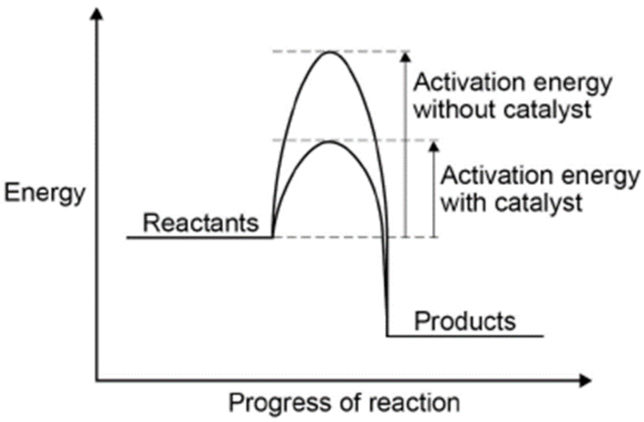
1. **Concentration**
   - more concentrated
   - more particles
   - more frequent collisions

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

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

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

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



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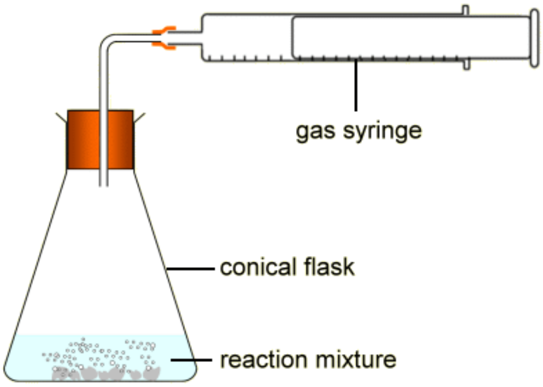
Rate of Reaction Practical Work

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

Method 1 eg. magnesium reacting with hydrochloric acid to make magnesium chloride and hydrogen, H_2

$$Mg_{(s)} + 2\,HCl_{(aq)} \longrightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$



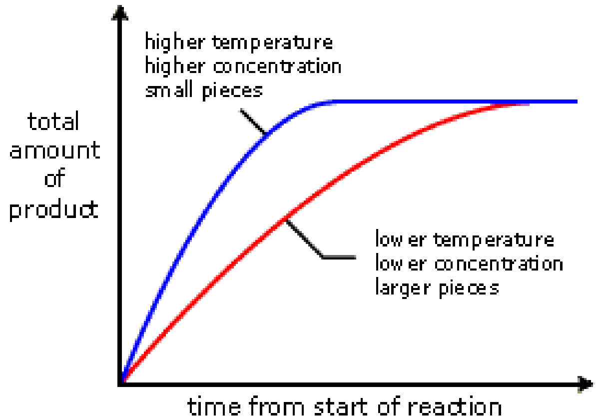
The **gas syringe** measures the volume of gas produced accurately.

A **stopwatch** would also be needed to time the reaction.

The volume of gas is recorded at regular timed intervals, eg. every 10 seconds.

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

- **I**ndependent variable = concentration of acid (what **I** changed)
- Dependent variable = volume of gas (what was measured)
- Control variables (what we keep the same) would be:
  - volume of acid (use a measuring cylinder)
  - mass of magnesium (use a balance)
  - surface area of magnesium
  - temperature



The results might be used to plot a graph.

The **steeper** the graph, the **faster** the reaction.

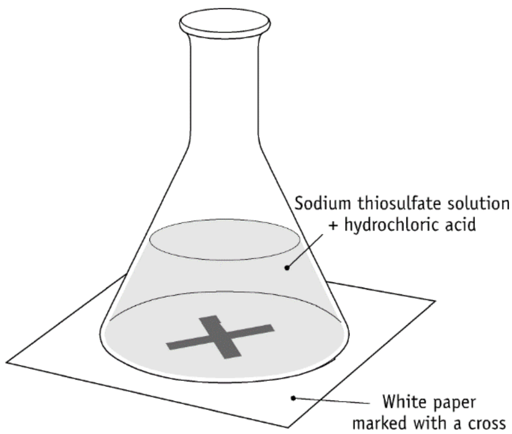
It gradually **slows down as particles get used up**.

This means **less frequent collisions** are happening.

The reaction **stops** when one of the **reactants** (the limiting factor) gets **used up** and the **graph goes flat**.

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

$$Na_2S_2O_{3\,(aq)} + 2\,HCl_{(aq)} \longrightarrow 2\,NaCl_{(aq)} + S_{(s)} + SO_{2\,(g)} + H_2O_{(l)}$$



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 cross eventually disappears as enough **sulfur** is formed, which is a **solid** so blocks out the cross.

The **faster the reaction, the less time it takes**.

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