Summary Sheet Year 9 Rate of Reaction:

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:

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

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

The quantity of reactant or product can be measured by the mass in grams or by a volume in cm^3.

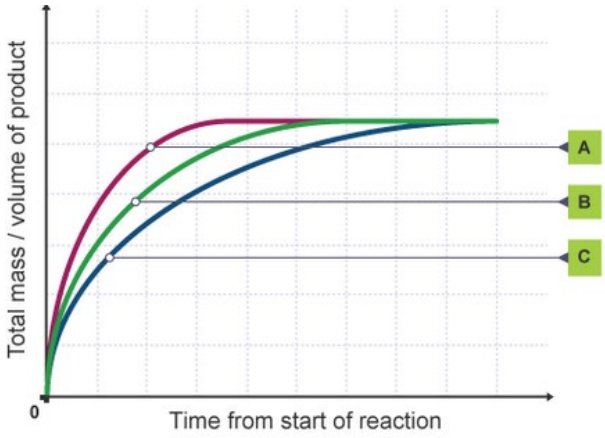
Units of rate of reaction may be given as **g/s** (change in mass divided by time) or **cm^3/s** (change in volume divided by time)

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.

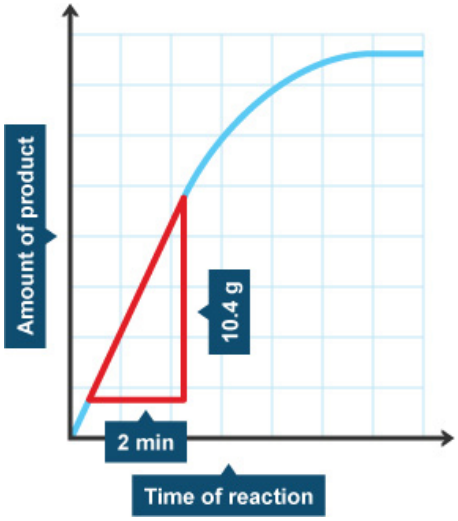
Extension – Using gradients to find rate

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**



Summary Sheet Year 9 Rate of Reaction:

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.

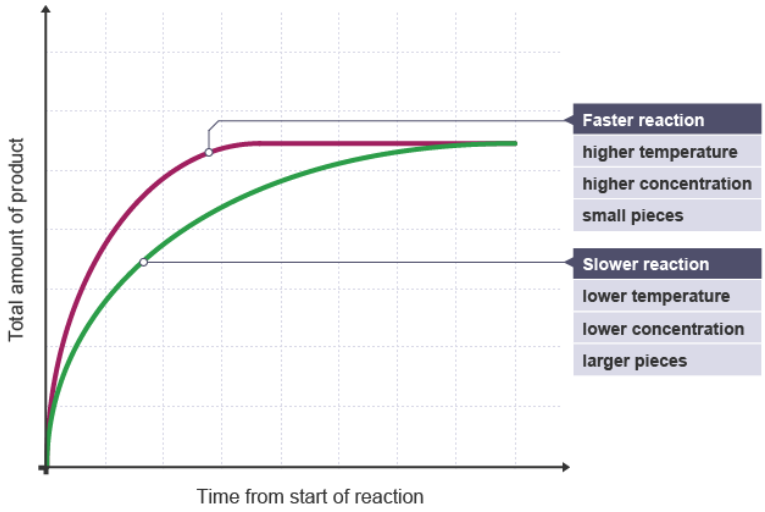
Reactions are always fastest at the beginning, as that is when there are more reactant particles present, so more frequent collisions occur.

Reactions always slow down as particles get used up.

FACTORS AFFECTING RATE (always explain using collision theory)

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

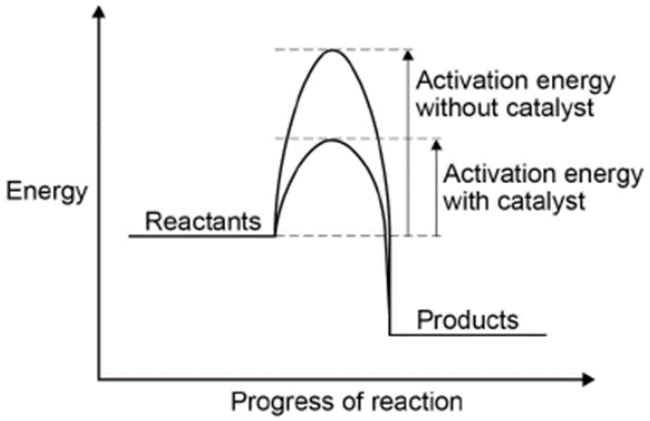
2. **Pressure**
   - more pressure (gases)
   - particles closer together
   - more frequent collisions



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



Summary Sheet Year 9 Rate of Reaction:

INVESTIGATING RATE USING PRACTICAL WORK

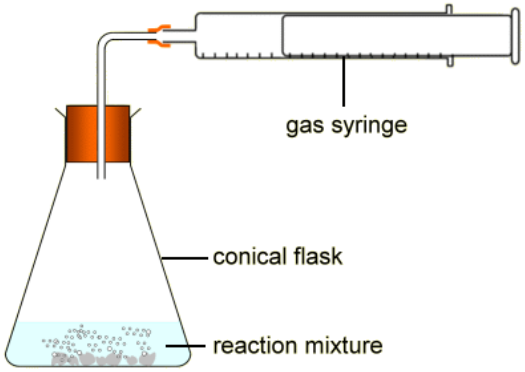
There are two main ways to investigate the rate of reaction.

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

It is important to identify the independent, dependent and control variables.

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

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



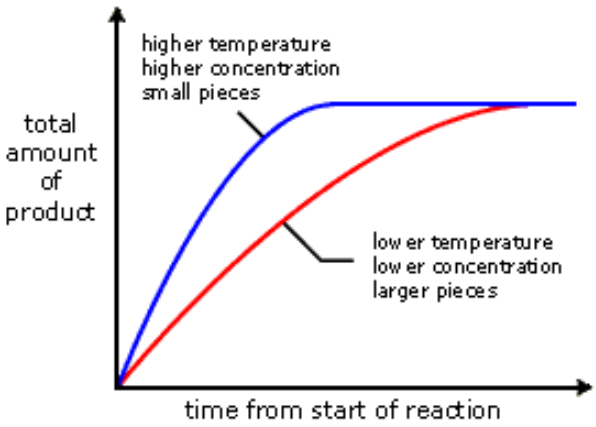
The **gas syringe** measures the volume of gas produced accurately.

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**

- Independent variable is concentration of acid (what I changed)
- Dependent variable is volume of gas (what was measured)
- Control variables (what we keep the same) 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.

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** or runs out and the **graph goes flat**.

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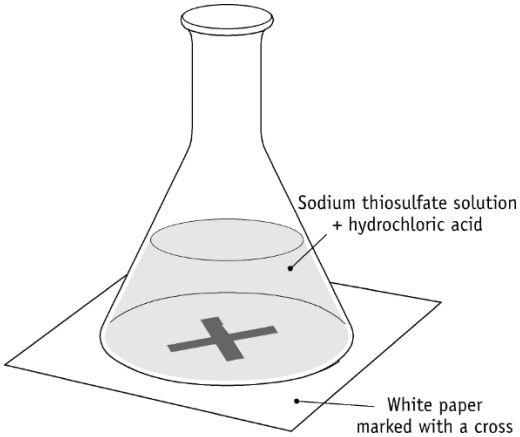
Method 2 eg. a reaction between sodium thiosulfate and hydrochloric acid, that produces a cloudy precipitate of sulfur (S)

$Na_2S_2O_3$ (aq) + 2 HCl (aq) —> 2 NaCl (aq) + S (s) + SO_2 (g) + H_2O (l)



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

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**.

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 frequent collisions occur)*

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