GCSE C6 – Rate & Extent of Chemical Change

science chemistry

1) What is rate?

The mean rate of reaction is defined as:

$$\frac{\text{the amount of product formed (or reactant used)}}{\text{time}}$$

Units

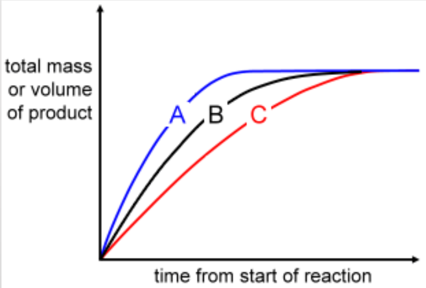
g/s (grams per seconds) or cm^3/s

(HT students also mols/s)

2) How rate changes

In a graph below, the steeper the gradient the faster the reaction (in the graph below A is fastest, C is slowest). When the reaction graph levels out, the reaction has stopped.

- Most reactions are fastest at the start as there are more reactant particles to react with.



- To calculate the rate from a graph we can calculate the gradient of a straight line (see reverse)
- If the graph shows a curve, we can draw a tangent to the curve and calculate the gradient of this **(HT only).**

3) Factors affecting rate

- Temperature
- Concentration of reactants in solution
- Pressure of gases
- Surface area of solid reactants
- Use of a catalyst

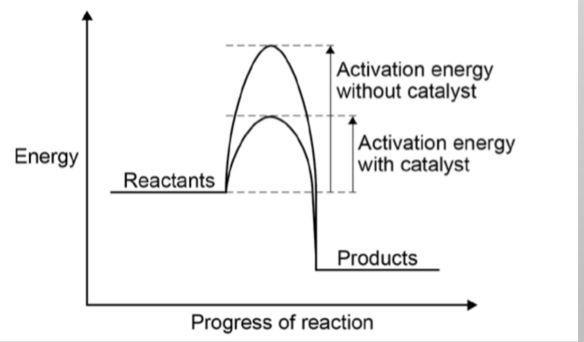
4) Collision Theory

Chemical reactions can occur only when reacting particles collide with each other AND with sufficient energy. So reaction rate depends on collision energy and collision frequency.

The minimum amount of energy that particles must have to react is called **the activation energy**.

- **Increasing temperature** increases rate as the particles have more kinetic energy so move around more quickly so they collide more frequently. Higher temperature means that the particles collide with more energy so more of the collisions are successful collisions (every 10°C increase ≈ double rate).
- **Increasing concentration** of a solution increases rate as there are more particles in a given volume, so the reactant particles collide more frequently so the rate increases (double conc ≈ double rate).
- **Increasing the surface area** of a solid means that the other reactant particles collide with the solid more frequently so the reaction rate increases (powders react faster than solid lumps).
- **A catalyst** is a substance that speeds up the rate of a reaction without being used up. Catalysts increase the rate of reaction by providing a different pathway for the reaction with a lower activation energy.

A reaction profile for a catalysed reaction can be drawn in the following form:



5) Reversible reactions and dynamic equilibrium

Reversible reactions can go forwards and backwards (i.e. products can turn back in reactants).

This symbol ⇌ is used to show a reversible reaction.

If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction.

When the forward reaction occurs at the same rate as the reverse reaction we say the reaction is in dynamic equilibrium (at this point concentrations of reactants and products do not change). There is no loss or gain of reactants or products to or from the surroundings (closed system).

When a reversible reaction reaches equilibrium, the relative amounts of all the reactants and products depend on the conditions of the reaction and these can be changed.

e.g. Ammonium chloride ⇌ ammonia + hydrogen chloride

Heating the reaction shifts the reaction to the left, cooling it shifts it to the right.

6) Changing conditions & Le Chatelier's Principle (HT ONLY)

If a reaction is at equilibrium and a change is made to any of the conditions, then the reaction responds to counteract the change (Le Chatelier's Principle). This can be used to predict the effects of changing reaction conditions.

- If the temperature is raised, the amount of products from the endothermic reaction increases (i.e. increasing the temperature shifts the reaction towards the endothermic reaction).
- In gaseous reactions, an increase in pressure causes the equilibrium position to shift towards the side with the smallest number of molecules as shown by the symbol equation for that reaction.
- If the concentration of a reactant is increased, more products will be formed until equilibrium is reached again.

Factors that affect rate also need to be thought about which is why sometimes a compromise in conditions needs to be used.

7) Effect of catalysts on position of equilibrium (HT ONLY)

Catalysts have no effect on the position of equilibrium (since they increase the rate of both sides of a reversible reaction).

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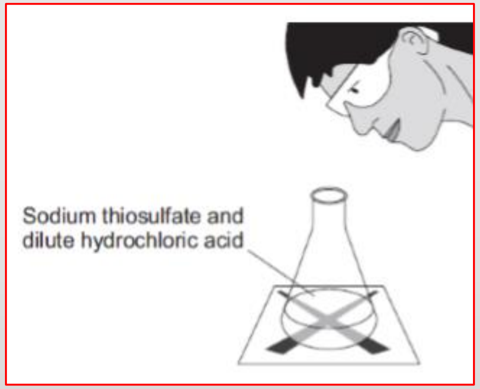
8) Required Practical – measuring rate by two methods

Investigate how changes in concentration affect the rate of reaction by a method involving a change in colour or turbidity (cloudiness).

- Used for reactions that produce a solid which appears in the flask which makes the solution cloudy

Variables

- Independent – Concentration of one of the reactants
- Dependent – time taken for cross to disappear
- Controls – temperature, mass of solid reactants, volumes of liquid reactants, same thickness of the cross.



9) Required Practical 2 – measuring rate

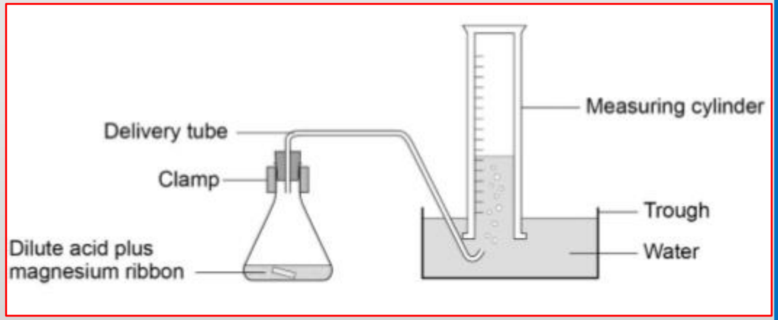
Investigate how changes in concentration affect the rate of reaction by a method involving measuring the volume of a gas produced.

- For reactions that produce gases
- Measuring volumes of gas in a measuring cylinder or gas syringe is more accurate than a simple test tube.

Variables

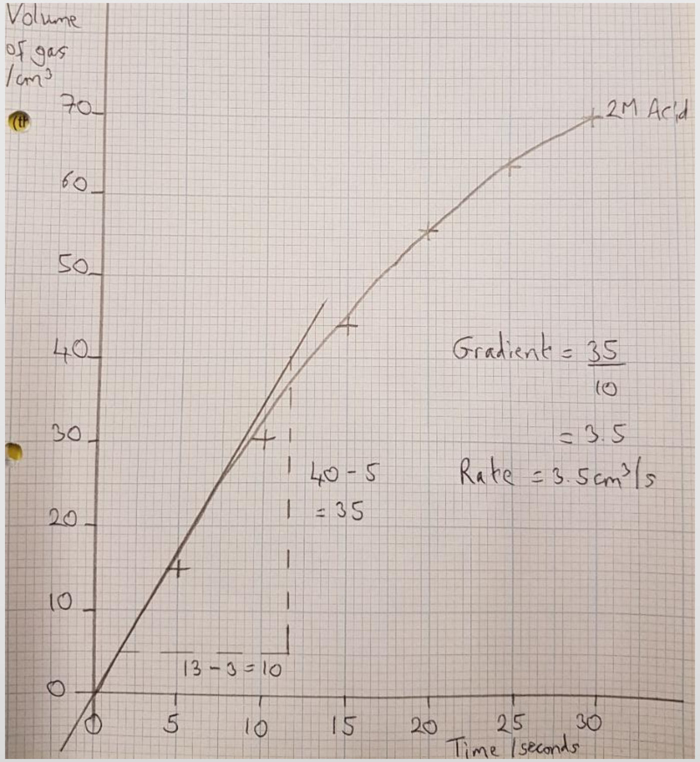
- Independent – Concentration of one of the reactants
- Dependent – volume of gas produced in a given time
- Controls – temperature, mass of solid reactants, volume of liquid reactants, surface area of solid reactants.

- Repeat the experiment with different concentrations of acid.



10) Calculating gradients / drawing tangents

We calculate gradients by measuring $\frac{dy}{dx}$ or $\frac{rise}{run}$



If the line is curved and not straight we can draw a tangent on the curve and calculate the gradient of the tangent.
Calculating the gradient of a tangent is HT but all students are expected to be able to draw a tangent

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