# The rate and extent of chemical change

Yellow background corresponds to **A** in the take 5 tracker
Purple background corresponds to **B** in the take 5 tracker

| Keyword | Definition |
|---|---|
| Rate of Reaction | A measure of how quickly a reactant is used up, or a product is formed |
| Tangent | A straight line that touches but does not cross through a curve. |
| Collision Theory | The theory that chemical reactions require reactant particles to collide with enough energy to react |
| Activation Energy | The minimum energy that colliding particles must have for a reaction to occur |
| Concentration | A measure of how much of a substance is dissolved in a solution. |
| Surface Area to volume ratio | A measure of the exposed area of a substance compared to the volume of the substance |
| Volume | The amount of 3D space an object takes up |
| Catalyst | A substance that speeds up a reaction without changing the products or being used up |
| Turbidity | How cloudy a liquid appears due to tiny suspended particles |
| Reversible Reaction | A chemical reaction which can go both ways. Represented by the ⇌ symbol |
| Equilibrium | A reaction in a closed system in which the forward reaction has the same rate as the reverse reaction. |
| Le Chatelier's Principle | An idea that explains how the position of equilibrium can be changed by changing pressure, concentration or temperature. |
| Closed System | A reaction in which nothing is allowed to enter or leave the reaction container. |

## Ra01: Rate of Reaction

The rate of a chemical reaction is either:
- How quickly a reactant is used up
- How quickly a product is formed

It can be calculated using the following equations:

$$mean\ rate\ of\ reaction = quantity\ of\ reactant\ used \div time\ taken$$

...or...

$$mean\ rate\ of\ reaction = quantity\ of\ product\ formed \div time\ taken$$

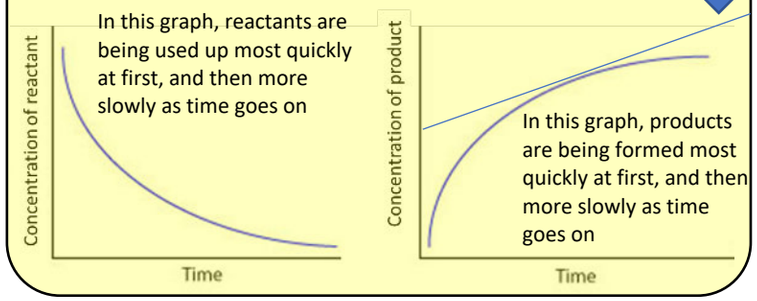
The quantity of reactants or products can be measured using grams, in $cm^3$, or in moles.

Therefore, rate can be measured in g/s, $cm^3$ /s or mol/s

## Ra01: Rate Graphs

Graphs can be used to show how rate changes over time – the steeper the graph, the higher the rate.

The gradient of a tangent to the graph at any point is equal to the rate of reaction at that point. An example of a tangent to a graph is shown:




## Required Practical:

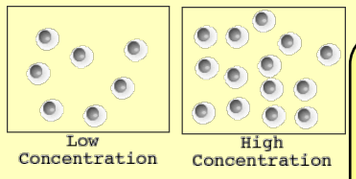
*Ra06 – Observing changes in appearance*
*Ra07 – measuring volume of gas produced*

## Mathematical Skills

*Be prepared to:*
- *Recognise and use expressions in decimal form*
- *Use ratios, fractions and percentages*
- *Estimate the results of simple calculations*
- *Translate information between graphs and numbers*
- *Draw and interpret graphs to determine rate of reaction*
- *Plot graphs using provided data*
- *Determine the gradient and intercept of linear graphs*
- *Use the gradient of a tangent to a curve to measure rate of change*
- *Calculate areas of triangles and rectangles*
- *Calculate surface areas and volumes of cubes*

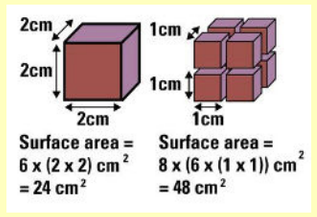
## Ra04: Concentration/Pressure

- Increasing the concentration of a reactant solution or the pressure of a reacting gas increases the rate of a reaction.
- This is because reactant particles are closer together, and so collide with each other more often.



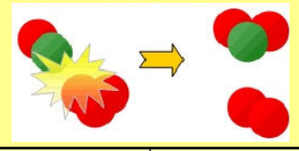

## Ra02: Surface Area

- Breaking lumps of a solid reactant into smaller pieces exposes more of the reactant – the overall volume stays the same.
- This increases the surface area-to-volume ratio
- The 2 diagrams below show the same volume but with a different surface area



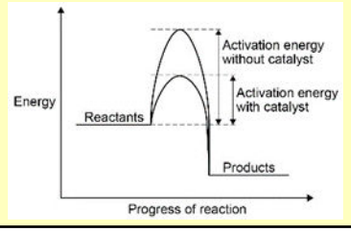

## Ra02: Factors affecting reaction rate

To increase or decrease the rate of a reaction, we consider collision theory. This states that for reactions to occur, the reacting particles must collide with enough energy for a reaction to take place. The more collisions there are with sufficient energy, the faster the reaction.



## Ra05: Catalysts

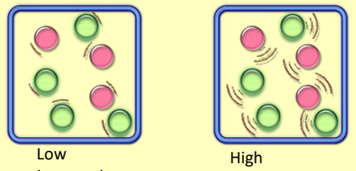
- Catalysts change the rate of a chemical reaction but are not used up.
- Different reactions need different catalysts
- In biology, enzymes act as catalysts
- Catalysts work by providing an alternate pathway for the reaction with a lower activation energy.




## Ra03: Temperature

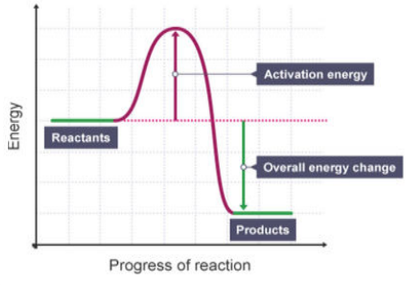
Increasing the temperature of a reaction has 2 effects:
- Increases the frequency of collisions
- Increases the energy of the collisions

Therefore at higher temperatures, there are more collisions that have enough energy for a reaction to take place




## Recap: Energy profiles

- Activation energy: difference between reactants and the peak of the curve
- Overall energy change – difference between reactants and products




## Ra08/Ra09: Reversible Reactions

These are reactions in which the products of the reaction can react to make the original reactants:

$$A + B \rightleftharpoons C + D$$

If a reversible reaction is exothermic in one direction then the other direction will be endothermic. The energy transfer will be exactly the same in each case.

When the reaction going forward and the reaction going backward have the same rate, the reaction is at equilibrium. At equilibrium, the concentration of the reactants and products does not change.

Equilibrium can only happen in a closed system.

## Ra10: Altering conditions– HT only

If a reversible reaction is at equilibrium and a change is made to the conditions, the reaction system responds to counteract the change.

**Exothermic**

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

**Endothermic**

For example:
- If the concentration of a reactant is increased, more products will be formed to remove the reactant and re-establish equilibrium

If pressure is increased, the system changes to reduce the pressure.
- In the equation on the left, increasing the pressure moves the equilibrium to the right because this side has fewer molecules

If temperature is increased, the system changes to reduce the temperature
- In the example on the left, increasing the temperature moves the equilibrium to the left because the left reaction is endothermic

## Linked Modules:

- Atomic Structure
- Energy Changes
- Chemical Changes
- Organic Chemistry
- Using Resources

## Useful YouTube links: