CAIE IGCSE Chemistry

6.2 Rate of reaction

Notes

Describe the effect on the rate of reaction of:

The rate of reaction is the time taken for a reactant to be used up or a product to be formed

(a) Changing the concentration of solutions

- Increasing the concentration of reacting solutions -> increases rate of reaction
- Decreasing the concentration of reacting solutions -> decreases rate of reaction

(b) Changing the pressure of gases

- Increasing the pressure of a reacting gas -> increases rate of reaction
- Decreasing the pressure of a reacting gas -> decreases rate of reaction

(c) Changing the surface area of solids

- Increasing the surface area of a solid -> increases rate of reaction
- Decreasing the surface area of a solid -> decreases rate of reaction
- E.g. 5g of a fine powder of a compound will have a faster reaction rate than 5g of a lump of the same compound

(d) Changing the temperature

- Increasing the temperature -> increases rate of reaction
- Decreasing the temperature -> decreases rate of reaction

(e) Adding or removing a catalyst, including enzymes

- Adding a catalyst increases the rate of reaction
- The removal of a catalyst will slow down the rate
- Biological catalysts are known as enzymes

State that…

- A catalyst increases the rate of a reaction and is unchanged (not used up) at the end of a reaction
- The addition of a catalyst to a reaction won't affect the products formed

Describe practical methods for investigating the rate of a reaction including change in mass of a reactant or a product and the formation of a gas

- Rates of reactions can be measured using the mass of reactant used, or mass of product or volume of gas formed over time:

$$\text{Rate of reaction} = \frac{\text{mass of reactant used}}{\text{Time}}$$

$$\text{Rate of reaction} = \frac{\text{mass of product formed}}{\text{Time}}$$

$$\text{Rate of reaction} = \frac{\text{volume of gas formed}}{\text{Time}}$$

  - The unit for mass of reactant or product is grams (g)
  - The unit for volume of gas formed is cm^3
  - The unit for time is usually seconds (s)
  - So the units for rate of reaction may be given as g/s or cm^3/s

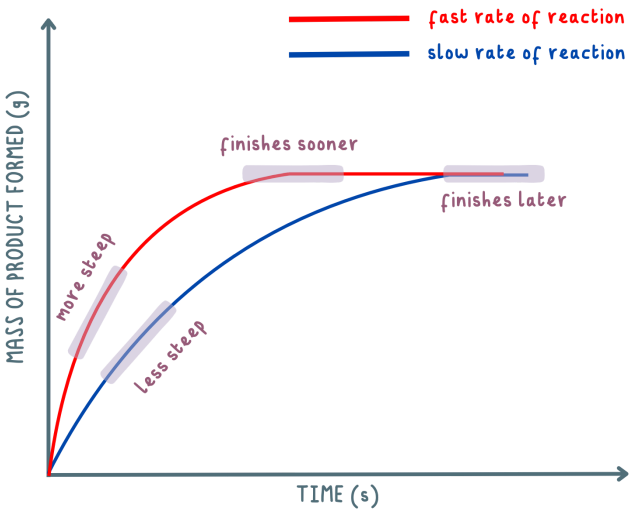
- Planning the investigation of the rate of reaction to compare the effect of changes in surface area/particle size, concentration, temperature, use of a catalyst etc:
  Begin by stating/identifying the:
  - Independent variable: The factor being changed, e.g temperature at regular intervals 0°C, 10°C, 20°C, 30°C, 40 °C.
  - Dependent variable: The variable being measured, e.g. the mass of product formed.
  - Controlled variables: Every factor that could affect the rate of reaction besides the independent variable, e.g. concentration, surface area, catalyst.

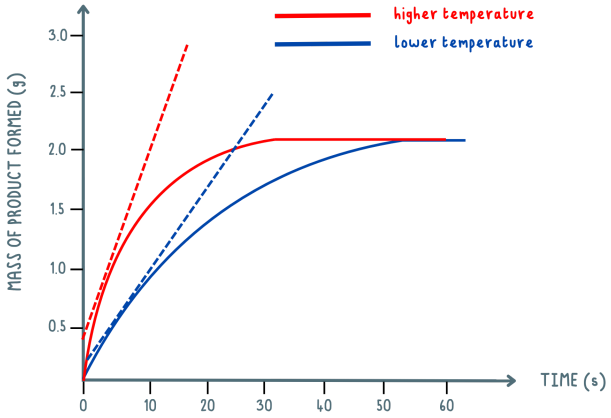
  Think about what apparatus is involved:
  - Measuring balance- Measure the mass of reactant used/product formed
  - Stopwatch- Measure time taken in seconds
  - Gas syringe- Collects and measures the volume of gas formed
  - Thermometer- Measures the temperature
  - Beaker- Measure rate of reaction when precipitate is formed: Mark a cross at the bottom of a beaker containing a reactant. Add the other reactant and time how long it takes for cross to not be visible

  Record and analyse the results:
  - Record the results as you go along in a table, e.g. record the volumes of gas formed at 0°C, 10°C, 20°C, 30°C, 40 °C
  - Calculate the rate of reaction for each result using the formula above
  - Plot the data on a graph to compare the rate of reaction at the different temperatures

Interpret data, including graphs, from rate of reaction experiments

- Graphs showing the rate of reaction will have the mass/volume of product formed (g or cm ^{3}) on the y-axis and time taken (s or min) on the x-axis
- The faster rate of reaction will begin with a steeper line and become horizontal sooner than a slower rate of reaction
- Once the line becomes horizontal, this indicates that all the products have been formed, so the reaction is complete



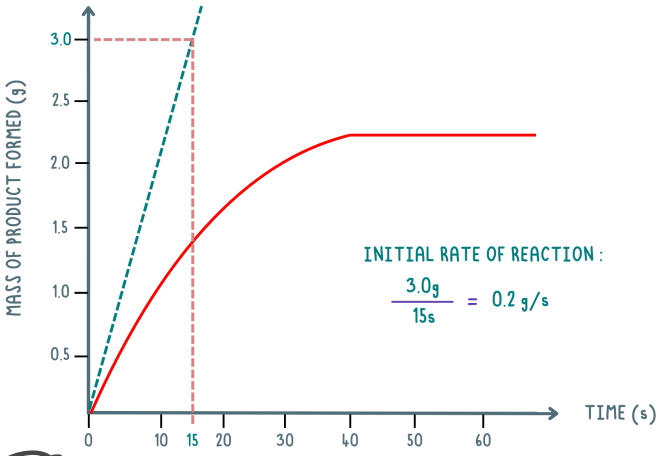


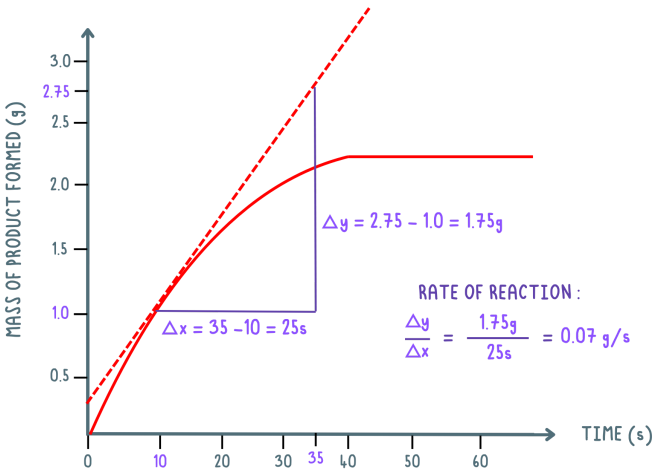
- To calculate the rate of reaction at the start of a reaction or at a specific time, a tangent is drawn:
- A tangent is a straight line that touches the curved line at a specific point
- E.g. A tangent has been drawn approximately at 5s for both reactions
- By looking at the steepness of the tangents we can see that the rate of reaction for higher temperature is greater(steeper) than the lower temperature.

- To calculate the initial rate of reaction:
- Draw the tangent at time= 0s
- Calculate the gradient of the tangent:

Rate of reaction =

$$\frac{\text{Change in mass of product}}{\text{Time}} = \frac{\Delta y}{\Delta x}$$





- To calculate the rate of reaction at a certain time:
- Draw the tangent at the time specified and calculate the gradient

Rate of reaction =

Change in mass of product / Time = Δ y / Δ x

- Δ means change in

E.g. Calculate the rate of reaction at 10s for the reaction on the graph on the left

(Extended only) Describe collision theory …

- For a chemical reaction to happen, the reactant particles must collide successfully with each other and
- There must be enough energy for the collision to occur successfully, this is known as the **activation energy E_a**
- Increasing the **kinetic energy of the particles** (by increasing the temperature) and increasing the **number of particles per unit volume**(by increasing the concentration of solutions or pressure of gas) means that there will be more frequent collisions between the particles
- The **more frequent successful collisions** between the reactant particles, the **faster the rate of reaction**.

(Extended only) Describe and explain the effect on the rate of reaction of:

(a) Changing the concentration of solutions

- Increasing the concentration of reacting solutions -> more reactant particles in the same volume -> more frequent collisions between the reactant particles -> increases rate of reaction
- Decreasing the concentration of reacting solutions -> fewer reactant particles in the same volume -> less frequent collisions between reactant particles -> decreases rate of reaction

(b) Changing the pressure of gases

- Increasing the pressure of a reacting gas -> more reactant particles in the same volume -> more frequent collisions between the reactant particles -> increases rate of reaction
- Decreasing the pressure of a reacting gas -> fewer reactant particles in the same volume -> less frequent collisions between the reactant particles -> decreases rate of reaction

(c) Changing the surface area of solids

- A fine powder of a solid will have a greater surface area to volume ratio than a lump of the same substance, even though both are in the same mass/volume, the fine powder will have more of its particles exposed on the surface.
- Increasing the surface area of a solid -> exposes more reactant particles at surface -> more frequent collisions between reactant particles -> increases rate of reaction
- Decreasing the surface area of a solid -> exposes less reactant particles at surface -> less frequent collisions between reactant particles -> decreases rate of reaction

(d) Changing the temperature

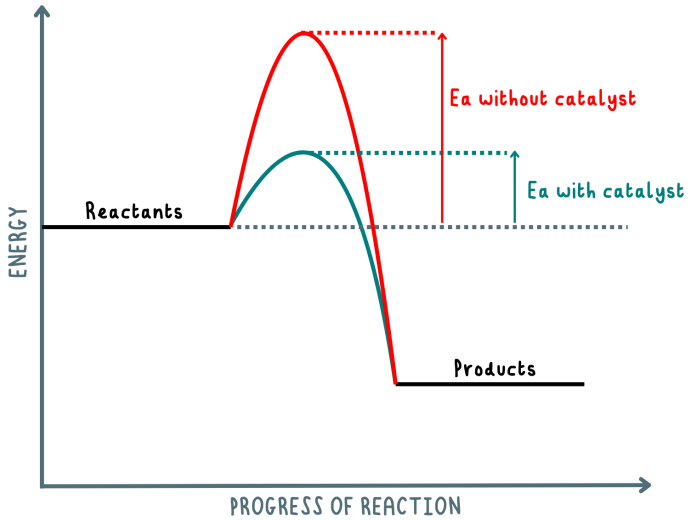
- Increasing the temperature -> more kinetic energy in the reactant particles (move more quickly) -> more frequent collisions between the reactant particles -> increases rate of reaction
- Decreasing the temperature -> less kinetic energy in the reactant particles (move more slowly) -> less frequent collisions between the reactant particles -> decreases rate of reaction

(e) Adding or removing a catalyst, including enzymes using collision theory

- Adding a catalyst increases the rate of reaction as the activation energy needed for the reaction to occur is lowered, so more reactant particles have sufficient energy to collide with each other successfully
- Biological catalysts are known as enzymes

(Extended only) State that a catalyst decreases the activation energy, E_a, of a reaction

- A catalyst decreases the activation energy, E_a, needed for the reaction to occur.
    - So more reactant particles have sufficient energy to collide with each other successfully, so the rate of reaction increases
- The effect of a catalyst can be shown on a reaction pathway diagram:



(Extended only) Evaluate practical methods for investigating the rate of a reaction including change in mass of a reactant or a product and the formation of a gas

- Look above for 'Describe practical methods for investigating the rate of a reaction including change in mass of a reactant or a product and the formation of a gas'
  Evaluate the practical method:
    - Were the controlled variables regulated carefully enough?
    - How many repeats were done? Was a mean rate of reaction calculated?
    - What are the advantages and disadvantages of the apparatus used? (Use 12.1 Experimental design notes for help)