The rate and extent of chemical change

Calculating rates of reaction

- Chemicals used in a reaction are called reactants.
- Chemicals formed in a reaction are called products.
- The quantity of reactant or product can be measured by mass in grams, volume in cm^3 or moles (mol) *[HT only].*
- How fast a chemical reaction proceeds is referred as a reaction's rate
- The equations for calculating rate are:

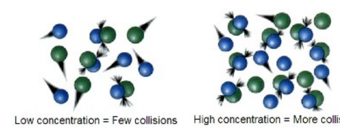
  mean rate of reaction = quantity of reactant used ÷ time taken

  mean rate of reaction = quantity product formed ÷ time taken
- The units for mean rate of reaction can be g/s or cm^3/s.
- To calculate the mean rate of reaction in an experiment where a colour change is timed the following equation is used:

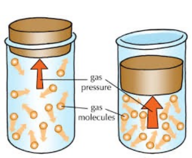
  mean rate of reaction = 1 ÷ time taken

Collision theory and activation energy

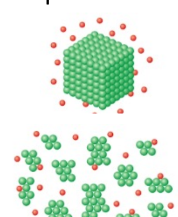
- Chemical reactions occur when particles of the reactants collide with sufficient energy
- The energy needed for a chemical reaction to occur is called the activation energy
- Increasing the concentration of a reactant increases the number of particles present. If more particles are present, then there will be more collisions. If there are more collisions, then the rate of reaction will be greater.



- Increasing the pressure of gases can be achieved in different ways Firstly, increasing the amount of a gas in a container, secondly, decreasing the size of the container and thirdly, by heating up the particles. All of these methods will increase the pressure by increasing the number of collisions with the container. The particles themselves will also collide more often. This will lead to a greater rate of reaction.



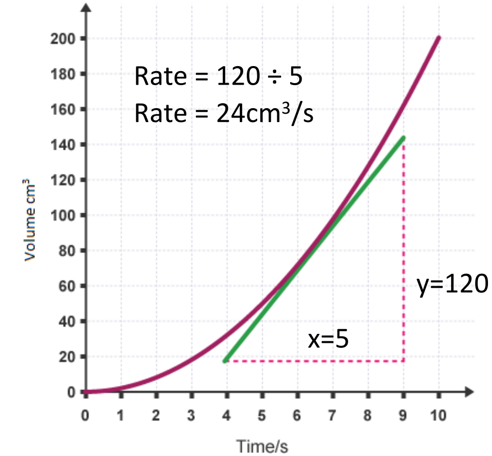
- Cutting solid reactants into smaller pieces increase the surface area to volume ratio. Increasing the surface area of solids by cutting solids into smaller pieces reveals more particles of the solid. This increases the number of particles colliding. The greater the number particles colliding the greater the rate of reaction.



- Increasing the temperature increases the particles kinetic energy. If particles have more energy they move faster. If particles are moving faster, they are more likely to collide and will also collide more energetically. This increases the rate of reaction.

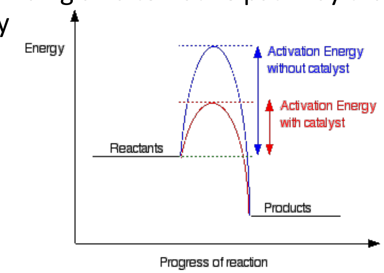
Calculating the rate of reaction from a graph

- Draw a tangent – this is a straight line that touches a curved surface at a single point but does not cross the curve at any point
- Complete a triangle using your tangent
- Use you scale to calculate the width and height of your graph (x & y)
- Calculate the rate of reaction by diving the height by the width of the triangle.
- The rate of the reaction is the same as the gradient of the graph (or tangent).



Catalysts

- Catalysts can be added to a reaction to change the rate of reaction
- Catalysts are not used up by the reaction and do not change the products of the reaction
- Different reactions need different catalysts
- Enzymes act as catalyst in biological systems
- Catalysts increase the rate of reaction by providing an alternative pathway that requires a lower amount of activation energy



Calculating surface area to volume ratio

Calculate the surface area of the reactant (area of 1 side x number of sides).

Calculate the volume of the reactant (length x width x height).

Calculating a ratio using the surface area and volume, e.g.

Surface area = $10cm^2$:Volume= $2cm^3$

Ratio= 5:1

The rate and extent of chemical change

Reversible reactions

- In some reactions the products of the reaction can react to form the original reactants.
- We show reversible reactions by using the ⇌ symbol.
- We can change the direction of a reversible reaction by changing the conditions of the reaction.

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

This shows that the reactants A and B react to form products C and D. The example also shows that the products C and D react together to form the reactants A and B.

Equilibrium

- If a reversible reaction takes place in a sealed container (one that prevents the escape of reactants or products) it will reach equilibrium when the rate of the forward and reverse reaction is equal.

The effect of changing conditions on equilibrium

- Changing the conditions of a reaction that has reached equilibrium will cause the reaction to respond and counteract the change.
- The conditions that can be changed are temperature, pressure, and concentration.

Changing concentration

- If the concentration of one of the reactants or products is changed then the reaction will no longer be at equilibrium.
- If a reaction is no longer at equilibrium the concentrations of all the substances involved in the reaction will change until a new equilibrium is found.
- If the concentration of a reactant is increased more products will be formed until a new equilibrium is reached.
- If the concentration of a product is increased more reactants will be formed until a new equilibrium is reached.

Energy changes and reversible reactions

- If a reversible reaction is exothermic in one direction it is endothermic in the opposite direction. The same amount of energy is transferred in each case.

$$A + B \underset{\textit{Endo}}{\overset{\textit{Exothermic}}{\rightleftharpoons}} C + D$$

- In this example the reaction is exothermic (releases heat energy/gets hotter) when A and B react to form C and D. The reaction is endothermic (takes in heat energy/gets colder) when C and D react to form A and B.

Changing temperature

- If we increase the temperature the reaction will move in the endothermic direction.
- If we decrease the temperature the reaction will move in the exothermic direction.

$$A + B \underset{\textit{Endo}}{\overset{\textit{Exothermic}}{\rightleftharpoons}} C + D$$

- In this example we will make more of A and B if we increase the temperature. We can say that the reaction moves in the endothermic direction.
- We will make more of C and D if we decrease the temperature. We can say that the reaction moves in the endothermic direction.
- If we decrease the temperature too much the rate of reaction will be very slow (see collision theory & activation energy). To prevent this from happening scientists often have to <u>compromise</u> by reducing the temperature to a point where the rate of reaction is still suitable.

Changing pressure

$$N_{2\,(g)} + 3H_{2\,(g)} \rightarrow 2NH_{3\,(g)}$$

- If we increase the pressure in a reaction involving gases the reaction will move to the side with the fewest molecules of gas. In this example there are only two molecules of NH_3 so the reaction will move to the right.
- If we decrease the pressure in a reaction involving gases the reaction will move to the side with the most molecules of gas. In this example there is one molecule of N_2 and three molecules of H_2 (four in total) so the reaction would move to the left.