

6 Chemical reactions

6.1 Physical and chemical changes

1 Identify physical and chemical changes, and describe the differences between them

- A change in appearance, state, or physical properties without altering chemical composition is called a physical change. Examples include:
 - Melting ice
 - Dissolving sugar in water
 - Cutting paper
- A change where bonds are broken and new ones formed, producing substances with new chemical identities is a chemical change. Examples include:
 - Burning wood/paper which turns into carbon dioxide and water vapour.
 - Rusting iron which turns into iron(iii)oxide.
 - Baking a cake

Aspect	Physical Change	Chemical Change
Composition	Unchanged (same substance)	Changed (new substance formed)
Reversibility	Often reversible	Usually irreversible or difficult to reverse
Energy Involvement	Small energy changes (state transitions)	Larger energy changes (bond breaking/forming)
Indicators	Change in state, shape, size	Color change, gas release, heat/light, precipitate

6.2 Rate of reaction

1 Describe the effect on the rate of reaction of: AND 6
Describe and explain the effect on the rate of reaction of:

(a) changing the concentration of solutions

- Increasing the concentration, increases the rate of reaction. This is because there will be more reactant particles per volume.

(b) changing the pressure of gases

- Increasing the pressure of gas, increases the rate of reaction. There will be more gas particles per unit volume.

(c) changing the surface area of solids

- Increasing the surface area of solid, increases the rate of reaction. More solid particles will be exposed to other reactant.

(d) changing the temperature

- Increasing the temperature, increases the rate of reaction. Kinetic energy of particles will increase and they will move faster, increasing frequency of successful collisions.

(e) adding or removing a catalyst, including enzymes

- Adding a catalyst increases the rate of reaction. A catalyst decreases the activation energy. More particles will have energy equal to or more than activation energy.

5 Describe collision theory in terms of:

(a) number of particles per unit volume

(b) frequency of collisions between particles

(c) kinetic energy of particles

(d) activation energy, E_a

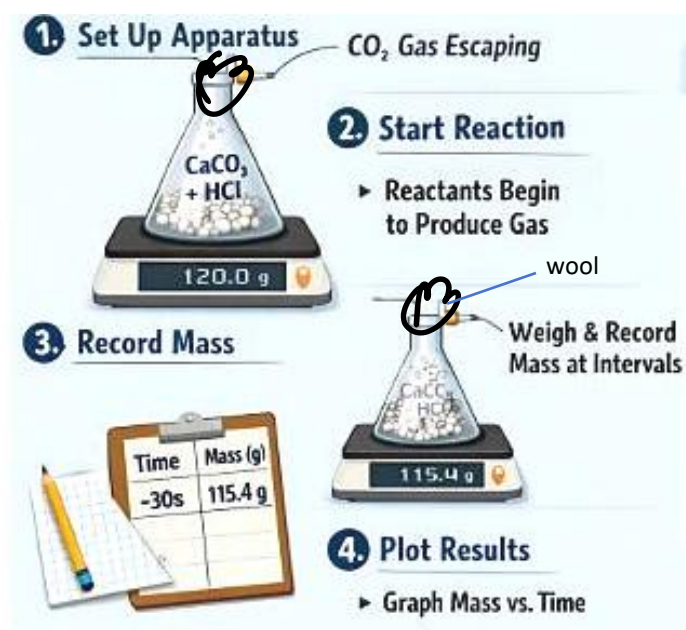
- An increase in particles per unit volume leads to an increase in frequency of collisions between particles. This applies to increasing the surface area of solid and pressure of gas.
- ONLY when the temperature increases, the kinetic energy of particles increases. This means that more particles will have energy above or equal to activation energy. This leads to frequency of successful collisions between particles.
- Addition of catalyst reduces activation energy. More particles will have sufficient energy to react, increasing frequency of successful collisions.

NOTE: ONLY the catalyst reduces activation energy of the reaction NOT increasing the temperature.

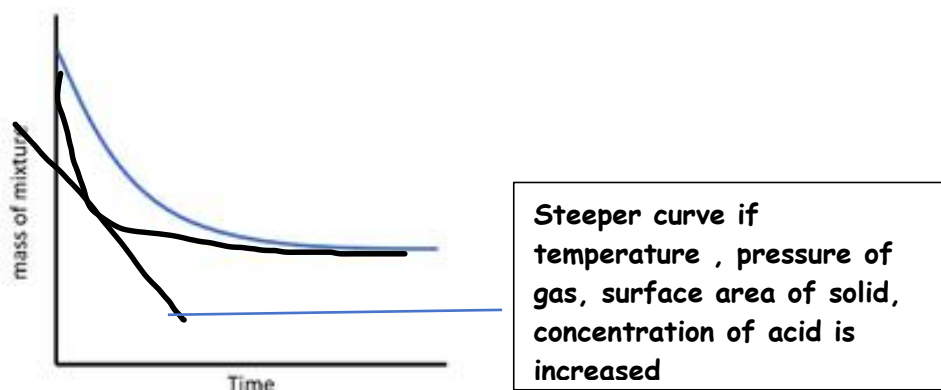
2 State that a catalyst increases the rate of a reaction and is unchanged at the end of a reaction AND 7 State that a catalyst decreases the activation energy, E_a , of a reaction

3 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 AND 4 Interpret data, including graphs, from rate of reaction experiments AND 8 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

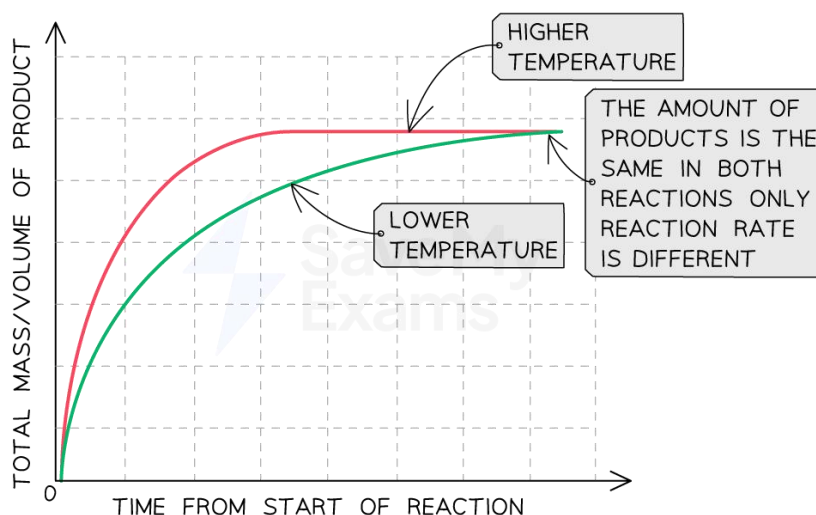
- Investigating the rate of reaction from changing mass of reactant AND formation of a gas:
 - The investigation involves adding calcium carbonate to hydrochloric acid which gives off carbon dioxide. As the carbon dioxide is released, the mass of reactants decrease.
 - This is the reaction:
$$\text{CaCO}_{3(s)} + 2\text{HCl}_{(aq)} \rightarrow \text{CaCl}_{2(aq)} + \text{H}_2\text{O}_{(l)} + \text{CO}_{2(g)}$$
 - Using a higher mass of calcium carbonate, higher surface area, greater volume or concentration of acid, increasing temperature leads to mass becoming constant in a shorter period of time, leading to a steeper curve (black line)

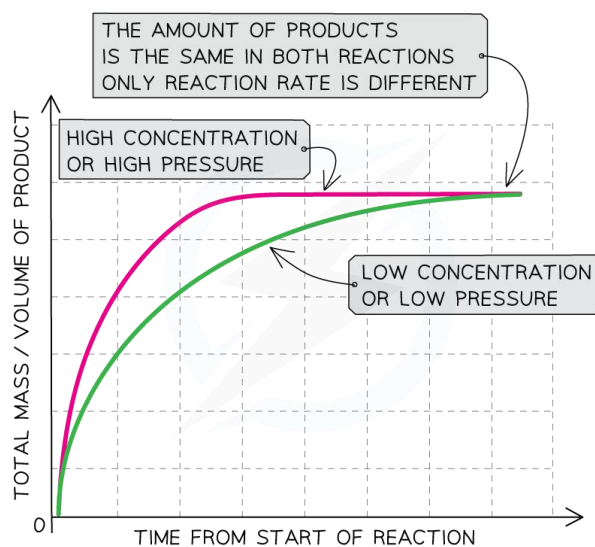
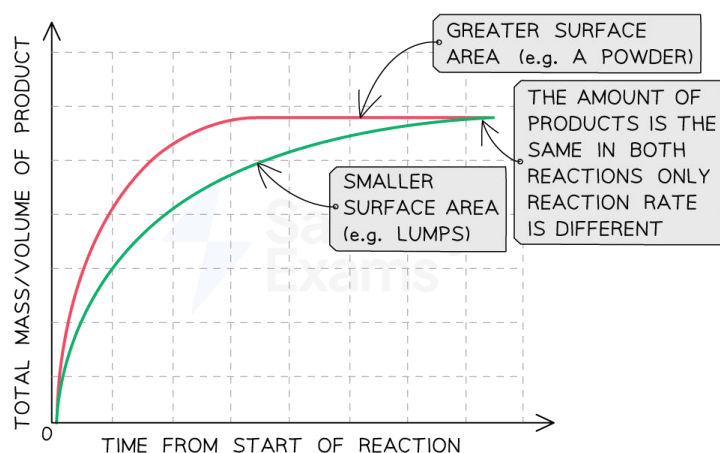


- This is the curve

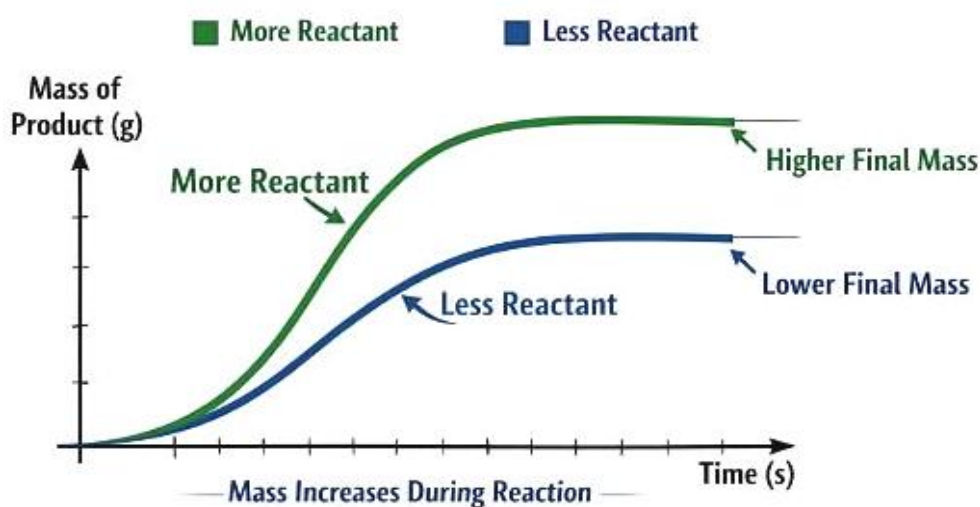


- Investigating the rate of reaction from changing mass of product:
 - The investigation involves heating magnesium metal in the presence of oxygen which produces magnesium oxide which leads to increase in mass.
 - This is the reaction: $2\text{Mg}_{(s)} + \text{O}_{2(g)} \rightarrow 2\text{MgO}_{(s)}$
 - If the temperature, surface area of solid, or pressure of gas then the mass becomes constant quicker, leading to a steeper curve.





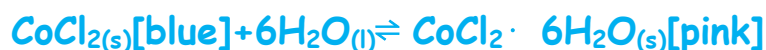
- **Curve for using different mass/volume of solid/acid reactants(a higher mass/volume leads to greater final mass and faster initial rate of reaction)**



6.3 Reversible reactions and equilibrium

1 State that some chemical reactions are reversible as shown by the symbol $\rightleftharpoons$

2 Describe how changing the conditions can change the direction of a reversible reaction for:



(a) the effect of heat on hydrated compounds

- Direction of reaction shifts to the right, giving water and anhydrous copper sulfate OR water and anhydrous cobalt(ii) chloride.

(b) the addition of water to anhydrous compounds

- Direction of reaction shifts to the left, giving hydrated copper(ii)sulfate OR hydrated cobalt(ii)chloride.

limited to copper(II) sulfate and cobalt(II) chloride

3 State that a reversible reaction in a closed system is at equilibrium when:

(a) the rate of the forward reaction is equal to the rate of the reverse reaction

(b) the concentrations of reactants and products are no longer changing

4 Predict and explain, for a reversible reaction, how the position of equilibrium is affected by:

(a) changing temperature

- An increase in temperature favors the endothermic reaction so the equilibrium direction of the reaction shifts to that side of the reaction. This reverses the change; thermal energy is added so more bonds are broken down.
- A decreases in temperature favors the exothermic reaction so the direction of the reaction shifts to that side of the reaction. This reverses the change; thermal energy is taken in so more bonds are formed.

(b) changing pressure

- Increase in pressure favors the side of the reaction with smaller number of molecules(less molecules=less pressure). The equilibrium direction shifts to that side. This decreases the pressure, reversing the change by decreasing the number of molecules.
- decrease in pressure favors the side of the reaction with greater number of molecules(more molecules=more pressure). The equilibrium direction shifts to that side. This increases the pressure, reversing the change by increasing the number of molecules.

(c) changing concentration

- If the concentration of reactants increases. This favors the products side and direction of equilibrium shifts to it. This decreases the concentration of reactants as more will be used, increasing concentration of product(yield) until both reactant and products are equal in concentration.
- If the concentration of products increases. This favors the reactants side and direction of equilibrium shifts to it. This decreases the concentration of products as more

will be used, increasing concentration(yield) of reactants until both reactant and products are equal in concentration.

(d) using a catalyst using information provided

- Speeds up forward and backward(reverse) reaction equally, equilibrium is reached faster.
- The yield does not change as catalyst does not effect direction of equilibrium.

5 State the symbol equation for the production of ammonia in the Haber process, $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$

6 State the sources of the hydrogen (methane) and nitrogen (air) in the Haber process

7 State the typical conditions in the Haber process as 450°C , 20000kPa/200atm and an iron catalyst

8 State the symbol equation for the conversion of sulfur dioxide to sulfur trioxide in the Contact process, $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$

9 State the sources of the sulfur dioxide (burning sulfur or roasting sulfide ores) and oxygen (air) in the Contact process

10 State the typical conditions for the conversion of sulfur dioxide to sulfur trioxide in the Contact process as 450°C , 200kPa/2atm and a vanadium(V) oxide catalyst

11 Explain, in terms of rate of reaction and position of equilibrium, why the typical conditions stated are used in the Haber process and in the Contact process, including safety considerations and economics

- **Habar process:**

- A low temperature would favour exothermic reaction giving more ammonia yield; **HOWEVER**, a low temperature slows down the speed of reaction.
- A high pressure favors the side with less molecules, which yields more ammonia/ sulfur trioxide; **HOWEVER**, a high pressure is dangerous and expensive to maintain as explosions could happen. This is safer and more cost-effective
- A catalyst speeds up the reaction making the reaction more cost-effective.

6.4 Redox

1 Use a Roman numeral to indicate the oxidation number of an element in a compound

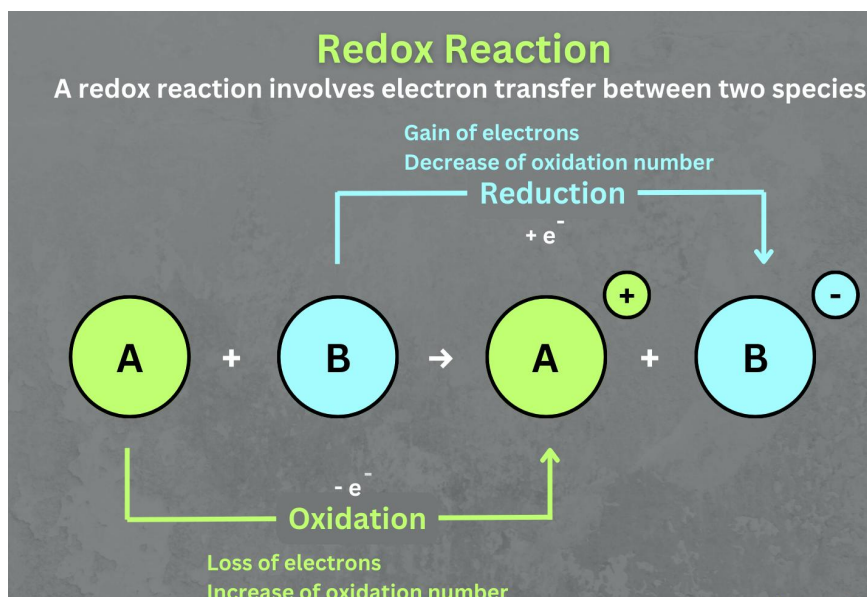
1	I	6	VI
2	II	7	VII
3	III	8	VIII
4	IV	9	IX
5	V	10	X

2 Define redox reactions as involving simultaneous oxidation and reduction

3 Define oxidation as gain of oxygen and reduction as loss of oxygen

4 Identify redox reactions as reactions involving gain and loss of oxygen

5 Identify oxidation and reduction in redox reactions



6 Define oxidation in terms of:

- (a) loss of electrons
- (b) an increase in oxidation number

7 Define reduction in terms of:

- (a) gain of electrons
- (b) a decrease in oxidation number

8 Identify redox reactions as reactions involving gain and loss of electrons

9 Identify redox reactions by changes in oxidation number using: EXAMPLES

- (a) the oxidation number of elements in their uncombined state is zero [Na, Mg, Cu]
- (b) the oxidation number of a monatomic ion is the same as the charge on the ion [Na⁺, Al³⁺, Cl⁻]
- (c) the sum of the oxidation numbers in a compound is zero {CH₄ : +4+4(-1)=0}

(d) the sum of the oxidation numbers in an ion is equal to the charge on the ion $[\text{CO}_3^{2-}: +4+3(-2)=-2]$

10 Identify redox reactions by the colour changes involved when using acidified aqueous potassium manganate(VII) or aqueous potassium iodide

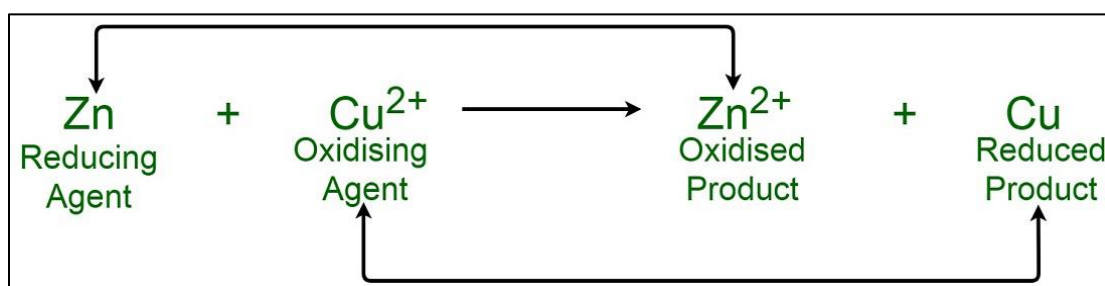
- Acidified aqueous potassium manganate(VII) is initially purple but when it is reduced, it turns colourless.
- Aqueous potassium iodide is initially colourless but when it is oxidised, it turns red-brown.

11 Define an oxidising agent as a substance that oxidises another substance and is itself reduced

12 Define a reducing agent as a substance that reduces another substance and is itself oxidised

13 Identify oxidising agents and reducing agents in redox reactions

- Zinc is oxidized and copper ion is reduced.



END OF CHAPTER