

Chemical reactions

IGCSE Chemistry 0620 · Topic 6 revision notes

Everything from the 6 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Physical and chemical changes

2. Rate of reaction

3. Collision theory and catalysts

4. Reversible reactions and equilibrium

5. The Haber and Contact processes

6. Redox

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1 Physical and chemical changes

Syllabus 6.1

A **physical change** does not produce a new substance: the particles are only rearranged or moved apart, as in melting, boiling, dissolving or separating a mixture, and it is usually easy to reverse. A **chemical change** produces one or more new substances with different properties, as in burning, rusting or neutralisation. Chemical changes are often accompanied by an energy change and are usually difficult to reverse.

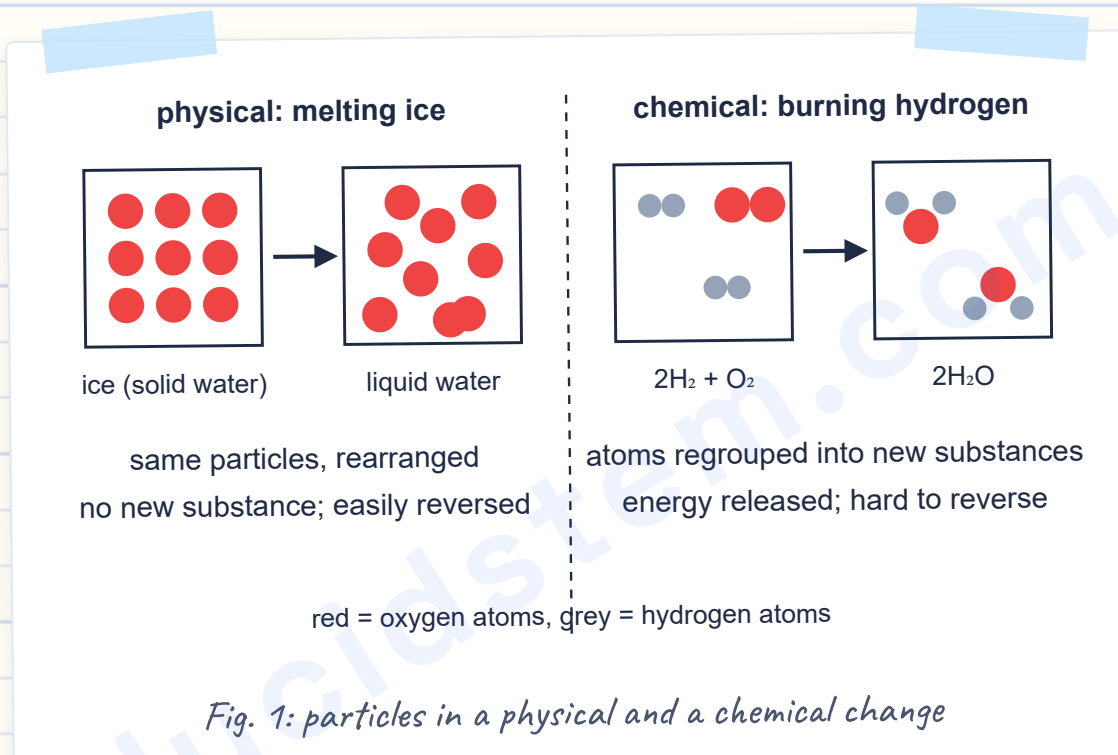


Fig. 1: particles in a physical and a chemical change

One question decides it.

- ✓ **New substance formed?** Yes: chemical. No: physical.
- ✓ **Physical:** changes of state, dissolving, separating mixtures.
- ✓ **Chemical:** burning, rusting, neutralisation, decomposition.
- ✓ **Evidence:** gas, precipitate, lasting colour change, temperature change.

Watch out!

Dissolving is a **physical** change: evaporate the water from salt solution and the salt is recovered unchanged. Do not confuse "it disappeared" with "it reacted". And a colour change alone is not proof: heating anhydrous copper(II) sulfate is a chemical change, but a solution simply getting paler when diluted is not.

2 Rate of reaction

Syllabus 6.2

The rate of a reaction **increases** when the concentration of a solution or the pressure of a gas increases, when a solid is broken into smaller pieces (larger surface area), when the temperature increases, and when a catalyst is added. A **catalyst** increases the rate of a reaction and is unchanged at the end. Rate is measured by following a product or reactant against time, for example the volume of gas given off or the loss in mass.

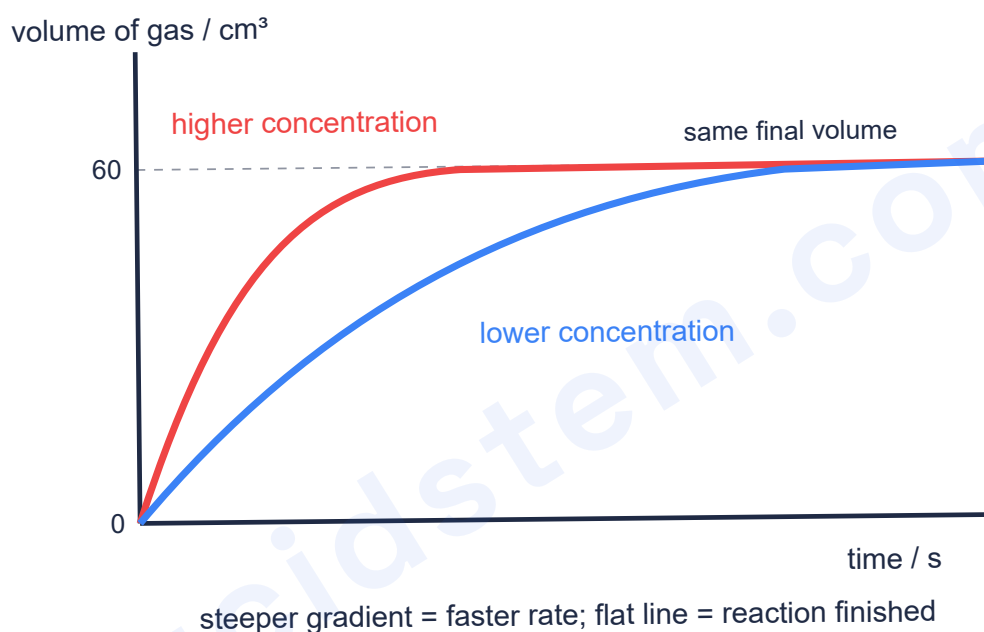


Fig. 1: gas produced over time at two concentrations of acid

Steeper means faster.

- ✓ **Faster:** higher concentration, pressure, surface area, temperature, or a catalyst.
- ✓ **Mean rate** = change in amount ÷ time taken.
- ✓ **Same reactant amounts** means the same final volume.
- ✓ **Fair test:** change one factor, keep the rest the same.

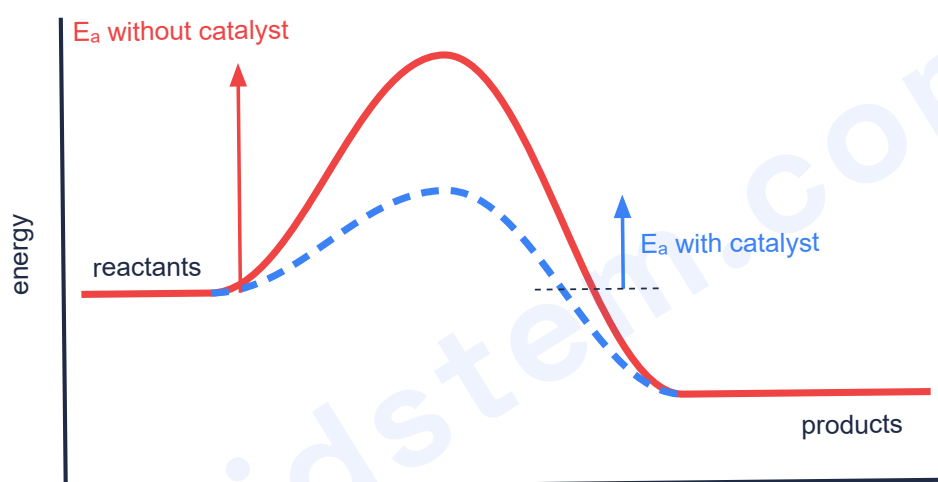
Watch out!

Changing the rate does not change the **amount** of product if the same amounts of reactants are used. On the graph, a faster reaction is steeper at the start but levels off at the **same** final volume. Only changing the amount of the limiting reactant changes the final volume.

3 Collision theory and catalysts

Syllabus 6.2

Extended. Particles react only when they **collide** with at least the **activation energy**. Higher concentration, higher pressure and larger surface area put more particles in contact, so the **frequency of collisions** increases. Higher temperature makes particles move faster: they collide more often and, more importantly, **more collisions have energy at least equal to the activation energy**. A catalyst provides a pathway with a lower activation energy, so more collisions are successful.



a catalyst gives a pathway with a lower activation energy, so more collisions have enough energy to react

Fig. 1: a catalyst lowers the activation energy

Frequency and energy.

- ✓ **Concentration, pressure, surface area:** more frequent collisions.
- ✓ **Temperature:** more frequent collisions and more with energy $\geq E_a$.
- ✓ **Catalyst:** alternative pathway, lower E_a , unchanged at the end.
- ✓ **Say "frequent",** not just "more".

Watch out!

"More collisions" is not enough for the marks: say **more frequent** collisions (more collisions per second). For temperature, you must also say that **more particles have energy greater than or equal to the activation energy**; that is the bigger effect.

4 Reversible reactions and equilibrium

Syllabus 6.3

A **reversible reaction** can go in either direction, shown by the symbol $\rightleftharpoons$. Heating hydrated copper(II) sulfate (blue) drives off water to leave anhydrous copper(II) sulfate (white); adding water reverses it. **Extended:** in a closed system a reversible reaction reaches **dynamic equilibrium**, where the forward and reverse reactions happen at the same rate and the concentrations of reactants and products stay constant. Changing the conditions moves the position of equilibrium to oppose the change.

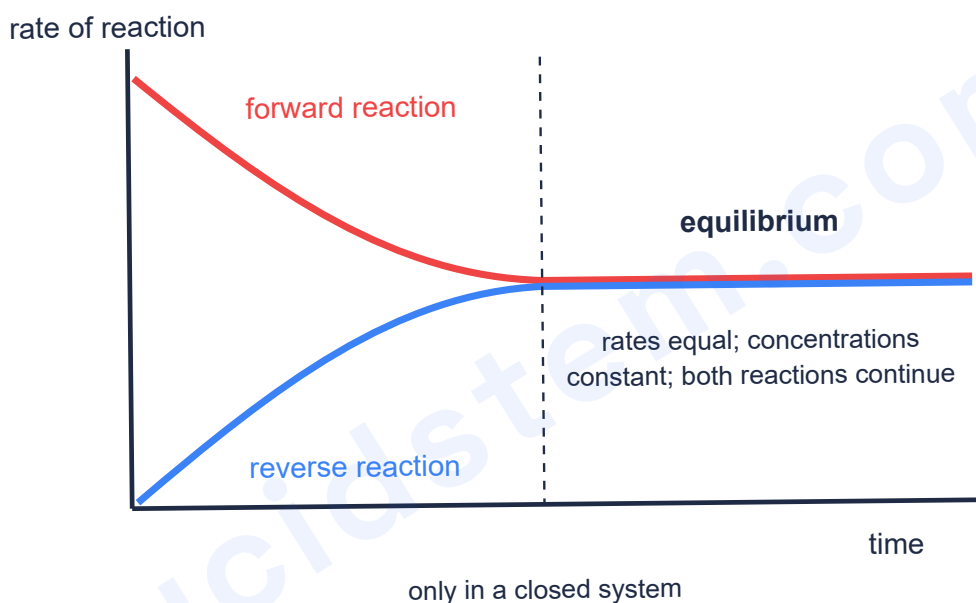


Fig. 1: reaching dynamic equilibrium in a closed system

Oppose the change.

- ✓ **Hydrated CuSO_4 :** blue; anhydrous: white.
- ✓ **Dynamic equilibrium:** equal rates, constant concentrations, closed system.
- ✓ **Hotter:** endothermic direction. **Higher pressure:** fewer gas molecules.
- ✓ **Catalyst:** faster to equilibrium, no shift.

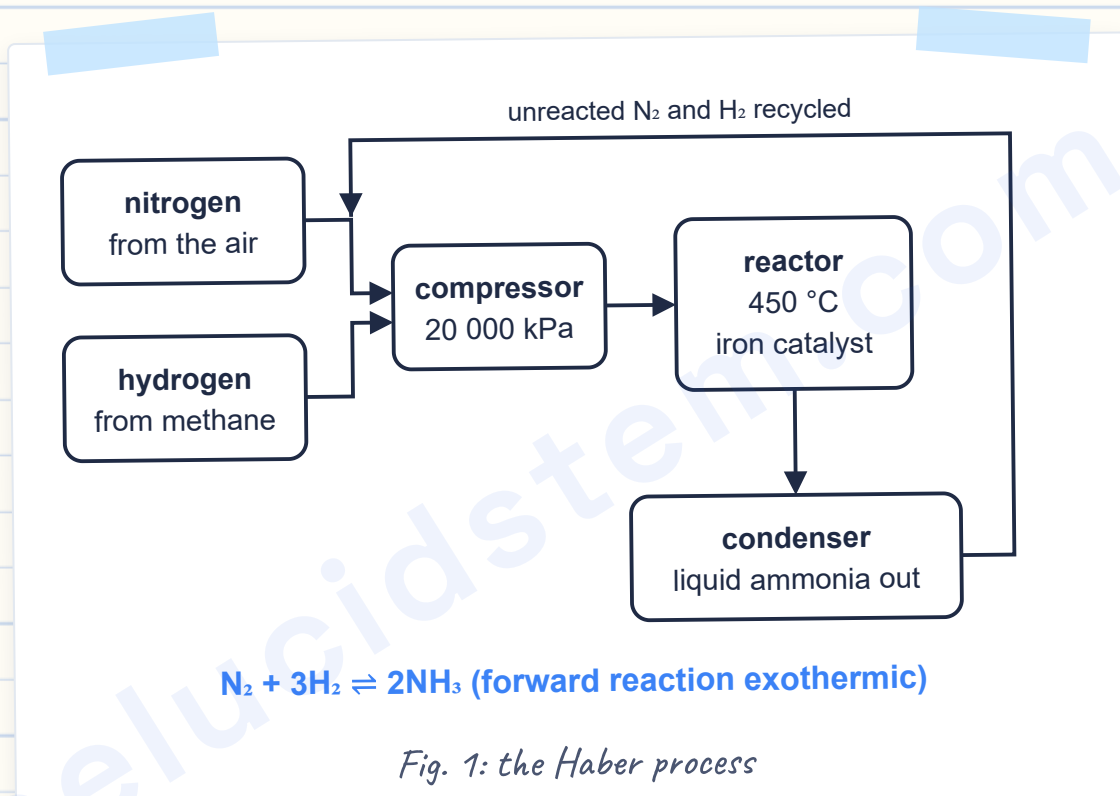
Watch out!

At equilibrium the concentrations are **constant**, not **equal**. There may be far more product than reactant, or the other way round. And a catalyst never moves the position of equilibrium: it speeds up the forward and reverse reactions equally.

5 The Haber and Contact processes

Syllabus 6.3

Haber process: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. Nitrogen comes from the air and hydrogen from methane. Conditions: 450 °C, 20 000 kPa (200 atm), iron catalyst. **Contact process:** $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. Sulfur dioxide comes from burning sulfur or roasting sulfide ores; oxygen from the air. Conditions: 450 °C, 200 kPa (2 atm), vanadium(V) oxide catalyst. **Extended:** both forward reactions are exothermic and reduce the number of gas molecules, so the conditions are a compromise.



Yield, rate, safety, cost.

- ✓ **Haber:** 450 °C, 20 000 kPa, iron; N_2 from air, H_2 from methane.
- ✓ **Contact:** 450 °C, 200 kPa, V_2O_5 ; SO_2 from burning sulfur.
- ✓ **Temperature:** compromise between yield and rate.
- ✓ **Catalyst:** faster, not more.

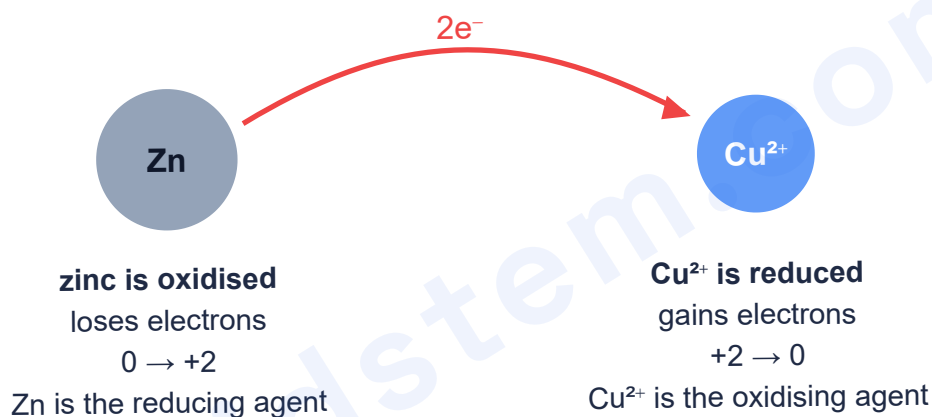
Watch out!

The catalyst does **not** increase the yield. And 450 °C is not chosen for the best yield: the best yield would be at a low temperature. It is a **compromise** between yield and rate. Name both in your answer.

6 Redox

Syllabus 6.4

Oxidation is gain of oxygen and **reduction** is loss of oxygen; a reaction in which both happen is a **redox** reaction. A Roman numeral in a name gives the oxidation number of the element, as in iron(III) oxide. **Extended:** oxidation is also loss of electrons and an increase in oxidation number; reduction is gain of electrons and a decrease in oxidation number. An **oxidising agent** oxidises another substance and is itself reduced; a **reducing agent** reduces another substance and is itself oxidised.



OIL RIG: oxidation is loss, reduction is gain (of electrons)

Fig. 1: electron transfer from zinc to copper(II) ions

OIL RIG.

- ✓ **Oxygen:** gain is oxidation, loss is reduction.
- ✓ **Electrons (Extended):** loss is oxidation, gain is reduction.
- ✓ **Oxidation number:** up is oxidation, down is reduction.
- ✓ **Oxidising agent** is reduced; **reducing agent** is oxidised.

Watch out!

The oxidising agent is the substance that is **reduced**, not the one that is oxidised. It sounds backwards, so reason it out: it causes oxidation in something else by taking that thing's electrons, and taking electrons is reduction.