Topic 4: Chemical changes

AQA GCSE Chemistry (8462), topic 4.4

Chemical changes: choose the reaction from the evidence

- place metals in the **reactivity series** from how they react with water, acids and other metal compounds;
- explain **oxidation** and **reduction** as gain or loss of oxygen and (higher tier) of electrons;
- make a pure, dry salt and work out its formula;

Chemical changes: choose the reaction from the evidence (2)

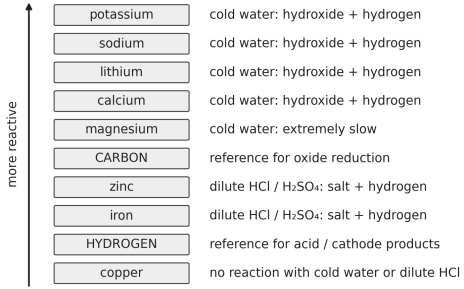
- explain pH, **neutralisation** and (higher tier) strong and weak acids, and (chemistry only) carry out and calculate a **titration**;
- predict the products of electrolysis and explain how aluminium is extracted.

The reactivity of metals

- When metals react, their atoms lose electrons and form a **positive ion** .
- The more easily a metal does this, the more reactive it is.
- The **reactivity series** puts the metals in order: potassium, sodium, lithium, calcium, magnesium, zinc, iron, copper, from most to least reactive.
- Carbon and hydrogen are not metals, but they are included as reference points.

$$\mathrm{Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)}$$

Figure: The reactivity of metals



Carbon and hydrogen are non-metals. Compare metals under matching conditions.

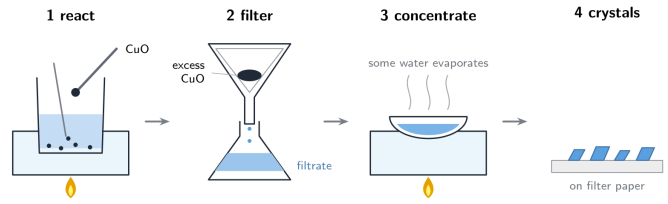
- Reactivity increases upwards; carbon and hydrogen are reference points.
- Match each part of the diagram to the text.

Acids, alkalis and salts

- Moles of NaOH $= 0.100 \times 0.0200 = 0.00200$ mol.
- The ratio is 1 : 2, so moles of $H_2SO_4 = 0.00200/2 = 0.00100$ mol.
- Concentration $= 0.00100/0.0250 = 0.0400$ mol/dm^3.
- In g/dm^3: $0.0400 \times 98 = 3.92$ g/dm^3.

$$\mathrm{H^+(aq) + OH^-(aq) \rightarrow H_2O(l)}$$

Figure: Acids, alkalis and salts

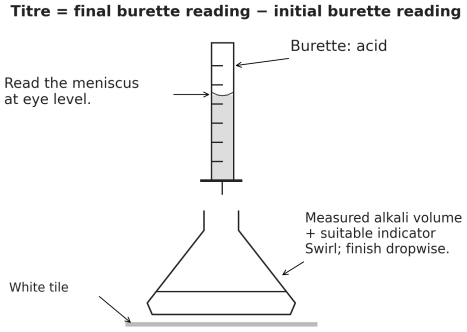


$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

filtering cannot remove dissolved acid, so use excess oxide; do not boil the solution dry

- Excess **oxide** is **insoluble**; the salt is dissolved.
- Crystallisation separates salt from some remaining water.

Figure: Acids, alkalis and salts ·



- A **burette** delivers acid into a measured alkali sample; read both burette levels.
- Match each part of the diagram to the text.

Electrolysis

- At the **cathode**, the metal forms if it is less reactive than hydrogen (such as copper). Otherwise hydrogen forms.
- At the **anode**, if the solution contains a **halide** ion (**chloride**, bromide or iodide), the **halogen** forms. Otherwise oxygen forms.
- hydrogen burns with a squeaky pop when a **lighted splint** is held near it;

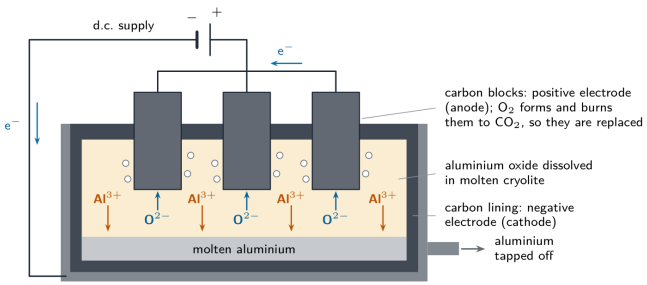
$$\mathrm{Al}^{3+} + 3\mathrm{e}^- \rightarrow \mathrm{Al} \qquad 2\mathrm{O}^{2-} \rightarrow \mathrm{O}_2 + 4\mathrm{e}^-$$

Electrolysis (2)

- oxygen relights a **glowing splint** ;
- chlorine bleaches damp **litmus paper** ;
- copper appears as a pink-brown coating on the **cathode**.

$$\mathrm{Cu^{2+} + 2e^- \rightarrow Cu} \qquad \mathrm{2Cl^- \rightarrow Cl_2 + 2e^-}$$

Figure: Electrolysis



- **Cryolite** lowers the operating melting point.
- Oxygen reacts with the carbon **anode**.

Sources for this lesson

- AQA, *GCSE Chemistry (8462) specification*, section 4.4, and the required practicals handbook.
- Smithsonian Institution, "The Aluminum Apex of the Washington Monument" (1884 capstone, 100 troy ounces).
- C. M. Hall, US Patent 400,766, "Process of Reducing Aluminium from its Fluoride Salts by Electrolysis" (filed July 1886), and P. Héroult, French patent 175,711 (April 1886).
- Royal Society of Chemistry, *Practical Chemistry*: "Preparing a salt" and "Electrolysis of solutions".

Common errors

- Saying copper reacts with dilute acid; it is below hydrogen and does not.
- Writing salt formulae without balancing the charges, such as $CaNO_3$ instead of $Ca(NO_3)_2$.
- Boiling the copper **sulfate** solution dry; the crystals then decompose and are not pure.

Common errors (2)

- Confusing strong with concentrated, or weak with dilute.
- Saying electrons flow through the **electrolyte**; ions carry the charge in the liquid.
- Predicting sodium at the **cathode** for sodium **chloride** solution; hydrogen forms because sodium is more reactive than hydrogen.
- Mixing up the electrodes: cations go to the cathode (negative), anions to the anode (positive).

Key terms

- **Reactivity series**: a list of metals in order of how readily they react.
- **Displacement**: a reaction in which a more reactive metal replaces a less reactive one in a **compound**.
- **Oxidation**: gain of oxygen or (higher tier) loss of electrons.

Key terms (2)

- **Reduction**: loss of oxygen or (higher tier) gain of electrons.
- **Neutralisation**: the reaction of an acid with a **base** to form a salt and water.
- **Strong acid**: an acid that is completely **ionised** in water.

Key terms (3)

- **Electrolysis**: the breaking down of an **electrolyte** by an electric current.
- **Half equation**: an equation that shows the change at one electrode, with electrons.

Check yourself

- 1.
- Metal Y reacts with dilute acid but does not displace iron from iron **sulfate**.
- Where could Y be in the **reactivity series**? 2.
- Name the salt made from zinc **oxide** and hydrochloric acid, and write a word equation. 3.