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| 1 | Ions are atoms that have lost or gained electrons and so become charged . |
| 2 | Ionic compounds need to be molten or dissolved for ions to be separated by electrolysis. |
| 3 | An ionic substance with freely moving ions is called an electrolyte. |
| 4 | Positive ions are called cations and are attracted to the negative electrode called the cathode . |
| 5 | Negative ions are called anions and are attracted to the positive electrode called the anode . |
| 6 | Half equations show what happens at the electrodes (OILRIG): Redu C tion at the C athode, oxid A tion at A node. <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="border: 1px solid black; padding: 5px; width: 45%;"> <p>Cathode reaction: $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$ reduction</p> <p>Anode reaction: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ oxidation</p> <p>Note that two Cl^- ions are needed to form one chlorine molecule.</p> </div> <div style="width: 45%;"> <p>ReduCtion takes place at the Cathode.</p> <p>OxidAtion takes place at the Anode.</p> </div> </div> |
| 7 | Oxidation is the Loss of electrons and Reduction is Gain of electrons during a reaction (OILRIG) |
| 8 | Copper is purified by electrolysis, more expensive but lower resistance when used in wires |
| 9 | Direct current (d.c.) is needed for electrolysis |
| 10 | Electrodes are washed in distilled water (remove surface impurities) and dipped in propanone (remove the water) to ensure an accurate reading on the mass balance . |

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| 11 | Molten salts undergoing electrolysis with inert electrodes decompose into their elements. The metal ions (+ve) move to the cathode (-ve), the non-metal (-ve) moves to the anode (+ve) |
| 12 | Opposite charges attract and like charges repel. |
| 13 | Products of salt solutions are harder to predict as water also ionises to a very small extent producing hydrogen ions (H^+) and hydroxide ions (OH^-) |
| 14 | At the negative electrode (cathode): If there is more than one type of positive ion in solution then the LEAST reactive element will be produced at the cathode. |

| Ions | $\text{Cu}^{2+}(\text{aq})$ and $\text{Cl}^-(\text{aq})$ (from salt), $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ (from water) | |
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| cathode | $\text{Cu}^{2+}(\text{aq})$ and $\text{H}^+(\text{aq})$ ions are attracted. Copper ions are discharged more readily than hydrogen ions, so copper is formed as a brown solid. | $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$ (reduction) |
| anode | $\text{Cl}^-(\text{aq})$ and $\text{OH}^-(\text{aq})$ ions are attracted. Chloride ions are discharged more readily than hydroxide ions, so chlorine is formed as a pale green gas. | $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ (oxidation) |
| Overall | The copper chloride decomposes but the water does not change. $\text{CuCl}_2(\text{aq}) \rightarrow \text{Cu}(\text{s}) + \text{Cl}_2(\text{g})$ | |

1 At the positive electrode (anode): oxygen is produced (from hydroxide ions), unless halide ions (chloride, bromide or iodide ions) are present. In that case, then negatively charged halide ions lose electrons and form the corresponding halogen (chlorine, bromine or iodine).

2 The **reactivity series** is a list of metals in order of **reactivity**, the most reactive are at the top.


3 The reactivity series is determined by how **vigorously** an element reacts with other substances e.g. water and acid. Elements higher up the reactivity series can **displace** those below them.
e.g. $\text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4$
More reactive zinc replaced copper.

4 **Displacement reactions** are also **redox** reactions. The reaction between zinc and copper sulphate above can be written as an ionic equation: $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Cu} + \text{Zn}^{2+}$
The copper has gained two electrons this is **reduction**, zinc has lost two electrons to become Zn^{2+} this is **oxidation**. This happens at the same time so a **redox** reaction.

5 An **ore** is a rock containing enough of a compound (or element) to be profitable when it's sold. Very unreactive metals can be found in their **native state** e.g. **gold** and **platinum**.

6 The metals below carbon in the reactivity series e.g. iron are extracted by **smelting**. Metals above carbon e.g. aluminium by **electrolysis**. Both processes use a lot of energy and cause a lot of pollution. Biological methods of extraction e.g. **bioleaching** and **phytoextraction** are less damaging to the environment and can work on ores with less metal in them.

| Ions | Na ⁺ (aq) and Cl ⁻ (aq) (from salt), H ⁺ (aq) and OH ⁻ (aq) (from water) | |
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| cathode | Na ⁺ (aq) and H ⁺ (aq) ions are attracted. Hydrogen ions are discharged more readily than sodium ions, so hydrogen gas is formed. | $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$ (reduction) |
| anode | Cl ⁻ (aq) and OH ⁻ (aq) ions are attracted. Chloride ions are discharged more readily than hydroxide ions, so chlorine is formed as a pale green gas. | $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ (oxidation) |
| Overall | The sodium chloride decomposes to form hydrogen and chlorine. The sodium and hydroxide ions remain in the solution. $2\text{NaCl}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) + 2\text{NaOH}(\text{aq})$ | |

| Metal | Reaction with water | Reaction with dilute acid | Tendency of metal atoms to form cations |
|-----------|---|--|---|
| potassium | react with cold water to form hydrogen and a metal hydroxide | react violently |  increasing ability of metal atoms to form positive ions |
| sodium | | | |
| calcium | | | |
| magnesium | react very slowly, if at all, with cold water but react with steam to form hydrogen and a metal oxide | react to form hydrogen and a salt solution | |
| aluminium | | | |
| zinc | | | |
| iron | | | |
| copper | do not react with cold water or steam | do not react | |
| silver | | | |
| gold | | | |



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| 1 | Most metals react with oxygen in the air, this is called corrosion . Paint , coating of oil and a sacrificial block of a more reactive metal can stop corrosion. An oxide layer (tarnish) also stops further reaction |
| 2 | Corrosion of iron needs water and is called rusting . |
| 3 | A life cycle assessment (LCA) is used to work out the environmental impact of a product. |
| 4 | Recycling can make natural reserves of metal ore last longer, reduced mining of ores results in less damage to habitats, noise and dust. Less energy is needed so less carbon dioxide (global warming) and sulphur dioxide (acid rain) is emitted. |

