

# WJEC (Wales) Chemistry GCSE

## 2.3 - Metals and Their Extraction Flashcards

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# What is metal extraction?



# What is metal extraction?

- Metals are extracted from ores which are rocks containing metal compounds found in the Earth's crust
- These metals can be extracted using chemical reactions



What is the relationship between metal reactivity and extraction?



# What is the relationship between metal reactivity and extraction?

- The more reactive a metal is, the more stable its metal compound so the harder it is to extract the pure metal - i.e. gold is very unreactive so it is found in its pure form



What are the extraction processes depending on the reactivity of the metal?



# What are the extraction processes depending on the reactivity of the metal?

- Electrolysis - for metals more reactive than carbon
- Reduction with carbon - for metals less reactive than carbon (this is a cheap process and is favoured over electrolysis)
- Metals less reactive than hydrogen are found pure in their native form



# What is a displacement reaction and how is it useful?





# What is a displacement reaction and how is it useful?

- When a more reactive metal displaces a less reactive metal from a compound
- Can be used to investigate the relative reactivities of metals



# What is oxidation?



# What is oxidation?

- Gain of oxygen
- Loss of electrons
- Loss of hydrogen
- The species oxidised is known as the reducing agent



# What is reduction?



# What is reduction?

- Loss of oxygen
- Gain of electrons
- Gain of hydrogen
- The species reduced is known as the oxidising agent



What are the reactions involved in the extraction of iron in a blast furnace?



# What are the reactions involved in the extraction of iron in a blast furnace?

- The process is a reduction process
- Coke reacts with oxygen in the air to form carbon dioxide (exothermic combustion reaction)
- The carbon dioxide reacts with more coke to form carbon monoxide (the carbon dioxide is reduced)
- The iron oxide reacts with the coke or carbon monoxide and is reduced to form molten iron



How are impurities removed from the iron ore in a blast furnace?





# How are impurities removed from the iron ore in a blast furnace?

- The main impurity in the mixture is silicon dioxide (sand)
- Limestone undergoes thermal decomposition into calcium oxide
- The calcium oxide reacts with the silicon dioxide to form solid calcium silicate which can be removed from the furnace
- This is a neutralisation reaction



# How does electrolysis work?



# How does electrolysis work?

- When a metallic compound is melted or dissolved, the ions are free to move within the liquid or solution
- Passing a current through molten liquids or solutions means that the solution can be broken down into elements
- During electrolysis the substance being broken down is the electrolyte



What happens during the electrolysis of molten ionic compounds (e.g. lead bromide)?



# What happens during the electrolysis of molten ionic compounds (e.g. lead bromide)?

- $\text{Pb}^{2+}$  ions are positively charged so these ions move to the cathode and lead is produced at the cathode
- The half equation at the cathode is  $\text{Pb}^{2+} (\text{aq}) + 2\text{e}^{-} \rightarrow \text{Pb}(\text{s})$
- $\text{Br}^{-}$  ions are negatively charged so these ions move to the anode where two bromide ions lose an electron each to form liquid bromine
- The half equation at the anode is  $2\text{Br}^{-} (\text{aq}) \rightarrow \text{Br}_2 (\text{l}) + 2\text{e}^{-}$



Explain the process of the industrial extraction of aluminium using electrolysis.



## Explain the process of the industrial extraction of aluminium.

- Aluminium oxide is melted so electricity can be passed through it
- Aluminium oxide is dissolved in cryolite which is a substance that lowers the melting point
- Aluminium metal forms at the negative electrode and sinks to the bottom of the tank
- Oxygen forms at the positive electrode and reacts with the carbon in the graphite electrodes forming  $\text{CO}_2$
- The positive electrode has to be replaced often to account for the reaction of carbon and oxygen



# What are the properties and uses of iron?





# What are the properties and uses of iron?

- Malleable
- An alloy, steel, can be formed from iron and carbon
- Steel is harder and stronger than iron and less likely to rust
- Used to build cars and used in the construction industry



# What are the properties and uses of aluminium?



# What are the properties and uses of aluminium?

- Low density
- Light weight for its size
- Resists corrosion due to the very thin layer of their oxides on the surface
- Used in aircraft, trains, overhead power cables, saucepans and cooking foil



# What are the properties and uses of copper?



# What are the properties and uses of copper?

- Good conductor of electricity and heat
- Soft, easily bent and shaped (malleable)
- Resistant to corrosion (very unreactive)
- Used in electrical wiring, gas and water pipes, and plumbing in houses as copper doesn't react with water



# What are the properties and uses of titanium?



# What are the properties and uses of titanium?

- Low density
- Light weight for its size
- Resists corrosion
- Used in fighter aircraft, artificial hip joints and pipes in nuclear power stations



# What are the general properties of transition metals?





# What are the general properties of transition metals?

- High melting points
- Form coloured compounds
- Have the ability to form ions with different charges
- Most are malleable and ductile
- Good conductors of both heat and electricity due to their delocalised electrons
- Hard
- Less reactive than alkali metals (group 1 metals)



# What is the test for metal ions?



# What is the test for metal ions?

- When sodium hydroxide (NaOH) is added:
  - Copper (II) ions give a blue precipitate
  - Iron (II) ions give a green precipitate
  - Iron (III) ions give a brown precipitate



# What is an alloy?



# What is an alloy?

- A substance made of a mixture of 2 or more elements, of which at least one is a metal
- They are made by mixing molten metals
- The composition of alloys can be changed to produce alloys with desired properties



Explain what happens during the  
electrolysis of water.



# Explain what happens during the electrolysis of water.

- Electrolysis can be used to separate water into hydrogen gas and oxygen gas
- Positively charged hydrogen ions move to the negative electrode and gain electrons in a reduction reaction
- Negatively charged hydroxide ions move to the positive electrode and lose electrons to form water and oxygen in an oxidation reaction



What are the half equations in the electrolysis of water?





# What are the half equations in the electrolysis of water?

- At the cathode the equation is  $4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2(\text{g})$
- At the anode the equation is  $4\text{OH}^-(\text{aq}) \rightarrow \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^-$



Explain what happens during the electrolysis of aqueous solutions.



# Explain what happens during the electrolysis of aqueous solutions.

- An ionic solution contains the ions that make up the ionic compound, and the ions in water ( $\text{OH}^-$  and  $\text{H}^+$ )
- At the cathode, hydrogen is produced unless the positively charged ions in the ionic compound are from a metal less reactive than hydrogen - then this metal will be produced instead
- At the anode, oxygen will be produced unless the ionic compound contains halide ions ( $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ), in this case the halogen will be produced



What are the electrode equations in the electrolysis of copper(II) chloride?



# What are the electrode equations in the electrolysis of copper(II) chloride?

- At the cathode, since copper is less reactive than hydrogen, copper ions are reduced to solid copper:  $\text{Cu}^{2+}_{(aq)} + 2e^{-} \longrightarrow \text{Cu}_{(s)}$
- At the anode chloride ions are oxidised:  $2\text{Cl}^{-}_{(aq)} \longrightarrow \text{Cl}_{2(g)} + 2e^{-}$



What are the electrode equations in the electrolysis of sodium chloride?



# What are the electrode equations in the electrolysis of sodium chloride?

- At the cathode hydrogen ions are reduced as sodium is more reactive than hydrogen:  $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$
- At the anode chloride ions are oxidised:  $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$



# What are the uses of electrolysis?





# What are the uses of electrolysis?

- Electroplating - Covering the surface of one metal with another metal e.g. jewellery coated in silver to make it silver-plated
- Purification of copper
- Manufacture of sodium hydroxide, hydrogen gas and chlorine gas



# What factors must be considered when extracting metals?



# What factors must be considered when extracting metals?

- Site of extraction plants:
  - Good infrastructure, close to power station, near a city as a source for workers, away from built-up areas due to noise and pollution
- The method used - reduction with carbon to be used where possible to lower energy and costs needed
- Recycling - using recycling plants to recycle and reuse materials as opposed to extract new raw materials

