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C8. Patterns & properties of metals

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C8.01 The alkali metals

The elements in group 1, on the left of the periodic table, are called the **alkali metals**.

lithium	→	Li
sodium	→	Na
potassium	→	K
rubidium	→	Rb
caesium	→	Cs
francium	→	Fr

- Very reactive, stored under oil - to stop them reacting with the oxygen and water vapour in the air
- soft - can be cut with a knife
- **Top to bottom** reactivity ↑ m.p ↓ b.p ↓ soft ↓ density ↑
- Melting point, density gradually down the group
- Hardness of Metals are similar
- Soft, low density metals
- React strongly and directly with non metals to form salts - white

1. The reaction of the alkali metals with water

- when it meets water, it always produce hydrogen gas and metal hydroxide



- Exothermic
- makes the water become alkaline
- $2\text{Na(s)} + 2\text{H}_2\text{O} = 2\text{NaOH} + \text{H}_2$

Metal ion	formula	Flame colour
lithium -steadily	Li^+	red
sodium - strongly	Na^+	yellow
potassium - violently	K^+	lilac

2. Group II metals - alkaline earth metals

Similar reactivity, but **less reactive** to group 1

- **as you go down a group, its more reactive**
- Mg
 - $2\text{Mg(s)} + \text{O}_2\text{(g)} \Rightarrow 2\text{MgO(s)}$ - burn fiercely with a brilliant white light - used in firework
 - $\text{Mg(s)} + \text{H}_2\text{O(l)} \Rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$ - reacts well with hot steam
- Ca - reacts well with cold water
 - $\text{Ca(s)} + 2\text{H}_2\text{O(l)} \Rightarrow \text{Ca(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ - alkaline solution produced
 - when you keep doing it, suspension obtained, because not all calcium hydroxide dissolves

C8.02 Aluminium

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Aluminium - one of the most common metal in the Earth's crust

Ore - **Bauxite**

1. Aluminium's usefulness

- light, strong, good electrical conductivity - used for construction
- alloyed with copper
- low density, electrical conductivity - powerlines
- useful for protection from corrosion by the stable layer of aluminium oxide that forms on its surface
 - good for food packaging because of the resist corrosion by natural acids
- resist weathering - window frame

C8.03 The transition elements

mostly used metals

Properties

- Hard and strong
- Have high m.p
- High densities
- Good conductors of heat and electricity
- Are malleable and ductile
- **Useful** metallic elements
- **Much less reactive**
- Excellent **corrosion resistance**
- Many of their compound are coloured
- Show more than one valency - they form more than one type of ion
- The metals or their compounds often make useful catalysts
- Few of metals are strongly magnetic(iron & cobalt & nickel)

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
Ac									

1. Coloured compounds

Group 1, 2 are colourless

Salts - coloured, produce coloured solution when dissolved

- used for stained glass

Metal ion in solution	Formula	Colour
Copper	Cu^{2+}	blue
iron(II)	Fe^{2+}	green
Iron(III)	Fe^{3+}	red-brown
Chromium	Cr^{3+}	green
cobalt	Co^{2+}	pink
manganate	MnO_4^{2+}	purple
chromate	CrO_4^{2+}	yellow
dichromate	$\text{Cr}_2\text{O}_7^{2-}$	orange

Corundum

- titanium + iron => sapphire
- Chromium produce red rubies

2. Catalytic properties

Catalyst: substances that speed up a chemical reaction without themselves being used up or changed at the end of the reaction

3. The reactions of certain transition elements

Ions

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Ions: moderately reactive metal



Copper

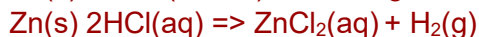
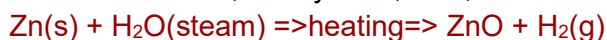
Copper: least reactive metals

CuO(black) is made when it's heated in air



Zinc

- When hot, ZnO yellow, cool, ZnO white



C8.04 The reactivity of metals

1. An overview of reactivity

- We can get these information
 - Ease of extraction
 - Reactions with air or oxygen
 - Reactions with water
 - Reactions with dilute acids
 - Metal displacement reactions
 - Heat stability of metal compounds

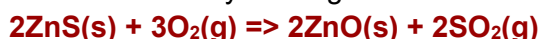
2. The reactivity series of metals

Potassium	Most reactive	K
Sodium		Na
Calcium		Ca
Magnesium		Mg
Aluminium		Al
Carbon		C
Zinc		Zn
Iron		Fe
Tin		Sn
Lead		Pb
Hydrogen		H
Copper		Cu
Silver		Ag
Gold		Au
Platinum	Least reactive	Pt

metal	Name of ore	Compound
aluminium	bauxite	Al_2O_3
copper	Copper pyrites	CuFeS_2
iron	hematite	Fe_2O_3
sodium	Rock salt	NaCl
tin	cassiterite	SnO_2
zinc	zinc-blende	ZnS
lead	galena	PbS

Sulfur

- moderately reactive metals(iron) exist as oxide or sulfide ore
- sulfide ores - easily converted to the oxide by heating in air



Carbon

- carbon - strong tendency to react with oxygen => good reducing agent
 - used for blast furnace

How to extract metal

	metal	Method of extraction
	K	

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Decreasing reactivity		Na	Electrolysis
		Ca	
		Mg	
		Al	
		Zn	Reduction of oxides with C Carbon good react with O ₂
		Fe	
		Sn	
		Pb	
		Cu	Uncombined In the ground

3. Metal displacement reactions

Displacement reaction: help us to place particular metals more precisely in the reactivity series

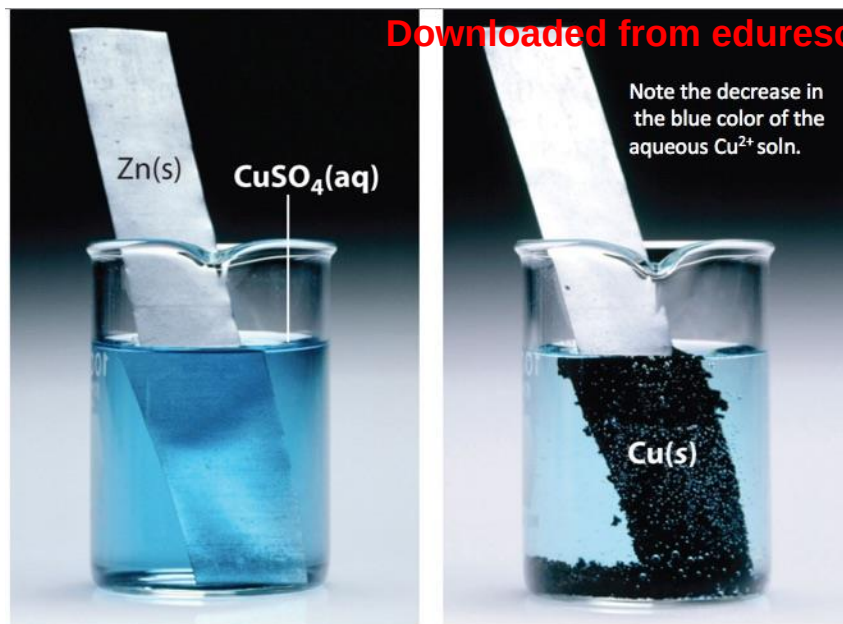


Zn is more reactive than Cu

4. Other redox competition reactions

- $\text{Zn} \Rightarrow \text{Zn}^{2+} + 2\text{e}^-$
 - $\text{Cu}^{2+} + 2\text{e}^- \Rightarrow \text{Cu}$
 - ∴ $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \Rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$
- Zn is oxidised - reducing agent
 - Cu^{2+} gains electrons
 - Cu^{2+} is reduced
 - ∴ **More reactive metal - good reducing agent**

- Cu is reduced - oxidising agent
 - Zn loses electrons
 - Zn is oxidised



4. Reactions of metals with air, water, and dilute acids

Reactivity series	Reaction with...		
	Air	Water	Dilute HCl
Na	Burn very strongly in air to form oxide	React with cold water to give H ₂	React very strongly to give H ₂
Ca			
Mg			
Al	Burn less strongly in air to form oxide	React with steam, when heated, to give H ₂	React less strongly to give H ₂
Zn			
Fe			
Pb	React very slowly to form oxide layer when heated	Do not react	Do not react
Cu			
Ag	Not react	Do not react	Do not react
Au			