

1		2												3	4	5	6	7	0																
																	1 H hydrogen 1								4 He helium 2										
		Key relative atomic mass atomic symbol name atomic (proton) number																																	
7 Li lithium 3		9 Be beryllium 4												11 B boron 5		12 C carbon 6		14 N nitrogen 7		16 O oxygen 8		19 F fluorine 9		20 Ne neon 10											
23 Na sodium 11		24 Mg magnesium 12												27 Al aluminium 13		28 Si silicon 14		31 P phosphorus 15		32 S sulfur 16		35.5 Cl chlorine 17		40 Ar argon 18											
39 K potassium 19		40 Ca calcium 20		45 Sc scandium 21		48 Ti titanium 22		51 V vanadium 23		52 Cr chromium 24		55 Mn manganese 25		56 Fe iron 26		59 Co cobalt 27		59 Ni nickel 28		63.5 Cu copper 29		65 Zn zinc 30		70 Ga gallium 31		73 Ge germanium 32		75 As arsenic 33		79 Se selenium 34		80 Br bromine 35		84 Kr krypton 36	
85 Rb rubidium 37		88 Sr strontium 38		89 Y yttrium 39		91 Zr zirconium 40		93 Nb niobium 41		96 Mo molybdenum 42		[97] Tc technetium 43		101 Ru ruthenium 44		103 Rh rhodium 45		106 Pd palladium 46		108 Ag silver 47		112 Cd cadmium 48		115 In indium 49		119 Sn tin 50		122 Sb antimony 51		128 Te tellurium 52		127 I iodine 53		131 Xe xenon 54	
133 Cs caesium 55		137 Ba barium 56		139 La* lanthanum 57		178 Hf hafnium 72		181 Ta tantalum 73		184 W tungsten 74		186 Re rhenium 75		190 Os osmium 76		192 Ir iridium 77		195 Pt platinum 78		197 Au gold 79		201 Hg mercury 80		204 Tl thallium 81		207 Pb lead 82		209 Bi bismuth 83		[209] Po polonium 84		[210] At astatine 85		[222] Rn radon 86	
[223] Fr francium 87		[226] Ra radium 88		[227] Ac* actinium 89		[267] Rf rutherfordium 104		[270] Db dubnium 105		[269] Sg seaborgium 106		[270] Bh bohrium 107		[270] Hs hassium 108		[278] Mt meitnerium 109		[281] Ds darmstadtium 110		[281] Rg roentgenium 111		[285] Cn copernicium 112		[286] Nh nihonium 113		[289] Fl flerovium 114		[289] Mc moscovium 115		[293] Lv livermorium 116		[293] Ts tennessine 117		[294] Og oganesson 118	

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

Metal extraction

Smelting

Electrolysis of molten ionic substances

Half equations

Aluminium extraction

Electrolysis of aqueous solutions

Metal purification and plating



Notes:

ORE : ROCK WITH AN EXTRACTABLE
AMOUNT OF A CERTAIN METAL

↓
SMELTING

↓
ELECTROLYSIS

Smelting

Metal ores

Malachite

Purifying copper by smelting

Haematite

Purifying iron by smelting

The blast furnace

Metal ores



A rock with an extractable amount of metal

Malachite



Copper ore



Wood ash



Wood ash is carbon

COPPER + CARBON^{*}
OXIDE



COPPER + CARBON
DIOXIDE

2x C~O

C



2x C~ + CO₂

Purifying Copper by smelting



Copper was first smelted
5500 bc!!

POTASSIUM

LITHIUM

ALUMINIUM

CARBON

IRON

COPPER

SILVER

ELECTROLYSIS

SMELTER

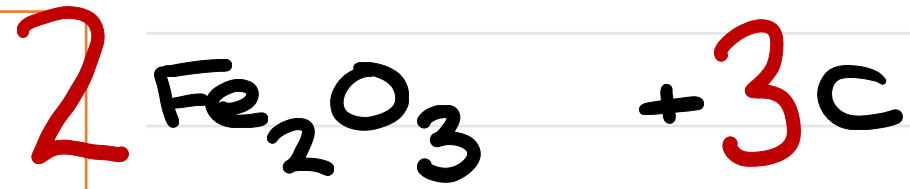
IRON OXIDE + CARBON

2
CARBON + IRON
DIOXIDE

Troy
(1250 bc)



Bronze: copper and tin



Atoms

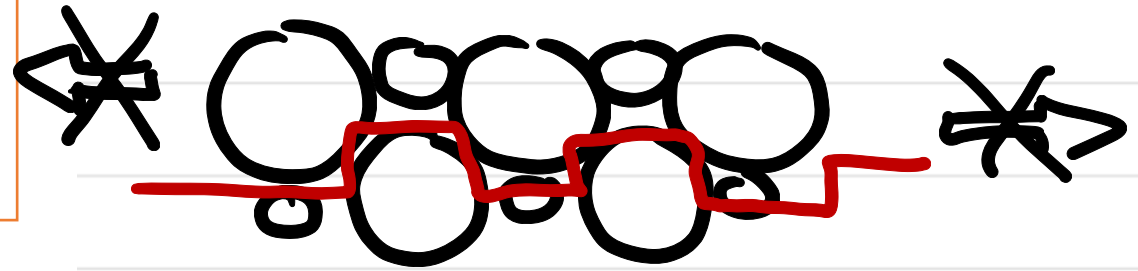


Stronger



Pure metal

Battle of Thermopylae (480 bc)



PARTICLES CANNOT
SLIDE OVER EACH
OTHER
⇒ RIGID.

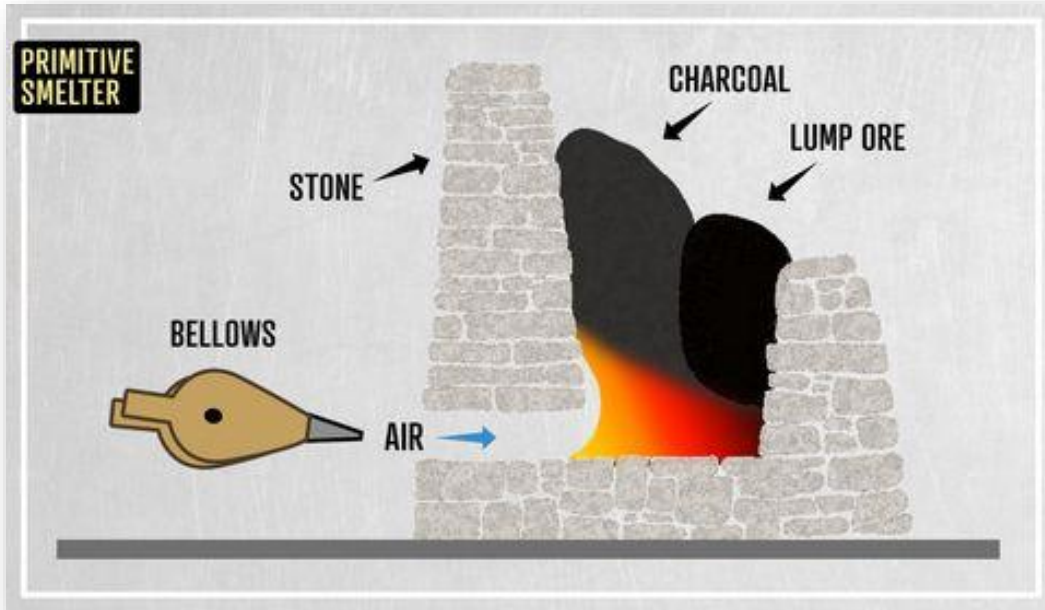
Haematite



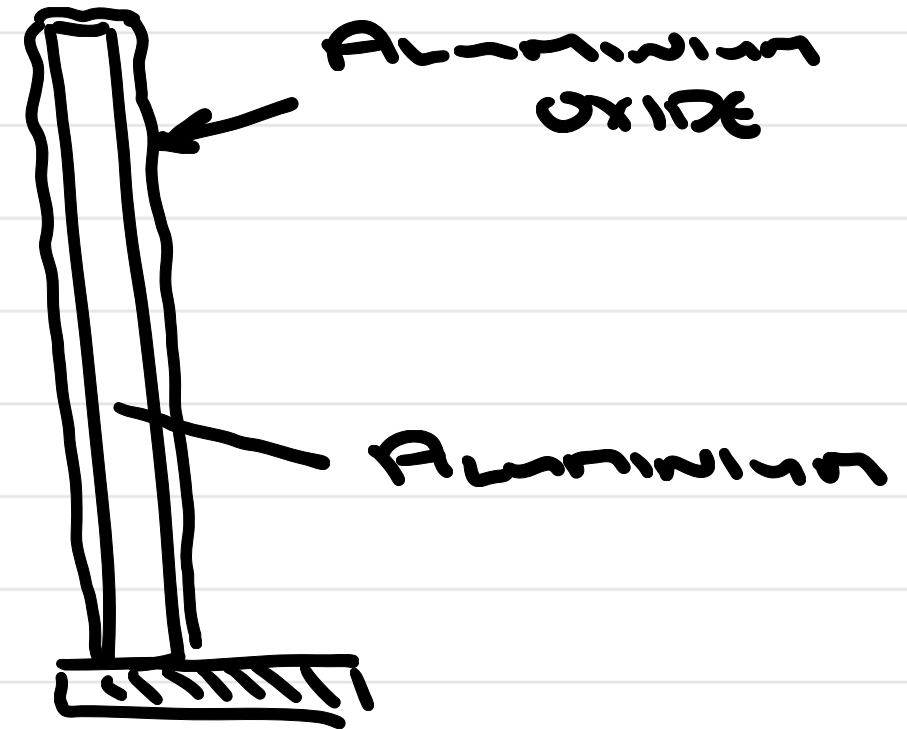
Iron ore



Purifying Iron by smelting

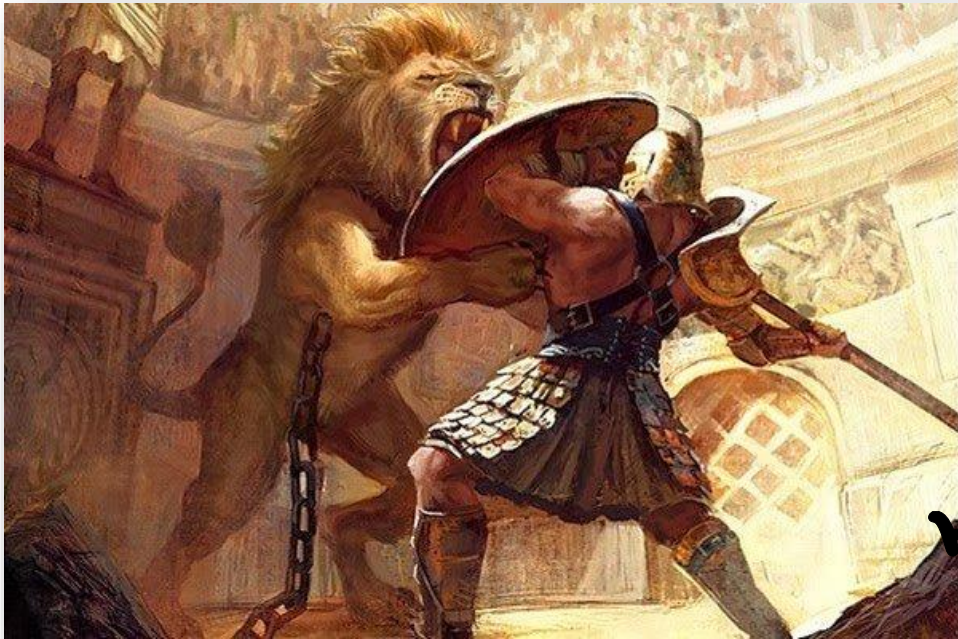


Iron was first smelted 2500 BC!!



Ancient Rome

(396 b.c. – 117 a.d.)



Rome stopped expanding after 117 AD

Rust

IRON + OXYGEN

water

HUMAN

^

IRON OXIDE

* $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$

HUMAN

^

IRON

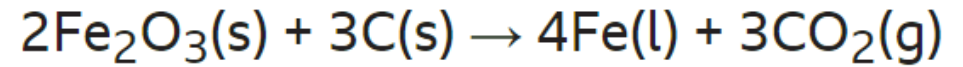
OXIDE

IS FUNNY :)

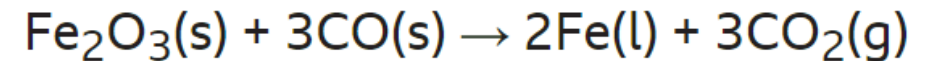
Rome's empire



Purifying Iron using a blast furnace



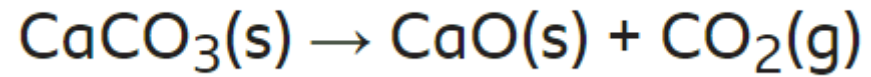
...or....



Raw materials in blast furnace

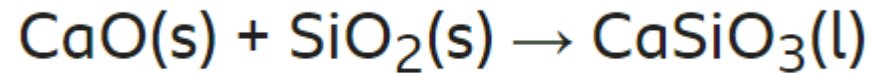
Raw material	Contains	Function
Iron ore (haematite)	Iron(III) oxide	A compound that contains iron
Coke	Carbon	Burns in air to produce heat, and reacts to form carbon monoxide (needed to reduce the iron oxide)
Limestone	Calcium carbonate	Helps to remove acidic impurities from the iron by reacting with them to form molten slag
Air	Oxygen	Allows the coke to burn, and so produces heat

Removing impurities



Limestone added

...then...

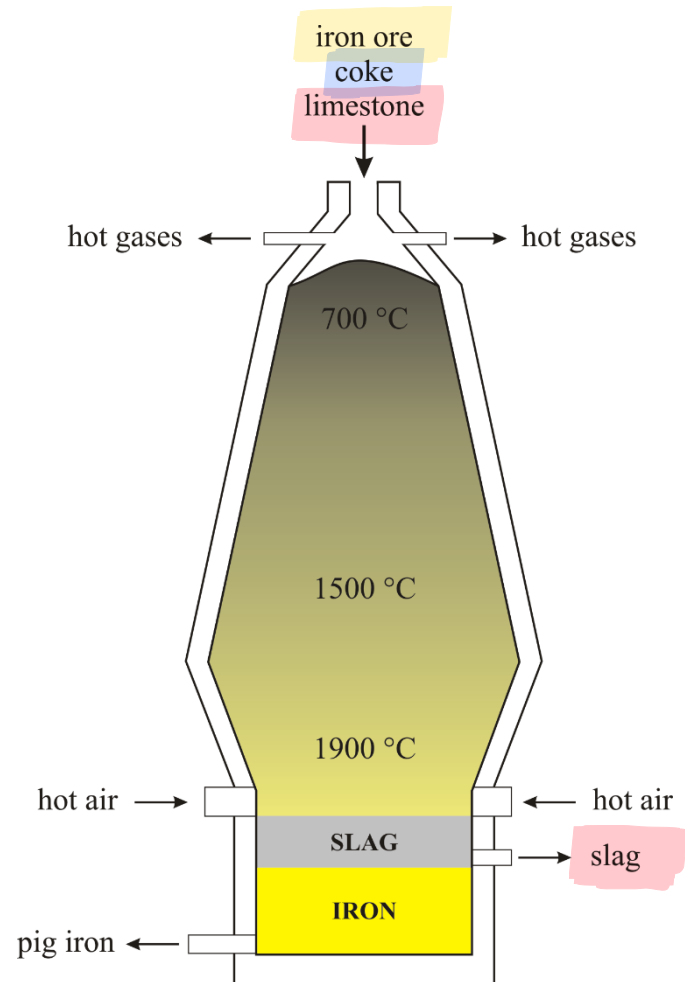


Impurities

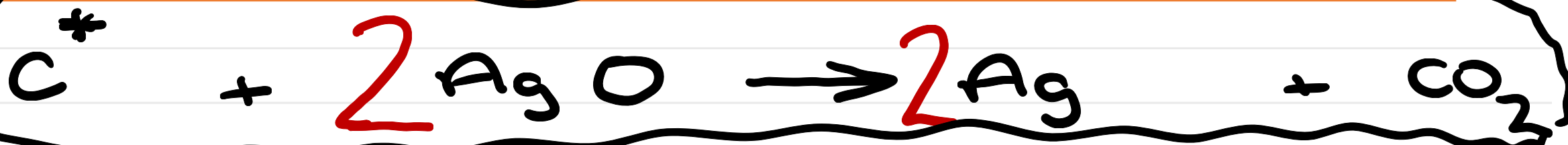
Slag

THERMAL DECOMPOSITION

Parts of blast furnace



Notes:



First

Ag
C

Equation

Reduced

Oxidised

∴

Electrolysis of molten ionic substances

Bauxite

Why can't bauxite be smelted?

The reactivity series

Electrolysis introduction

Ionic lattices

Flowing ions

Materials produced by simple electrolysis

→ HAS TO BE
USED FOR METALS
MORE REACTIVE
THAN CARBON
↳ HEAT &
ELECTRICITY &&

Bauxite



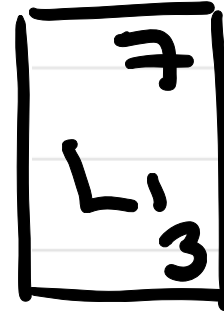
Aluminium ore



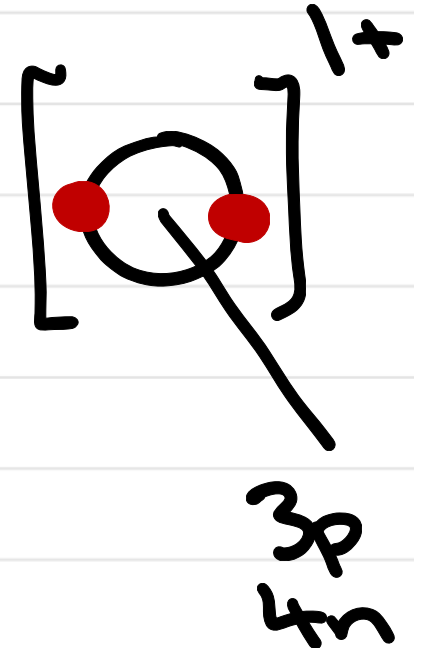
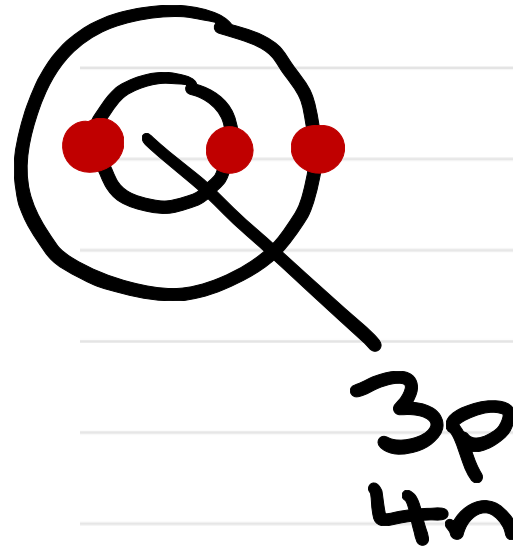
CATIONS

α

CATHODE



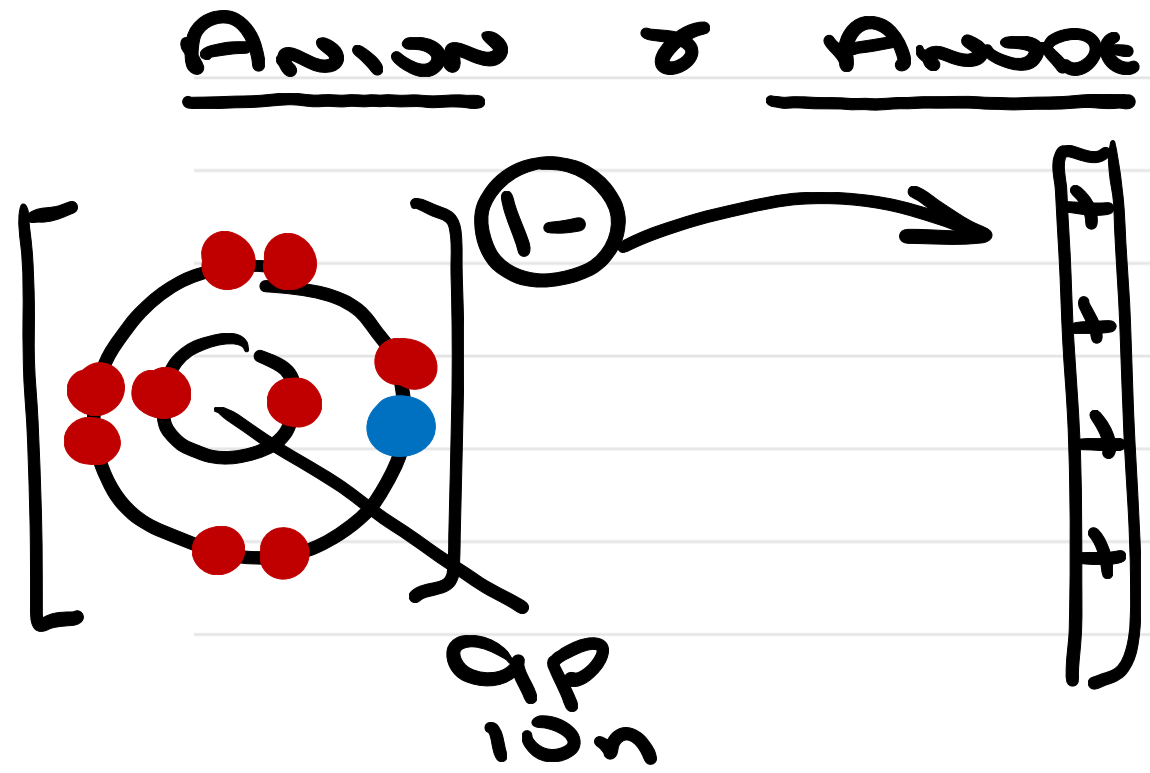
CAT ION



$$3p - 2e = +1$$

Brain teaser

Why can't Bauxite be obtained by smelting?



Reactivity Series

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

} ELECTROLYSIS

Electrolysis



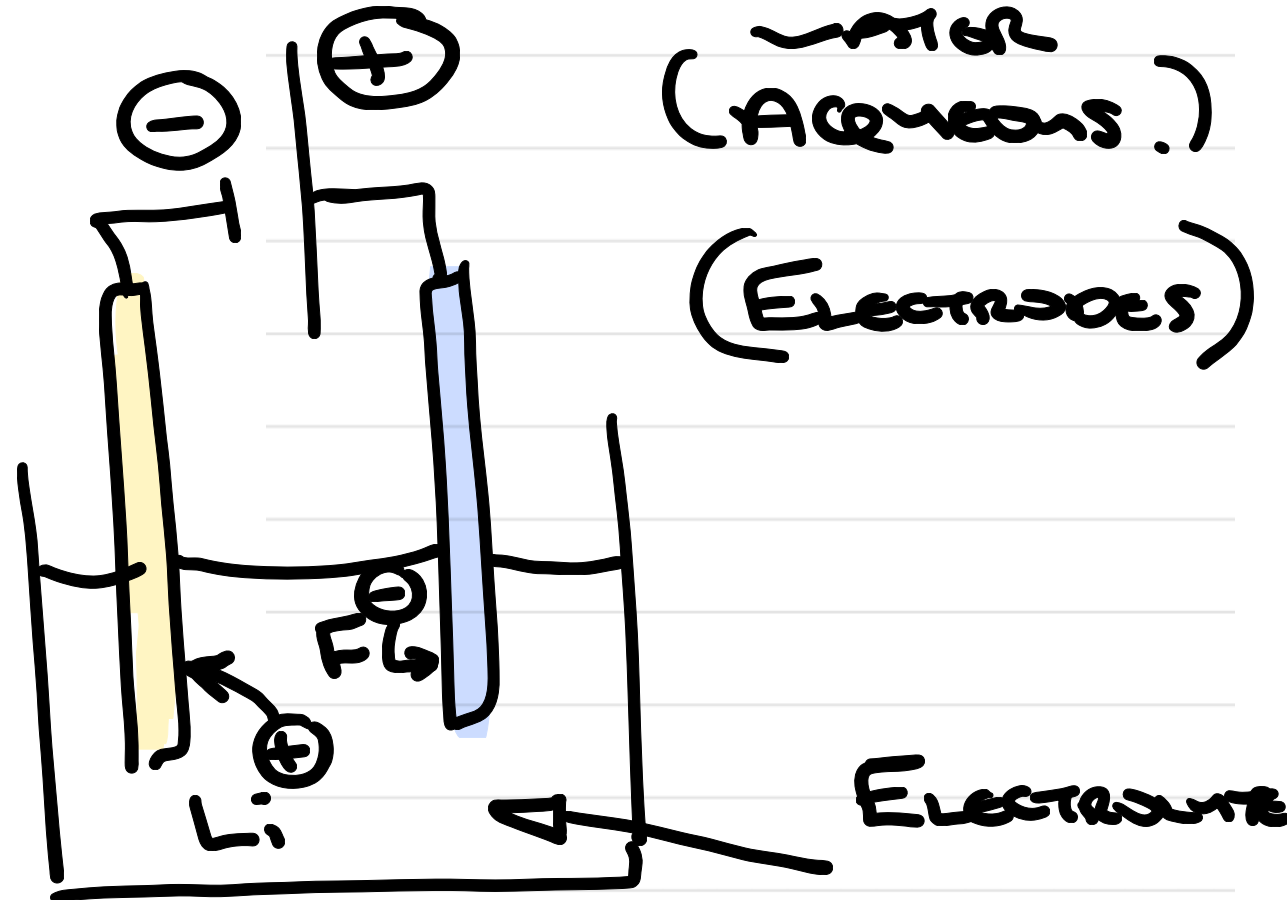
① CATHODE
⊕ ANODE

MOLTEN OR

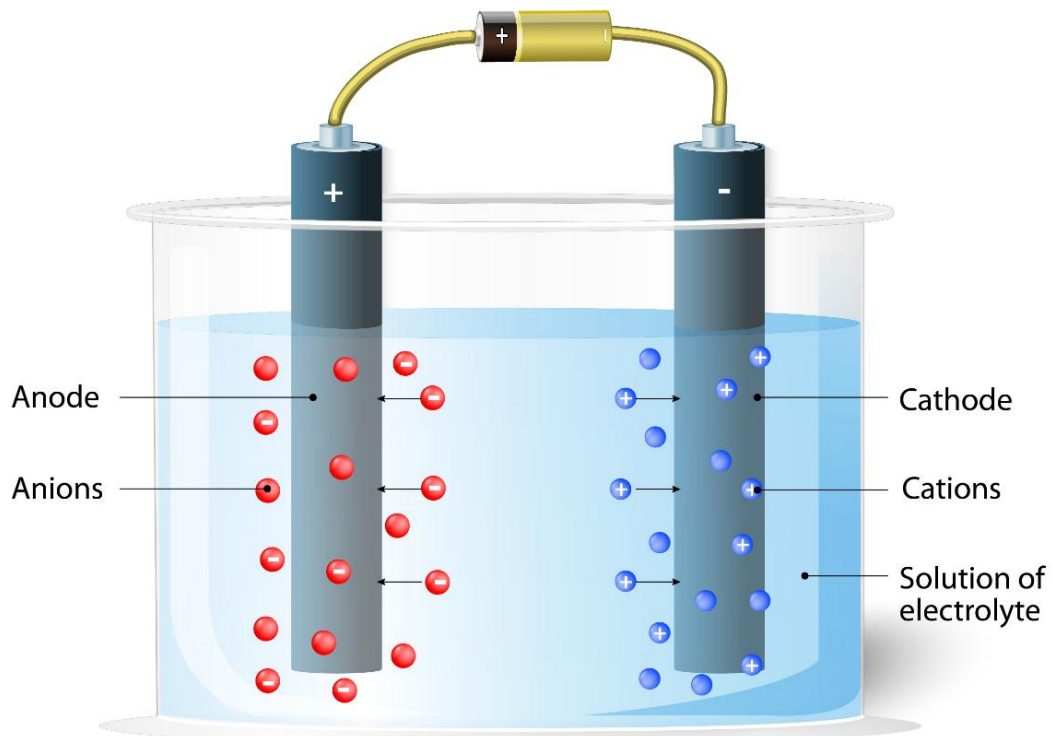
DISSOLVED IN

WATER
(AQUEOUS.)

(ELECTRODES)



Electrolysis Key Terms



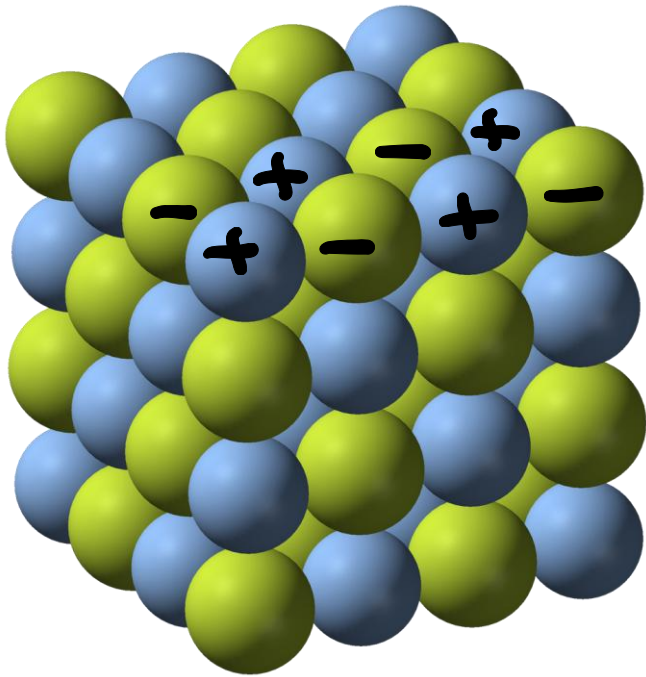
Key Term	What it means
Electrode	A conductor through which electricity enters or leaves
Anode	Oxidation occurs here The positive electrode
Cathode	Reduction occurs here The negative electrode
Electrolyte	A liquid or gel which contains ions
Ion	A charged particle

Aluminium



There would have been no aluminium before the mid 1800's

Ionic Lattice



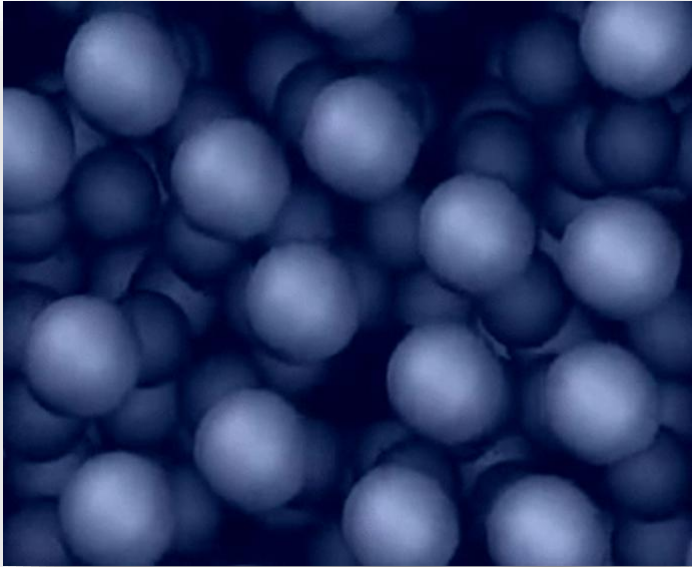
Electrolysis cannot occur when ionic materials are solid



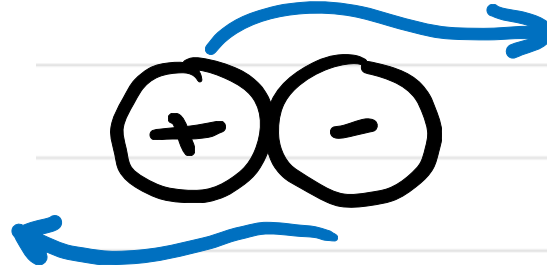
SOLID
(IONS
CANNOT
MOVE)

ELECTROLYTES CONDUCT
ELECTRICITY BECAUSE
IONS MOVE

Flowing ions



Ions need to be able to flow in order for electrolysis to work



What materials would be produced?

LITHIUM



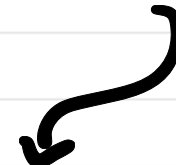
LITHIUM
(CATHODE)

FLUORIDE



FLUORINE
(ANODE)

SODIUM



SODIUM
(CATHODE)

OXIDE



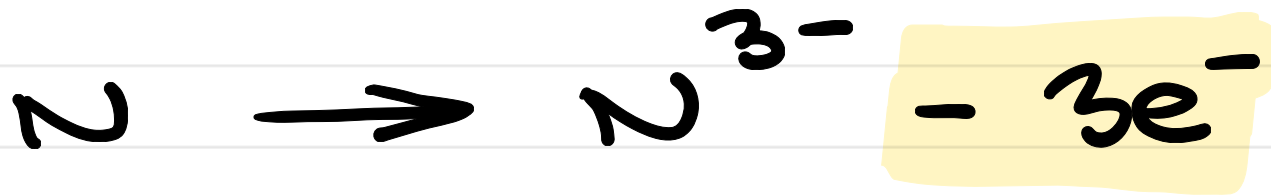
OXYGEN
(ANODE)

METALS ARE ALWAYS MADE AT THE CATHODE!

What materials would be produced? (MOLTEN)

Compound	What is collected at the cathode?	What is collected at the anode?
Lithium iodide	LITHIUM	IODINE
Calcium oxide	CALCIUM	OXYGEN
Aluminium bromide	ALUMINIUM	BROMINE
Magnesium sulphide	MAGNESIUM	SULPHUR

Notes:



FREE FLOWING

IONS

molten or Aqueous

Half equations

What is a half equation?

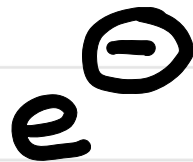
Molten sodium chloride

Molten hydrogen chloride

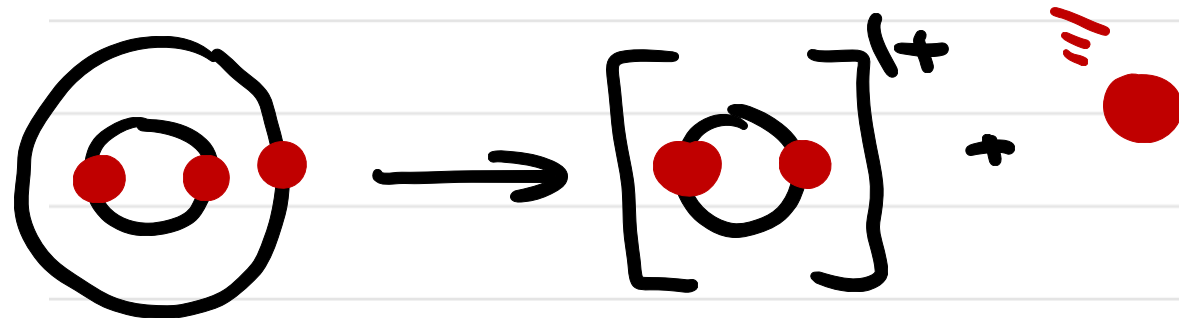
OIL/RIG

Molten calcium oxide

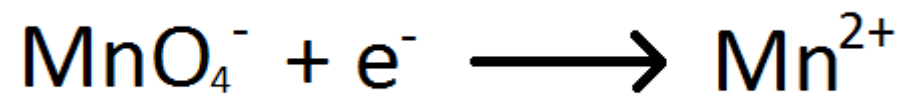
Molten aluminium nitride



Group 1



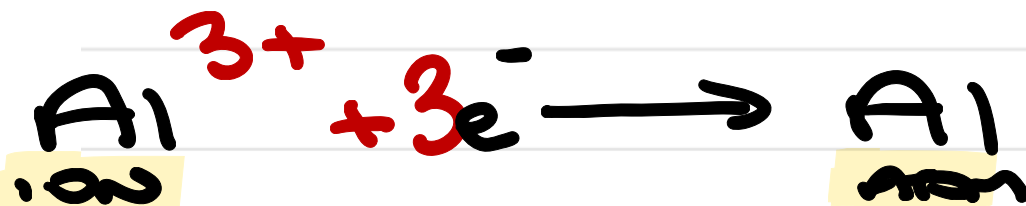
What is a half equation?



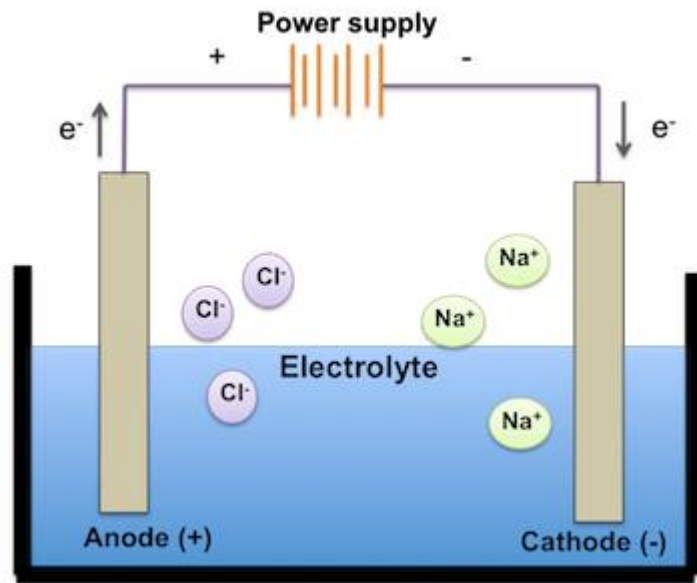
Group 2



Group 3

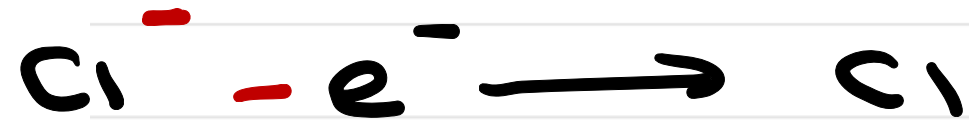
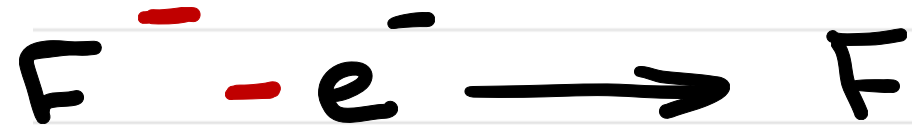


Electrolysis molten Sodium Chloride

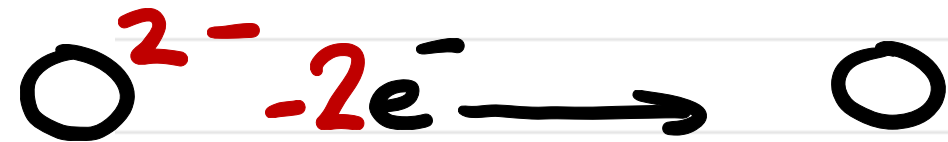


Half equations
Balance with e^-

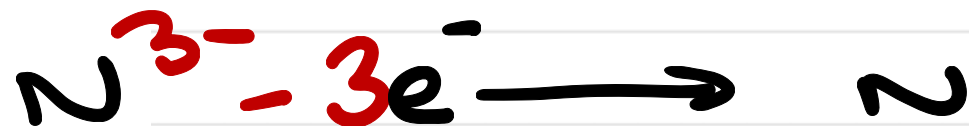
Group 7



Group 6



Group 5



OIL/RIG

Oxidation

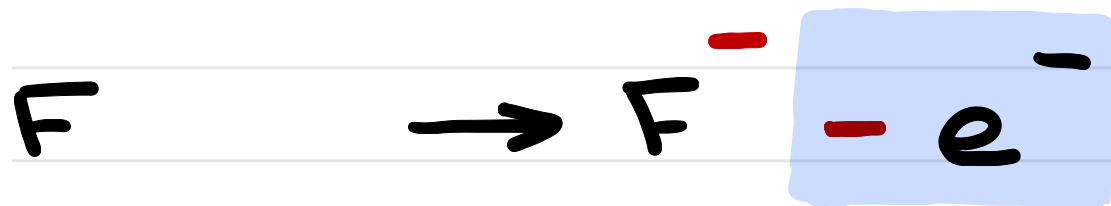
Is

Loss (of electrons)

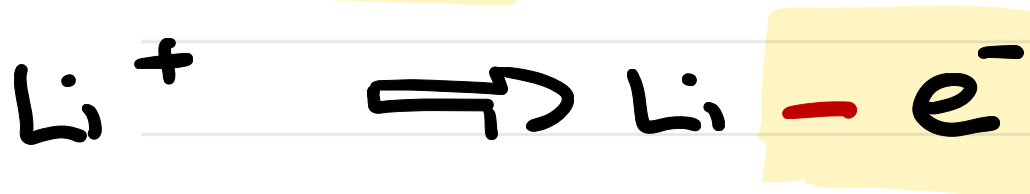
Reduction

Is

Gain (of electrons)



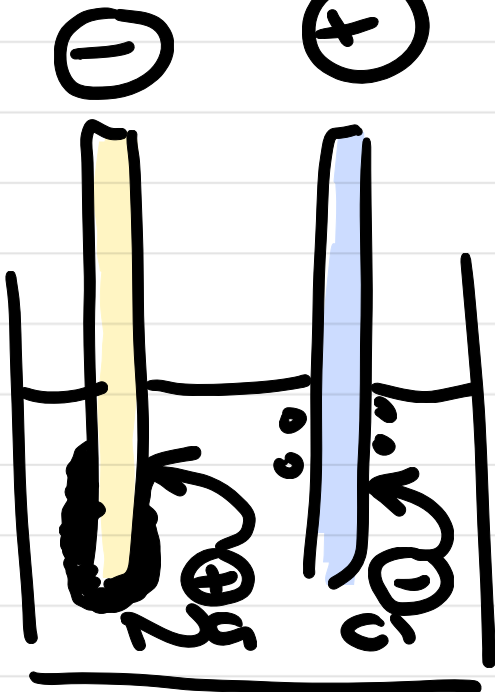
CHANGE THE SIDE CHANGE
THE SIGN :)



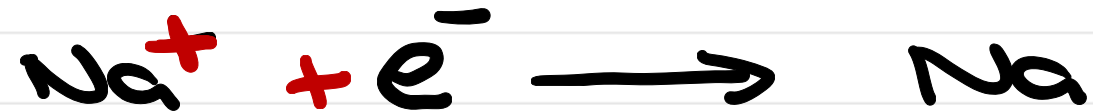
Electrolysis of molten sodium chloride

REDUCTION

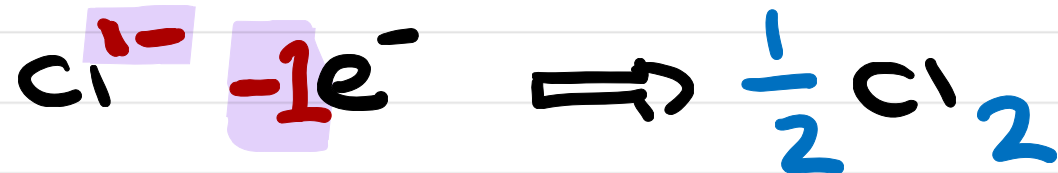
OXIDATION



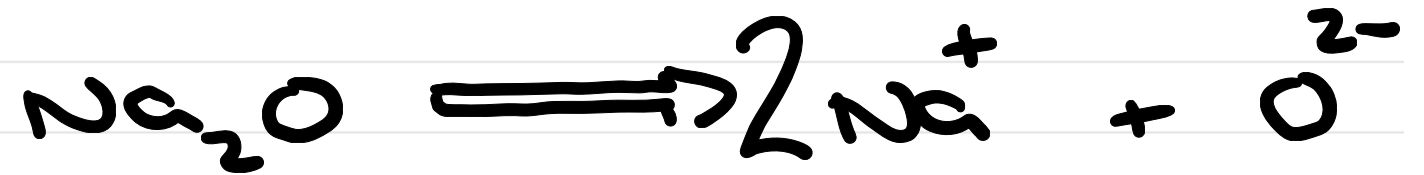
CATHODE



ANODE



Electrolysis of molten sodium oxide

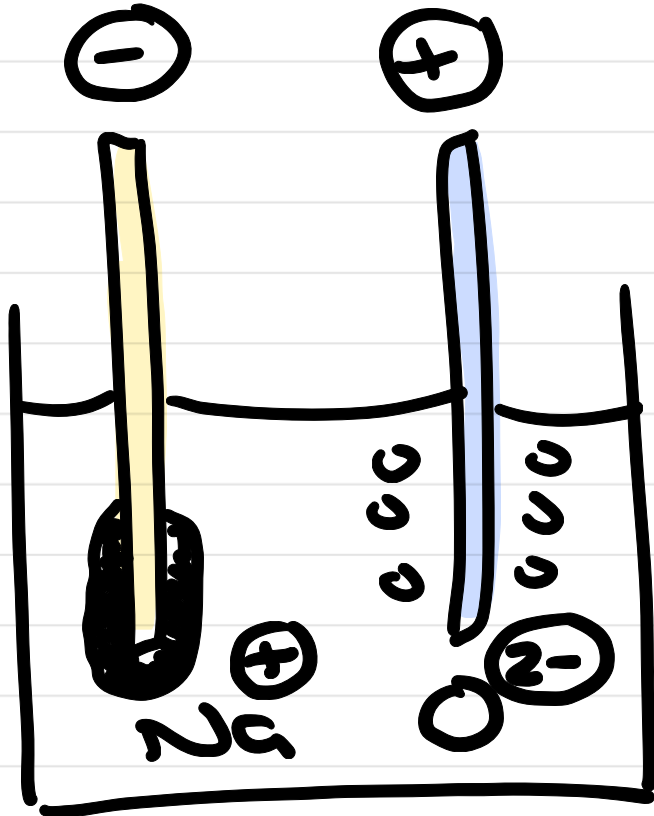
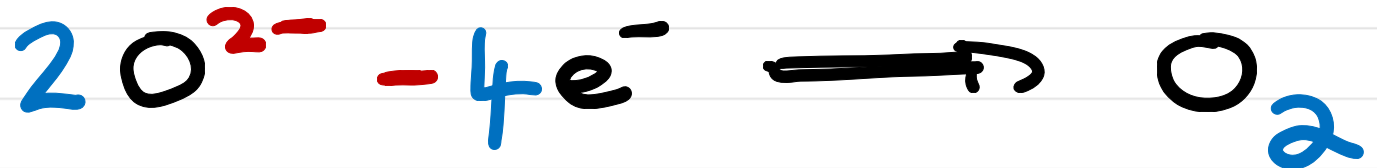


CATHODE

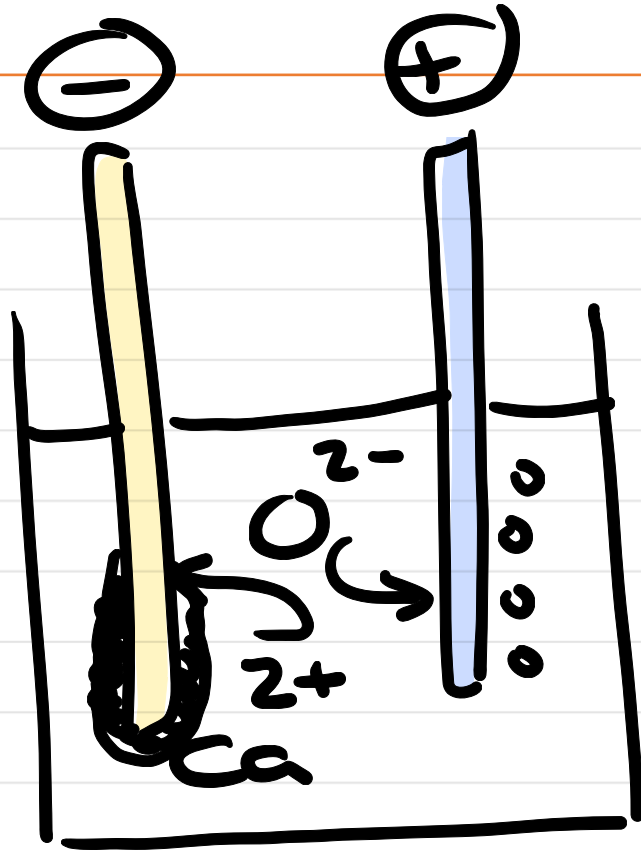


Red-ox

ANODE



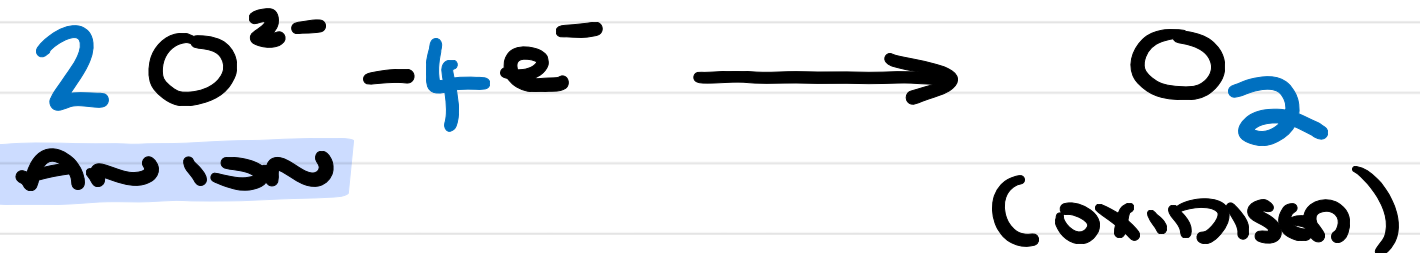
Electrolysis of molten calcium oxide



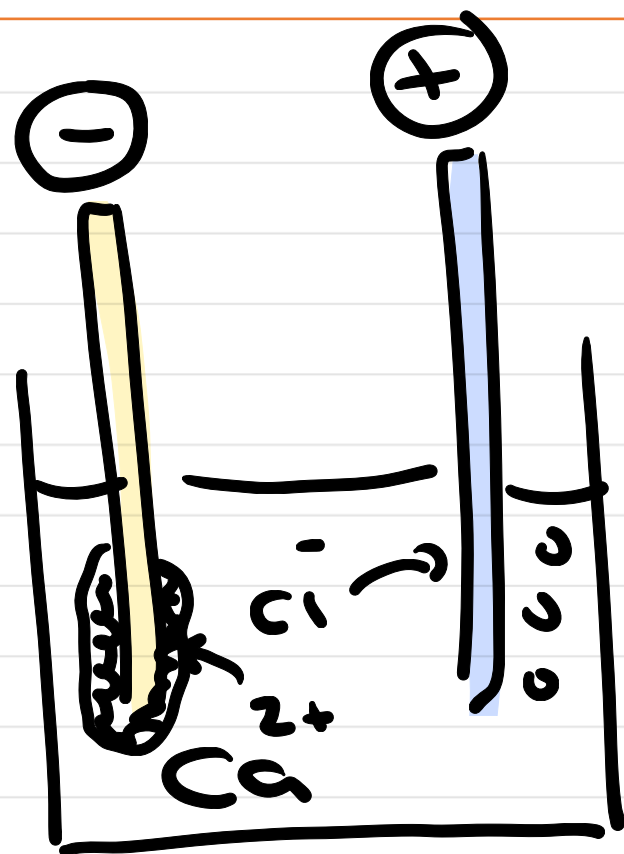
CATHODE



ANODE



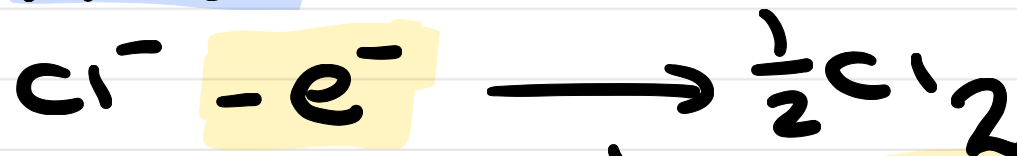
Electrolysis of molten calcium chloride



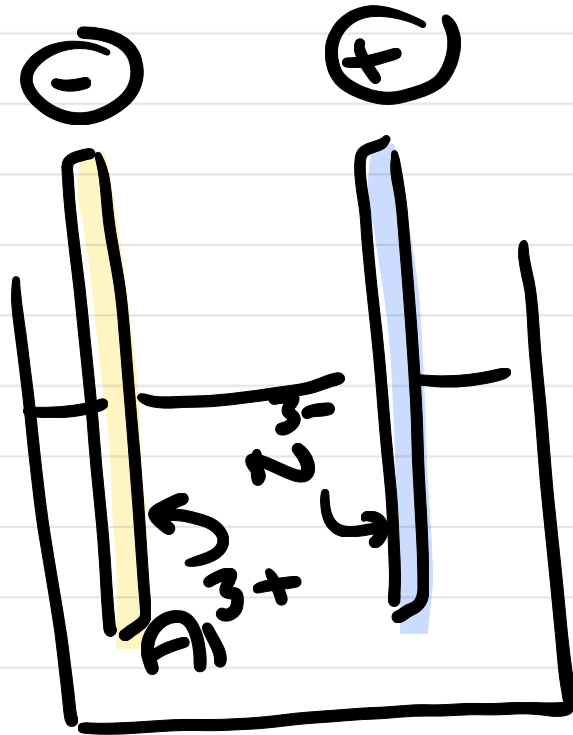
CATHODE



ANODE



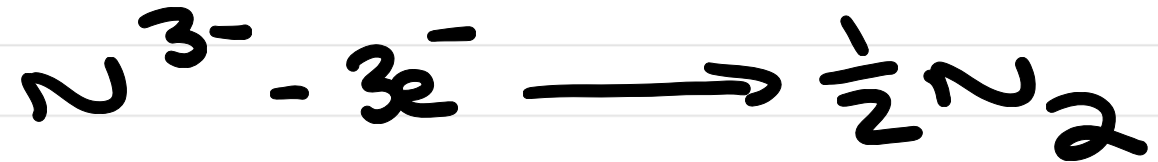
Electrolysis of molten aluminium nitride



CATHODE



ANODE



Notes:

Aluminium extraction

Aluminium ore

Half equations electrolysis molten bauxite

The giant bathtub

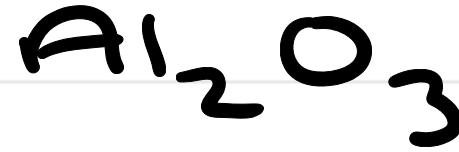
Graphite electrodes

Cryolite

Aluminium Ore: Bauxite



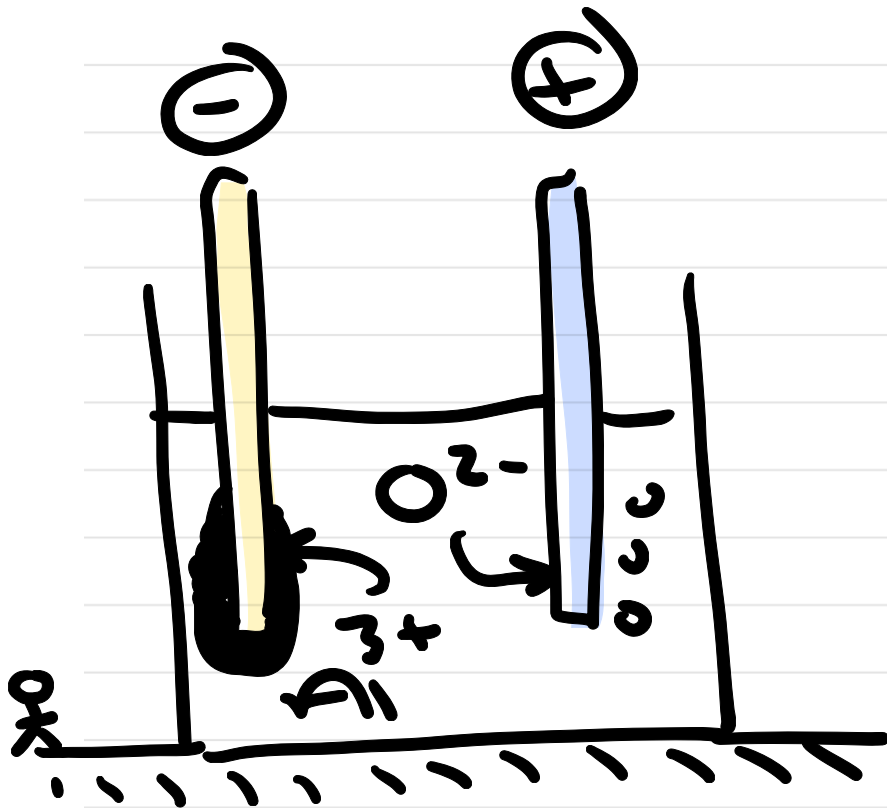
Pure aluminium was first obtained in 1825 by a Danish chemist called Hans-Christian



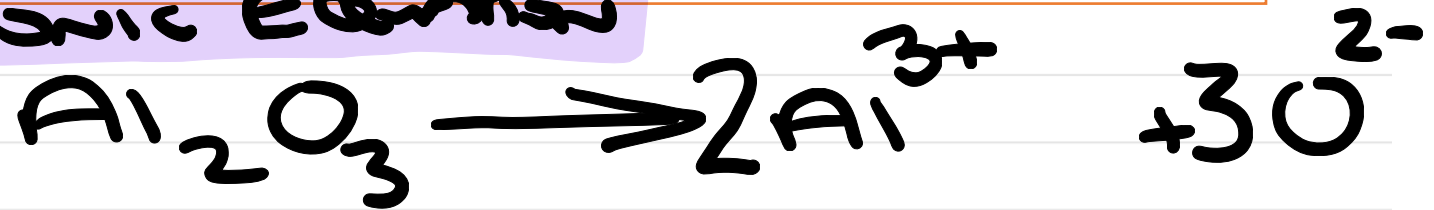
↳ BAUXITE

* CARS — LIGHT
CORROSION
RESISTANT.

Half equation electrolysis aluminium oxide



IONIC Equation



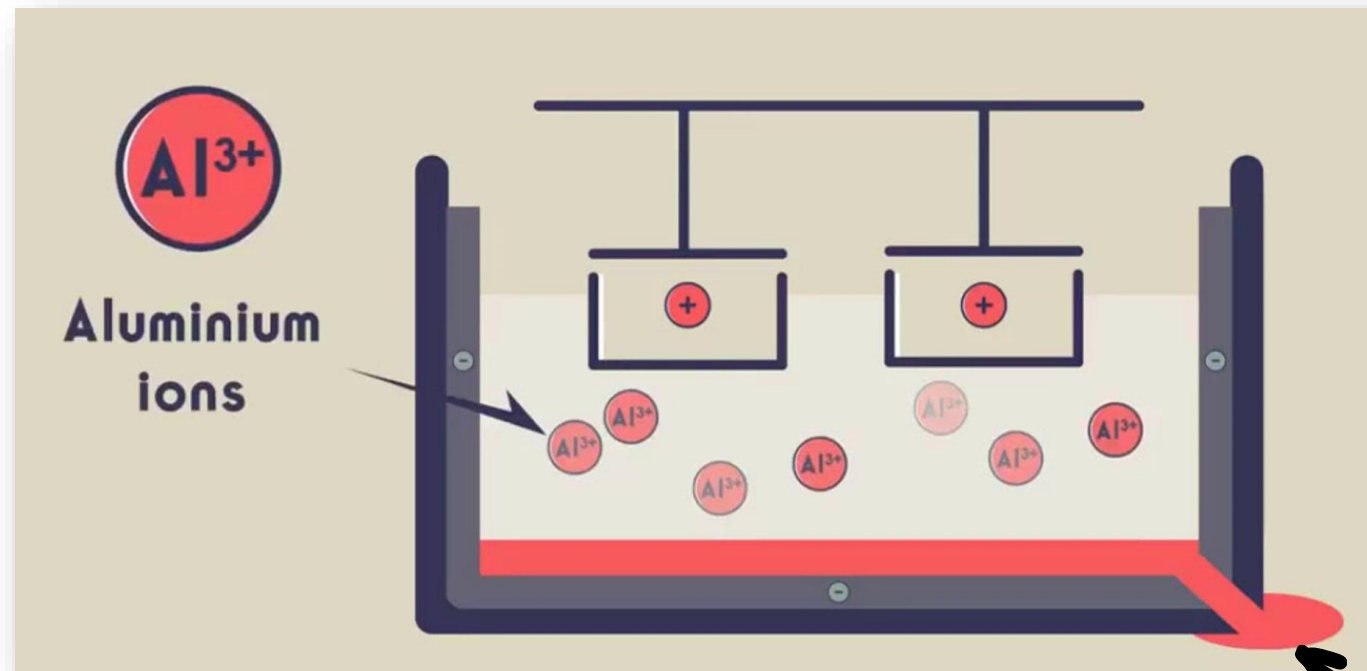
CATHODE



ANODE

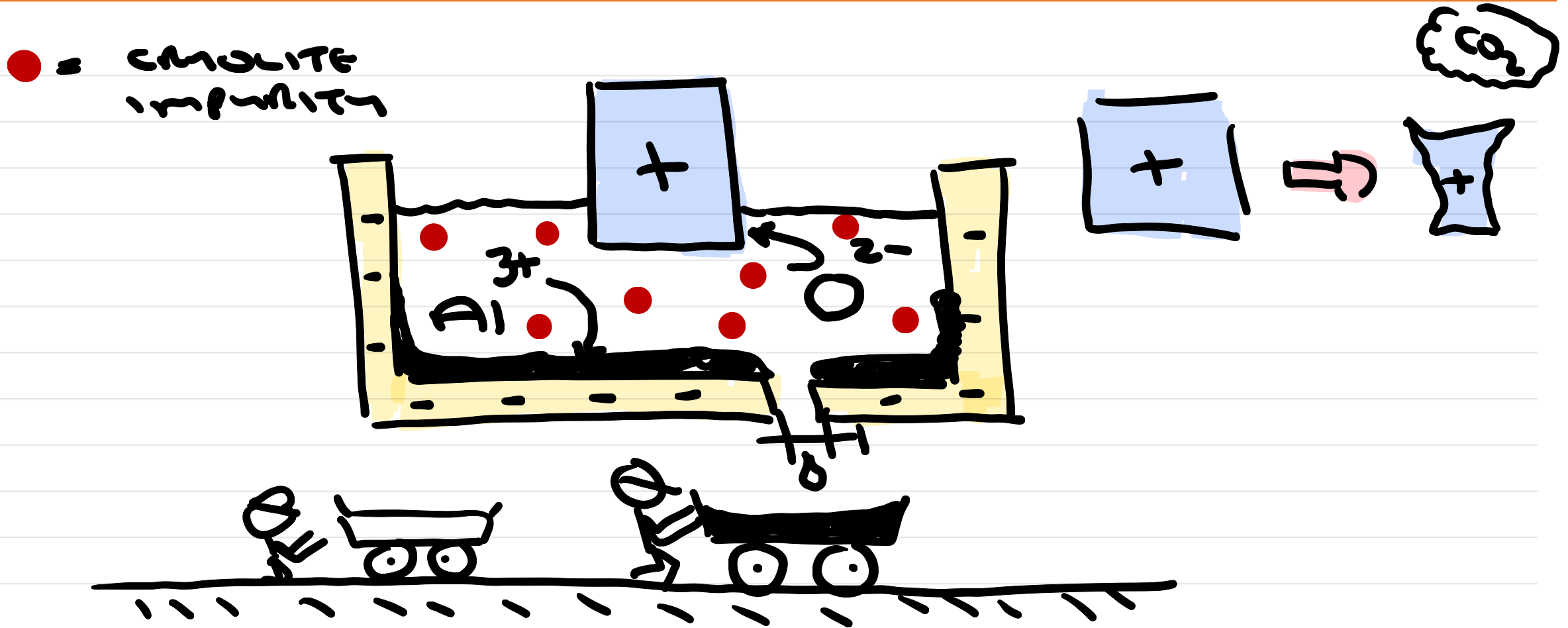


Extracting aluminium from Bauxite using a giant bathtub

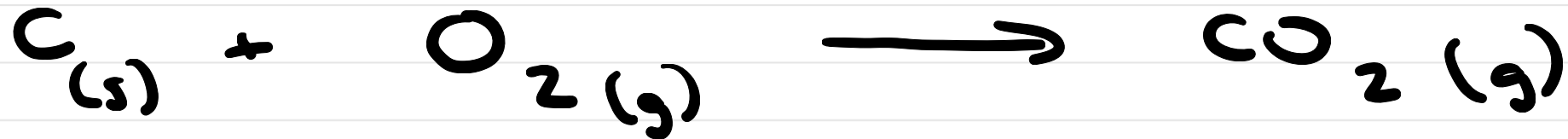


Aluminium (l)

Extracting aluminium from Bauxite using a giant bathtub



Graphite electrodes !



THE GRAPHITE ELECTRODES OXIDISE &

TURN INTO CARBON DIOXIDE

AFTER A WHILE, THE NEG REACTING

Cryolite

- impurity
- Lowest melting point
- Cheaper to melt.

Notes:

Electrolysis of an aqueous solutions

Electrolysis of aqueous ionic compounds

Aqueous sodium chloride

Aqueous calcium oxide

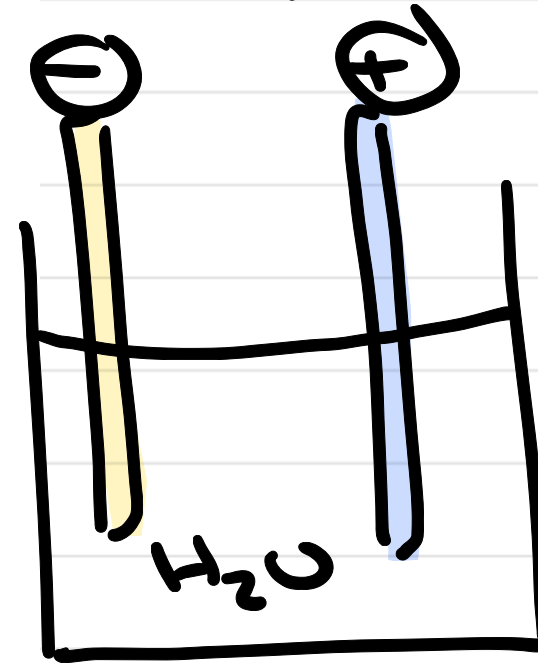
Aqueous aluminium nitride

Electrolysis of ionic salts

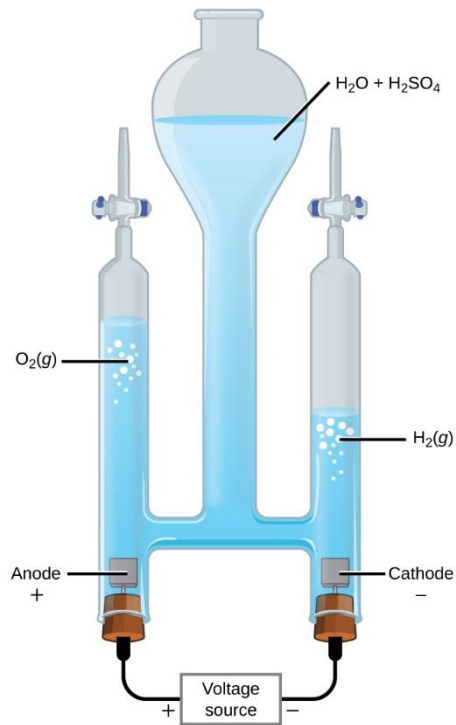
→ Dissolved in water



Ions can move



Electrolysis of water



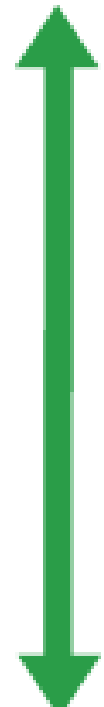
Half equations

Balance with e^-

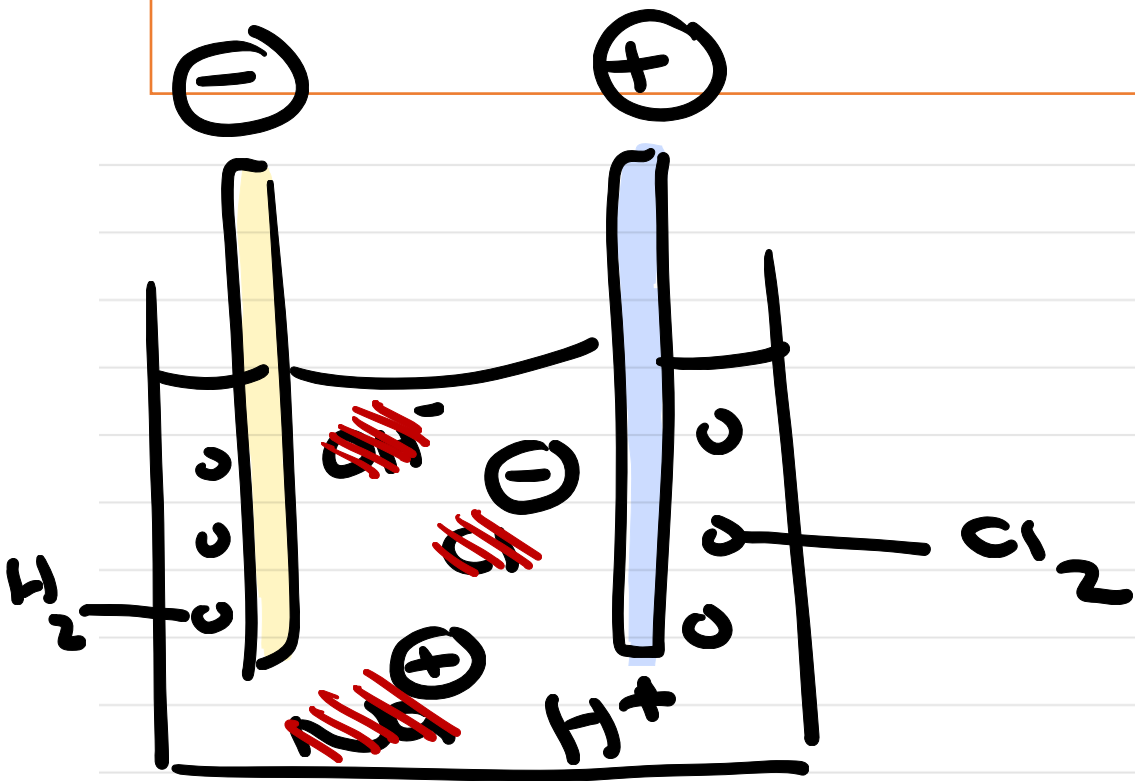
Electrolysis of aqueous ionic compounds

Metal compound	What's collected at the cathode
Metal less reactive than hydrogen	The metal
Metal more reactive than hydrogen	Hydrogen

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



Electrolysis $\text{NaCl}_{(\text{aq})}$



Potassium		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		Pt

Most reactive

Least reactive

Notes:



ANODE



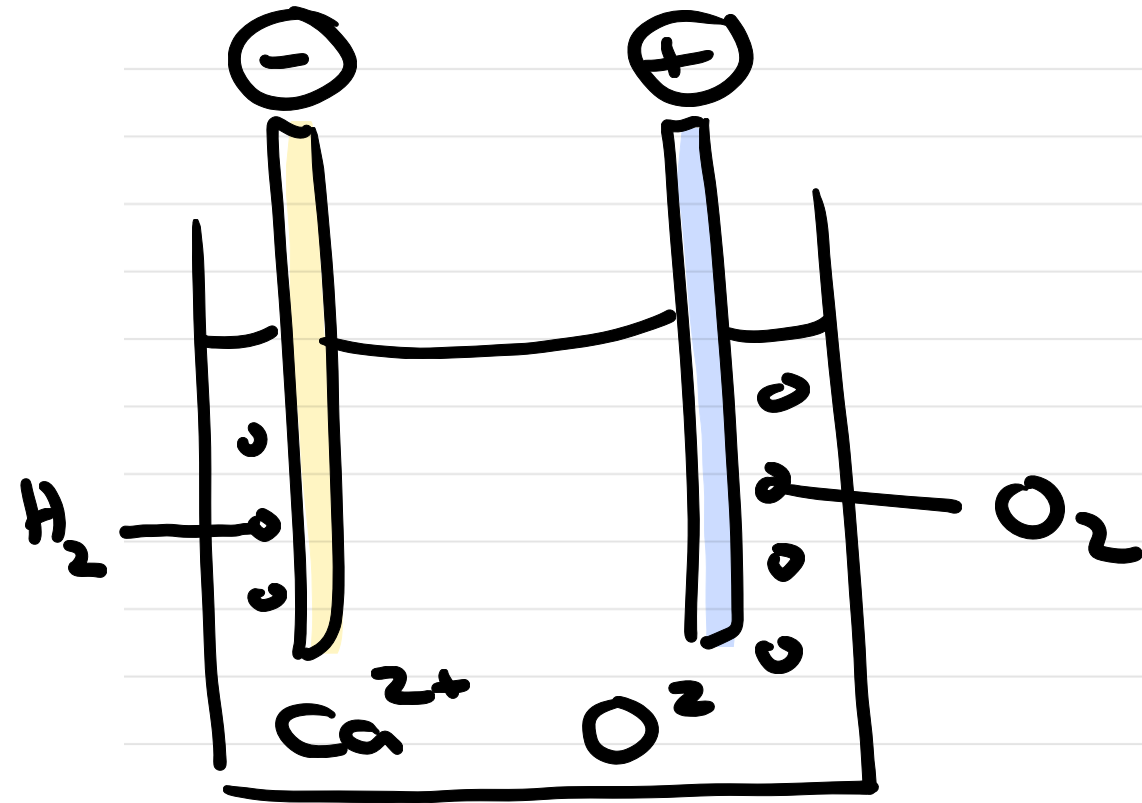
THE PRIZE



CATHODE



Electrolysis $\text{CaO}_{(\text{aq})}$



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

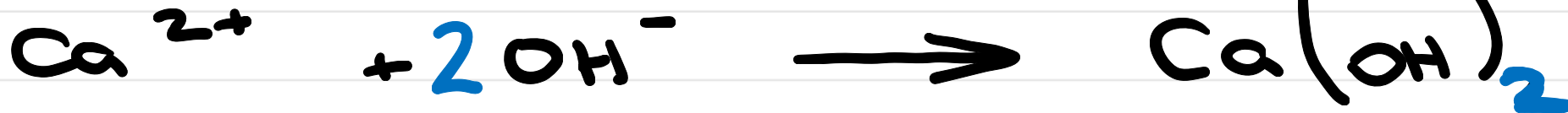
Notes:



Anode



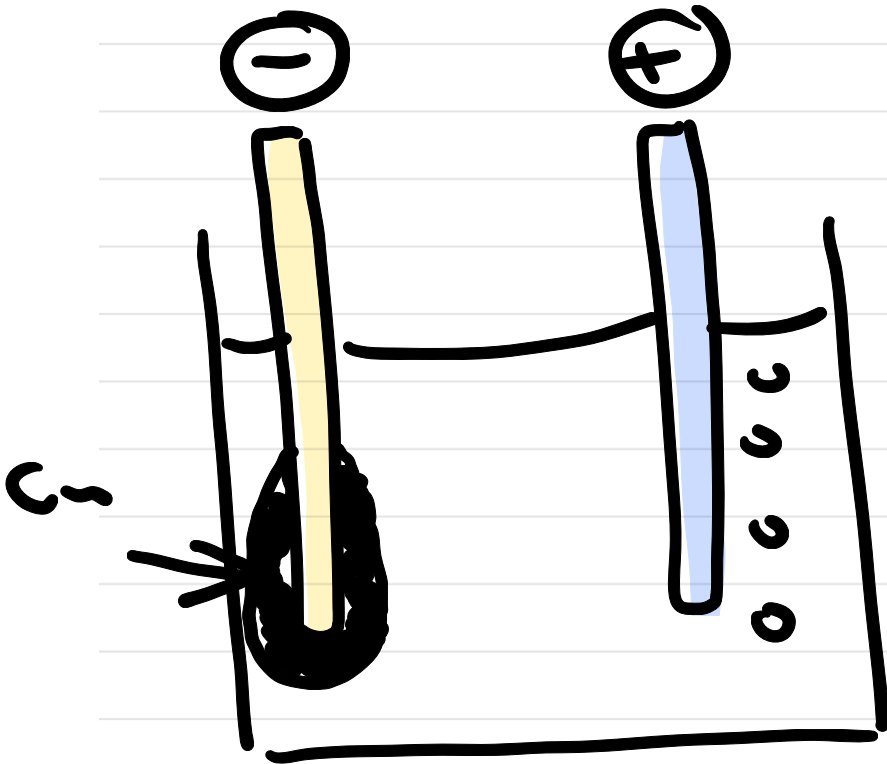
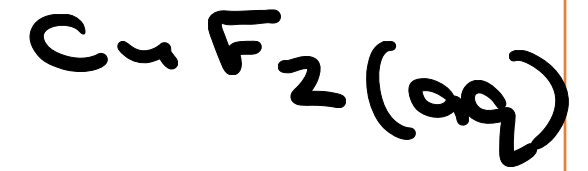
Prize



CATHODE



Electrolysis ~~Al₂O₃~~ (aq)



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

Notes:



ANODE

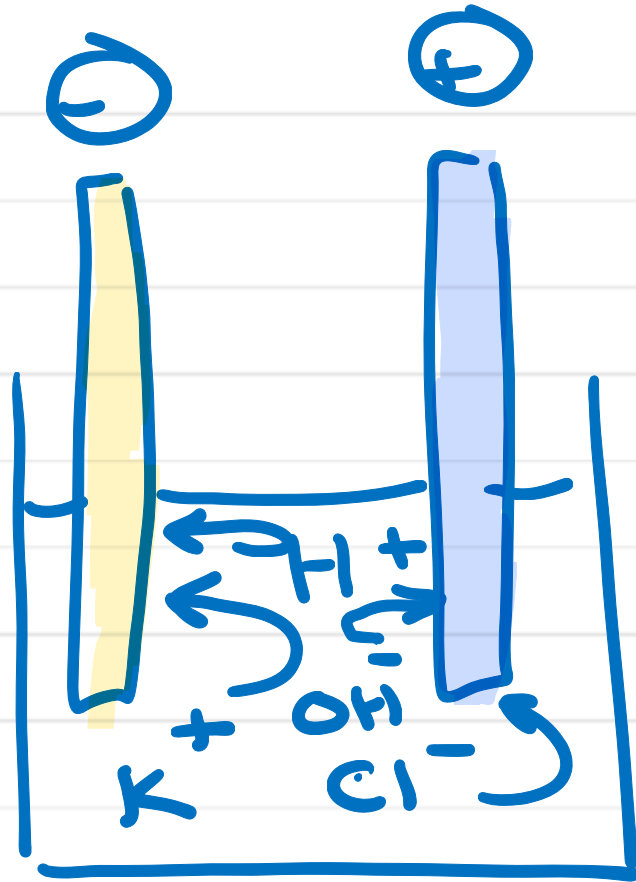


CATHODE



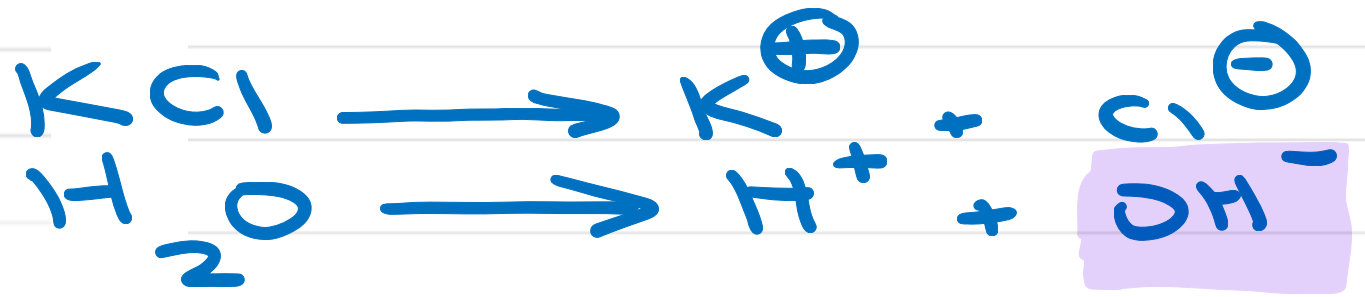
CATHODE





IF THE METAL
MORE REACTIVE THAN
HYDROGEN

H_2 COLLECTS
AT CATHODE



ANODE



Electrolysis of aqueous salts

"ATE"

Salt	What is evolved at anode
Sulphate Nitrate Phosphate	Oxygen

Prize winners



vs



+



→



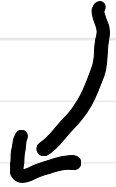
CATHODE



unreactive

Examples
compounds

COPPER



COPPER

SULPHATE (aq)



OXYGEN

COPPER



COPPER

SULPHIDE (aq)



SULPHUR

Examples

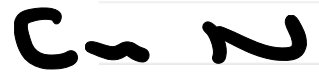
ATE

vs

IDE

(Simple compound
+ oxygen)

(Simple compound)



Examples

unreactive (less reactive than H)

SILVER

CHLORIDE (aq)



SILVER

CHLORINE

GOLD

FLUORATE



GOLD

OXYGEN

Notes:

REACTIVE METALS

POTASSIUM



Hydrogen

FLUORIDE (aq)



Fluorine

Sodium



Hydrogen

BROMATE



Oxygen

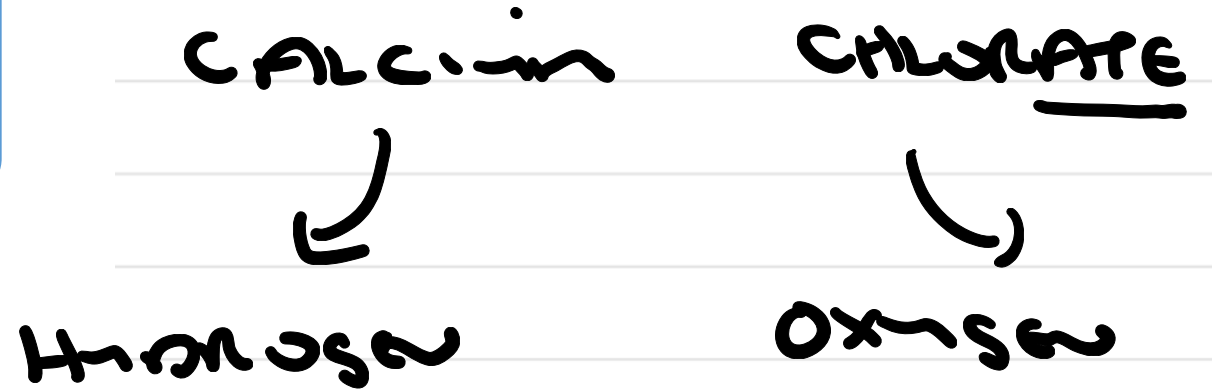
Metal purification and plating

Purifying impure copper

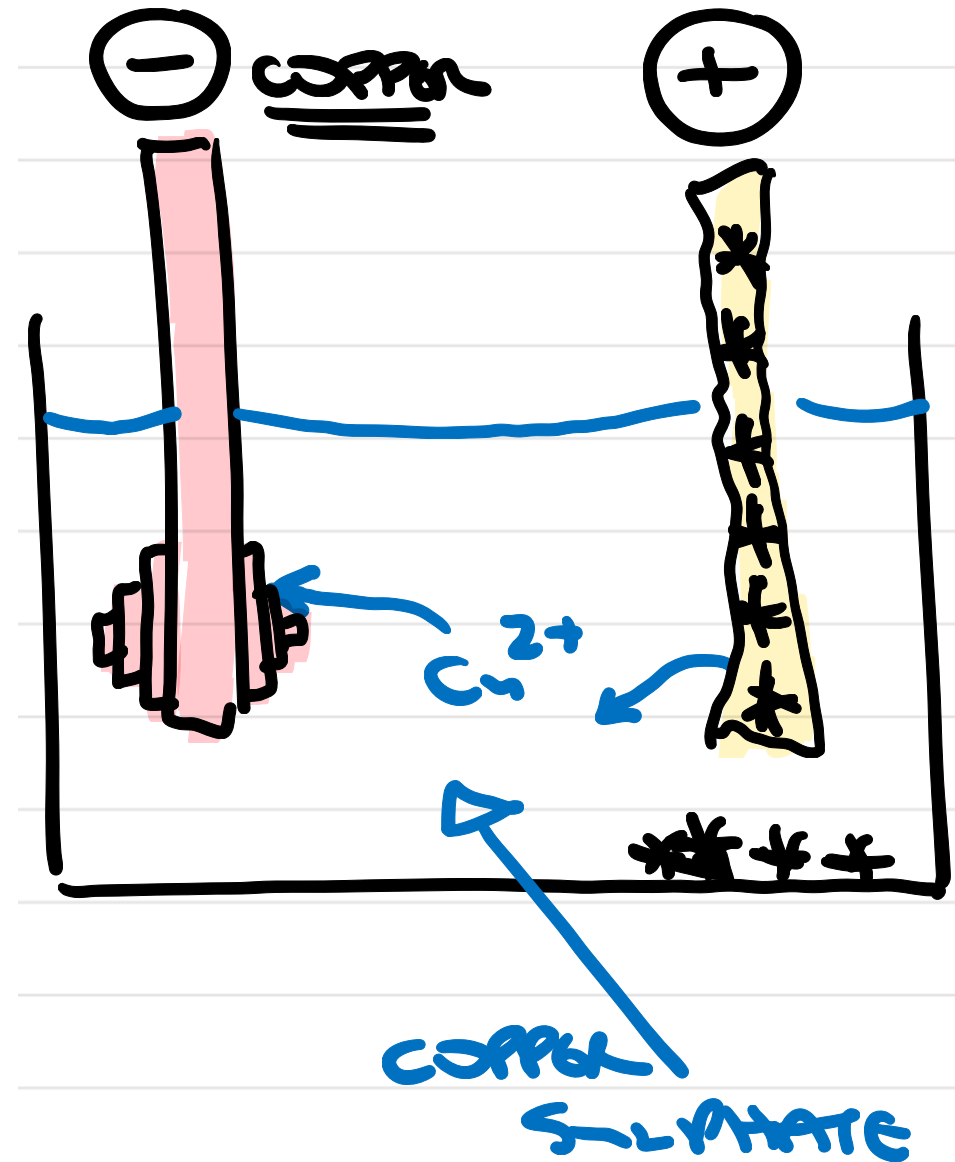
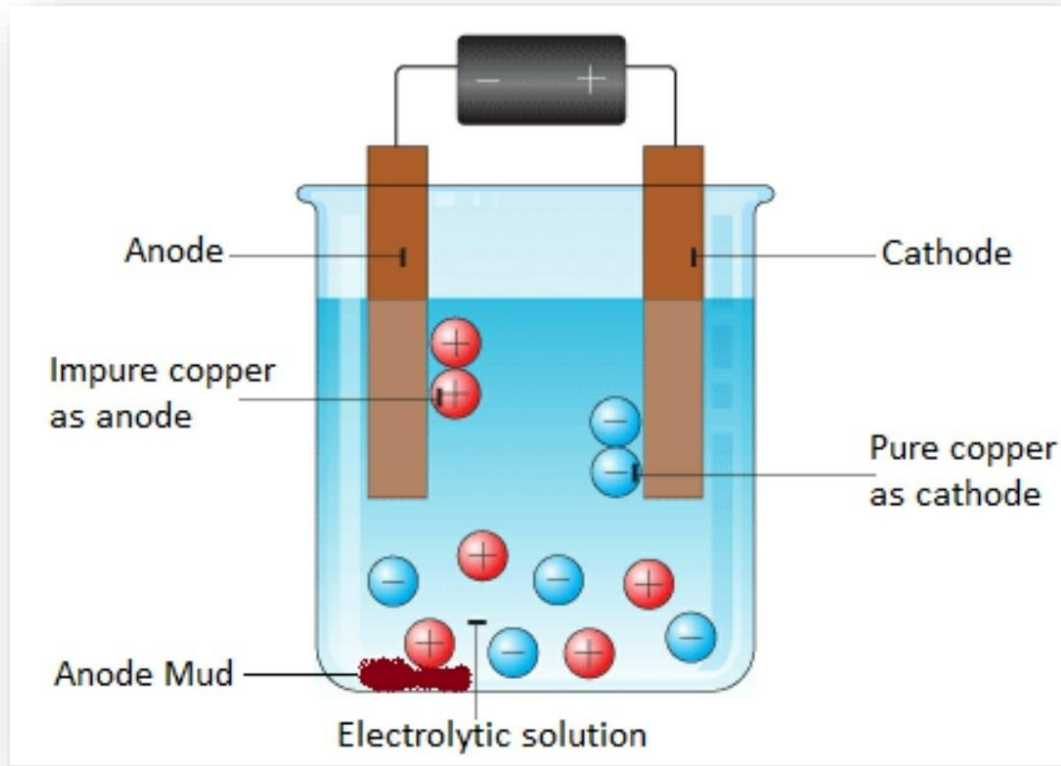
Copper plating

Silver plating

Making gold rings

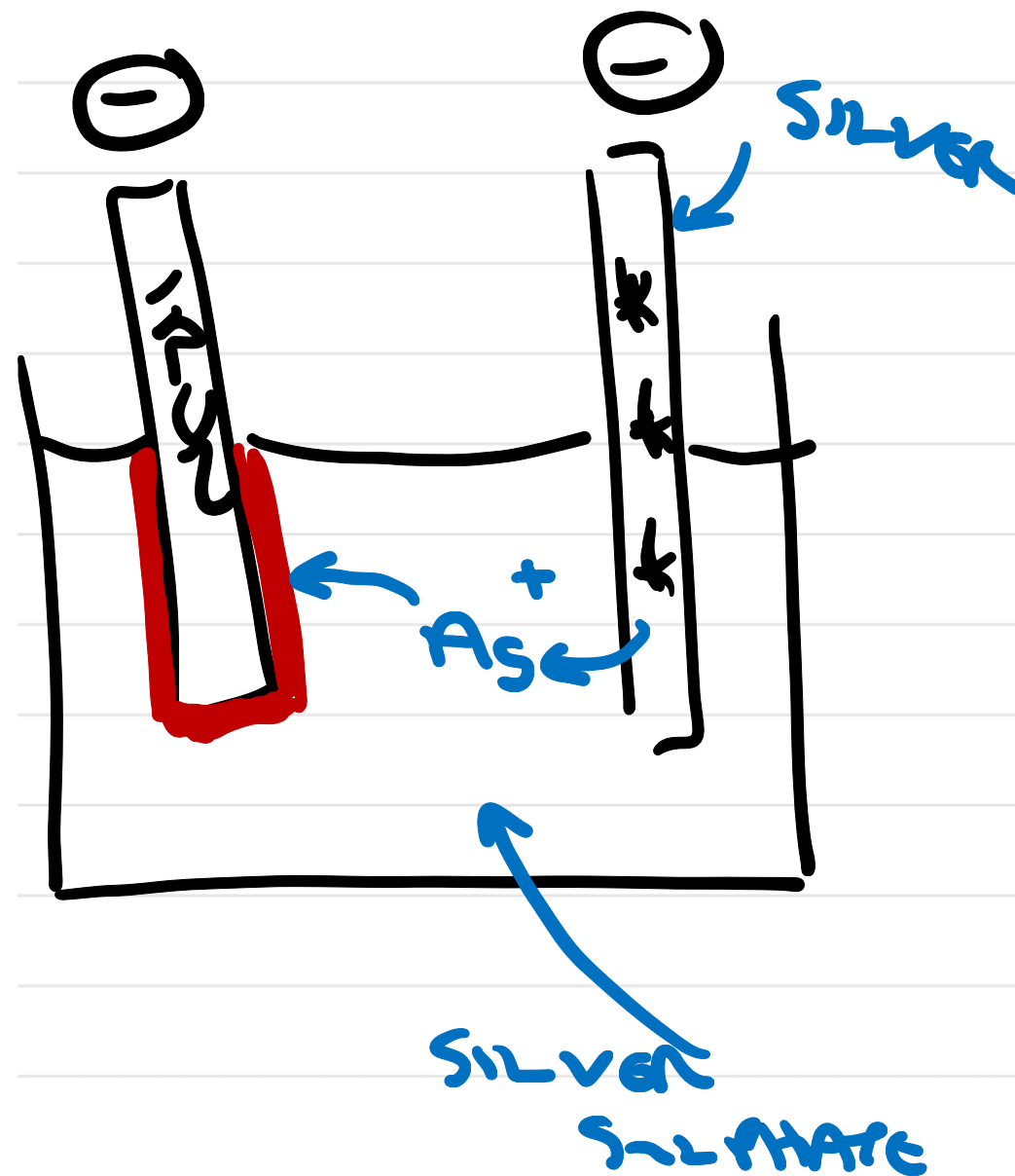
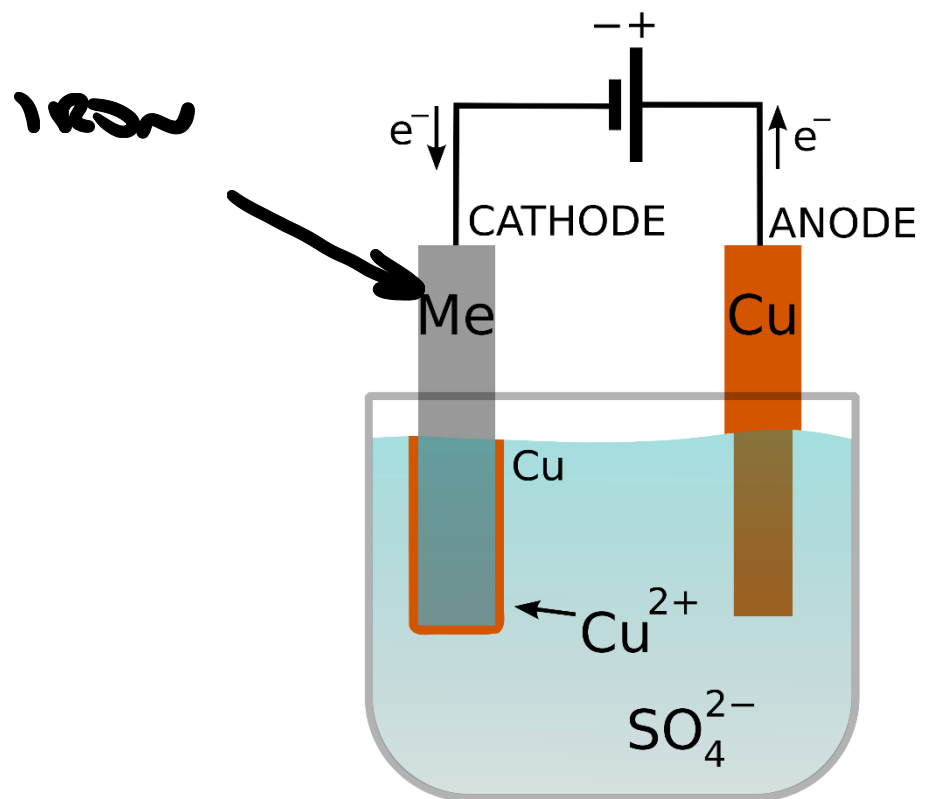


Purifying impure copper

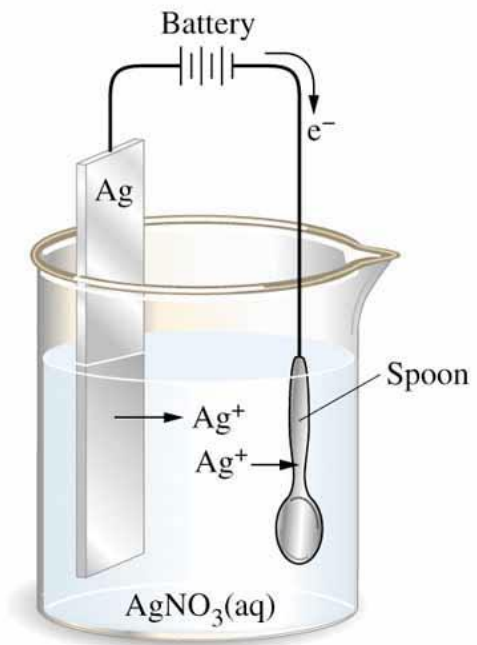


THIS IS HOW
PURIFYING COPPER TRICK
WORKS.

Copper plating



Silver plating



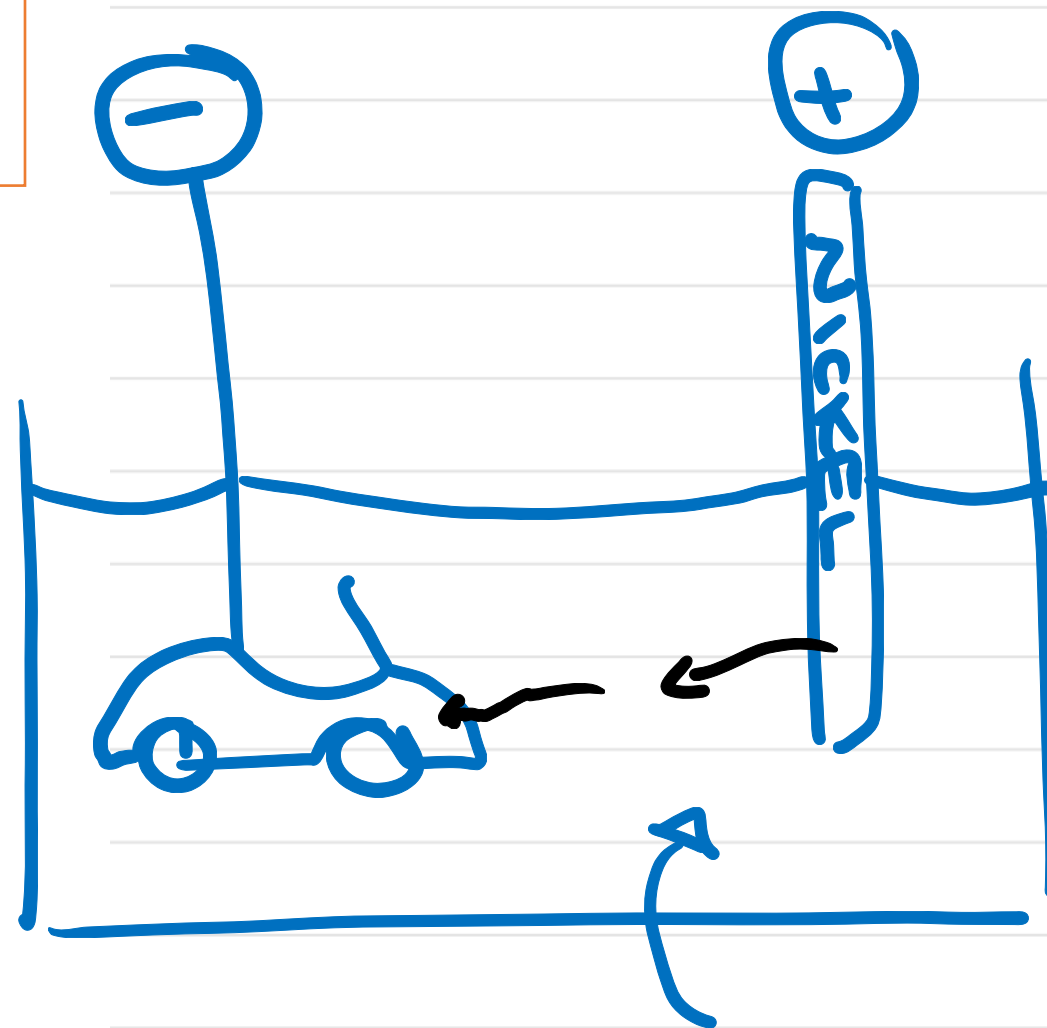
Gold plating



24
18

CARAT
CARAT

GOLD
GOLD



NICKEL
SULPHATE

Notes:

$$P_{\text{crit}} = \frac{12}{24} \times 100 = 75\%$$

Practice Questions

Question	Answer
Define the term smelting and explain its limitations	SMELT - HEAT WITH CARBON ONLY WORKS ON ELEMENTS LESS REACTIVE THAN CARBON
What is a metal ore?	ROCK CONTAINING AN ECONOMICALLY EXTRACTABLE AMOUNT OF A METAL
Define the term electrolysis	ELECTROLYTIC DECOMPOSITION
Explain the difference between an anode and a cathode	ANODE :- POSITIVE ELECTRODE (NON METALS) CATHODE :- NEGATIVE ELECTRODE (METALS)
What is always given off at the cathode when reactive metal aqueous solutions are electrolysed?	HYDROGEN !

Notes: