ALJAZEERA CHEMISTRY
BY KHALID M JAMA



Lesson 1

a) Extraction and uses of metals

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5.1 explain how the methods of extraction of the metals in this section are related to their positions in the reactivity series

5.2 describe and explain the extraction of aluminium from purified aluminium oxide by electrolysis, including:

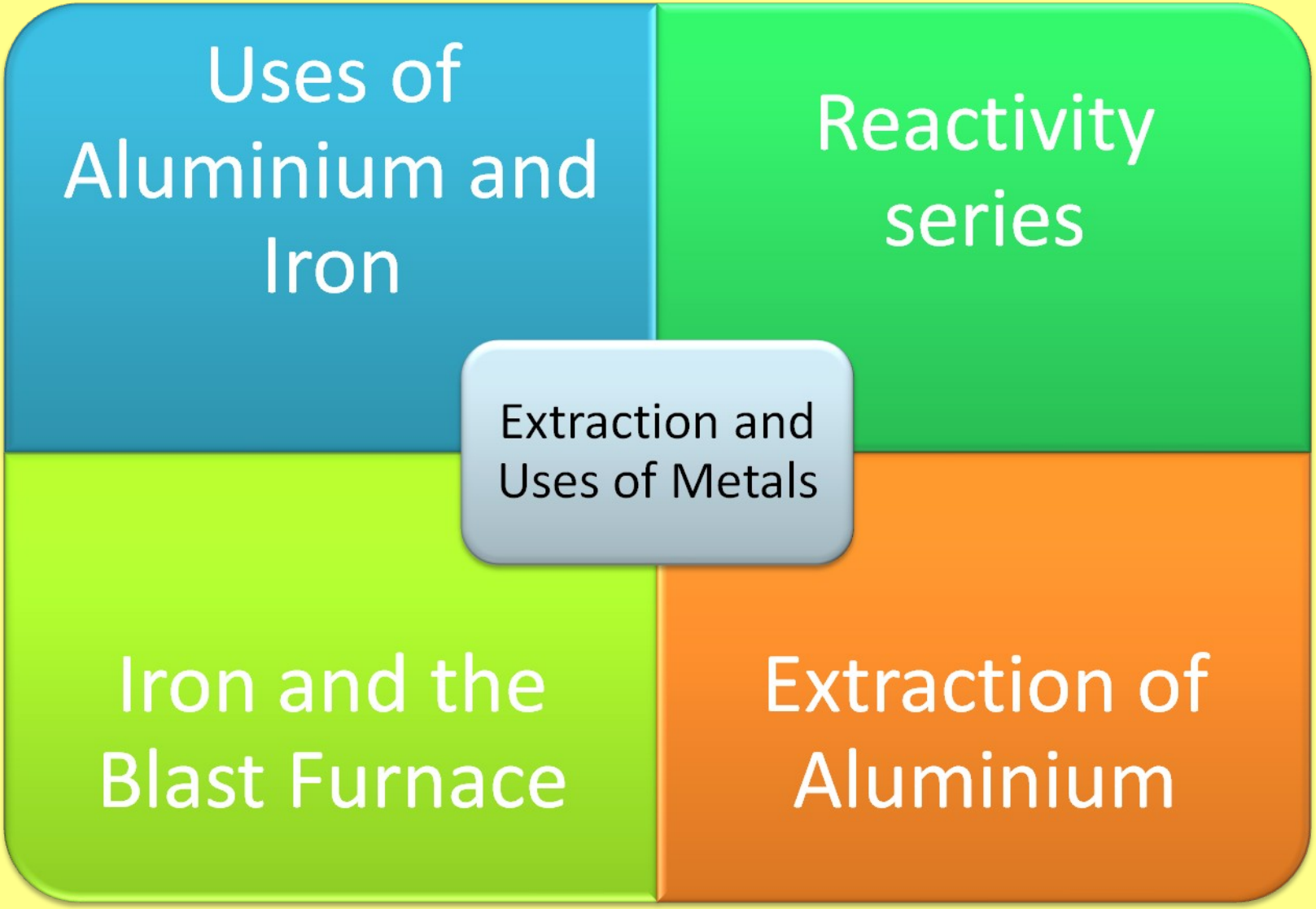
i the use of molten cryolite as a solvent and to decrease the required operating temperature

ii the need to replace the positive electrodes

iii the cost of the electricity as a major factor

5.3 write ionic half-equations for the reactions at the electrodes in aluminium extraction

5.4 describe and explain the main reactions involved in the extraction of


Uses of Aluminium and Iron
Reactivity series
Extraction and Uses of Metals
Iron and the Blast Furnace
Extraction of Aluminium

The Reactivity Series of Metals

GOLD

IRON



SODIUM

Which of these metals is the most reactive?

MAGNESIUM

The Reactivity Series of Metals

GOLD

To help with this, we have the REACTIVITY SERIES

IRON

SODIUM



MAGNESIUM

The Reactivity Series of Metals

GOLD

To help with this, we have the

THE REACTIVITY SERIES OF METALS LISTS METALS ACCORDING TO THEIR GENERAL REACTIVITY, FROM MOST REACTIVE TO LEAST REACTIVE

S

MAGNESIUM



The Reactivity Series of Metals

Very reactive	POTASSIUM K SODIUM Na CALCIUM Ca
Fairly reactive	MAGNESIUM Mg ALUMINIUM Al (CARBON) ZINC Zn IRON Fe
Not very reactive	LEAD Pb (HYDROGEN) COPPER Cu SILVER Ag
Not at all reactive	GOLD Au PLATINUM Pt

The Reactivity Series of Metals

Very reactive	POTASSIUM K
	SODIUM Na
	CALCIUM Ca
Fairly reactive	MAGNESIUM Mg
	ALUMINIUM Al
	(CARBON)
	ZINC Zn
	IRON Fe
Not very reactive	LEAD Pb
	(HYDROGEN)
	COPPER Cu
	SILVER Ag
Not at all reactive	GOLD Au
	PLATINUM Pt

Metals above carbon must be extracted from their ores by electrolysis

The Reactivity Series of Metals

Very reactive

Fairly reactive

Not very reactive

Not at all reactive

M

LEAD Pb
(HYDROGEN)
COPPER Cu
SILVER Ag
GOLD Au
PLATINUM Pt

carbon
acted
es by
sis

An ORE is a type of rock that contains minerals with important elements including metals.



The Reactivity Series of Metals

Very reactive	M	
Fairly reactive		
Not very reactive	LEAD	Pb
	(HYDROGEN)	
	COPPER	Cu
Not at all reactive	SILVER	Ag
	GOLD	Au
	PLATINUM	Pt

carbon
acted
es by
sis

ELECTROLYSIS is the process by which ionic substances are broken down into simpler substances when an electric current is passed through them.



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	SODIUM Na
	CALCIUM Ca
Fairly reactive	MAGNESIUM Mg
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Metals above carbon must be extracted from their ores by electrolysis

Metals below carbon can be extracted from their ores using reduction with coke or charcoal

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carbon
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on can be
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REDUCTION is a chemical reaction in which oxygen is removed from a compound.



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	CALCIUM Ca
Fairly reactive	MAGNESIUM Mg
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Not at all reactive	GOLD Au
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Metals above carbon must be extracted from their ores by electrolysis

Metals below carbon can be extracted from their ores using reduction with coke or charcoal

Metals below hydrogen don't react with water or acid. They don't easily tarnish or corrode.

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Not very reactive	LEAD Pb
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Not at all reactive	GOLD Au
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The reactivity series depends upon three standard reactions. These reactions are with:

1.AIR
2.WATER
3.DILUTE ACID

The Reactivity Series of Metals

		Reaction with AIR
Very reactive	POTASSIUM K SODIUM Na CALCIUM Ca	Burn very easily with a bright flame
Fairly reactive	MAGNESIUM Mg ALUMINIUM Al (CARBON) ZINC Zn IRON Fe	React slowly with air when heated
Not very reactive	LEAD Pb (HYDROGEN) COPPER Cu	
Not at all reactive	SILVER Ag GOLD Au PLATINUM Pt	No reaction

The Reactivity Series of Metals

		Reaction with WATER
Very reactive	POTASSIUM K SODIUM Na CALCIUM Ca	React with cold water
Fairly reactive	MAGNESIUM Mg ALUMINIUM Al (CARBON)	React with steam
	ZINC Zn IRON Fe	Reacts reversibly with steam
Not very reactive	LEAD Pb (HYDROGEN)	
Not at all reactive	COPPER Cu SILVER Ag GOLD Au PLATINUM Pt	No reaction with water or steam

The Reactivity Series of Metals

		Reaction with DILUTE ACID
Very reactive	POTASSIUM K SODIUM Na CALCIUM Ca	Violent reaction with dilute acids
Fairly reactive	MAGNESIUM Mg ALUMINIUM Al (CARBON) ZINC Zn IRON Fe	React fairly well with dilute acids
Not very reactive	LEAD Pb (HYDROGEN) COPPER Cu	No reaction with dilute acids
Not at all reactive	SILVER Ag GOLD Au PLATINUM Pt	

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Metals above carbon must be extracted from their ores by electrolysis

Metals below carbon can be extracted from their ores using reduction with coke or charcoal

Metals below hydrogen don't react with water or acid. They don't easily tarnish or corrode.

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	ALUMINIUM	Al
	(CARBON)	
	ZINC	Zn
	IRON	Fe
Not very reactive	LEAD	Pb
	(HYDROGEN)	
	COPPER	Cu
	SILVER	Ag
Not at all reactive	GOLD	Au
	PLATINUM	Pt

Metals above ca… must b… f… ores by electrolysis

eg. Aluminium

Metals below carbon can be extracted from their ores using reduction with coke or charcoal

Metals below hydrogen don't react with water or acid. They don't easily tarnish or corrode.

Extracting Aluminium from Bauxite

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Bauxite is impure aluminium oxide, Al_2O_3



Extracting Aluminium from Bauxite

Bauxite is impure aluminium oxide, Al_2O_3



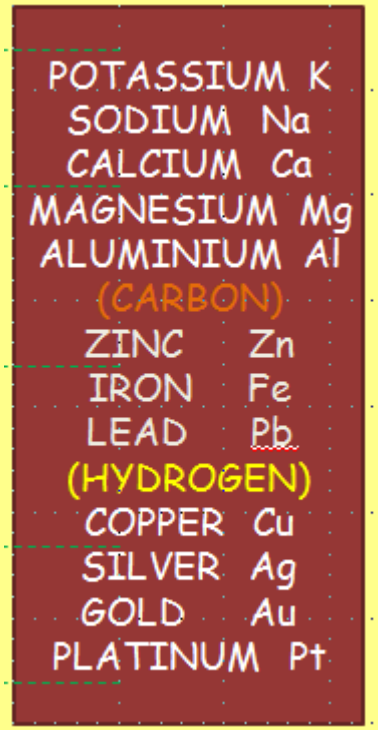
Because aluminium is high up in the reactivity series, a lot of energy is needed to extract it – this energy comes from ELECTRICITY

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SODIUM Na
CALCIUM Ca
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ALUMINIUM Al
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Extracting Aluminium from Bauxite

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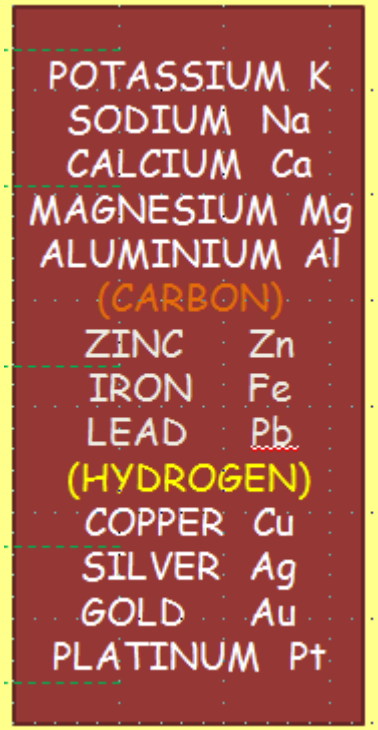
ELECTROLYSIS is the term used for the extraction of a metal from its' ore. This technique is used for all metals above CARBON in the reactivity series.



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After mining and purifying of bauxite, a white powder is left.



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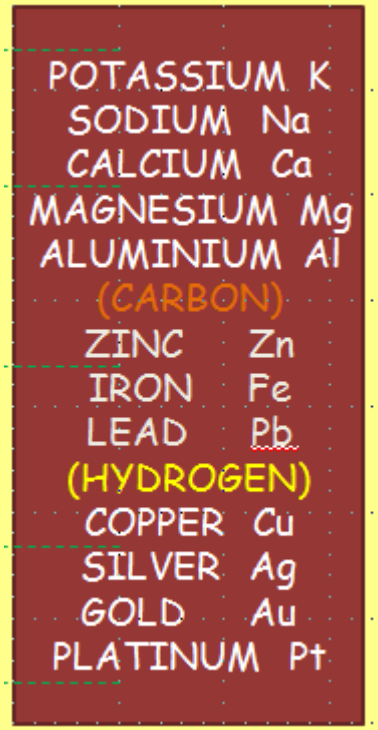
ELECTROLYSIS is the term used for the extraction of a metal from its' ore. This technique is used for all metals above CARBON in the reactivity series.
After mining and purifying of bauxite, a white powder is left.
This is pure aluminium oxide, Al_2O_3, which melts at over 2000°C.

POTASSIUM K
SODIUM Na
CALCIUM Ca
MAGNESIUM Mg
ALUMINIUM Al
(CARBON)
ZINC Zn
IRON Fe
LEAD Pb
(HYDROGEN)
COPPER Cu
SILVER Ag
GOLD Au
PLATINUM Pt

Extracting Aluminium from Bauxite

Because aluminium is high up in the reactivity series, a lot of energy is needed to extract it – this energy comes from ELECTRICITY

For electrolysis to work, the oxide needs to be in a molten state. To achieve this, the aluminium oxide is dissolved in molten cryolite.

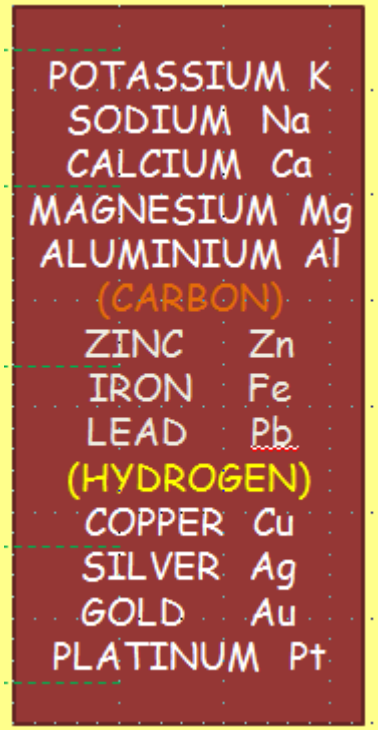


Extracting Aluminium from Bauxite

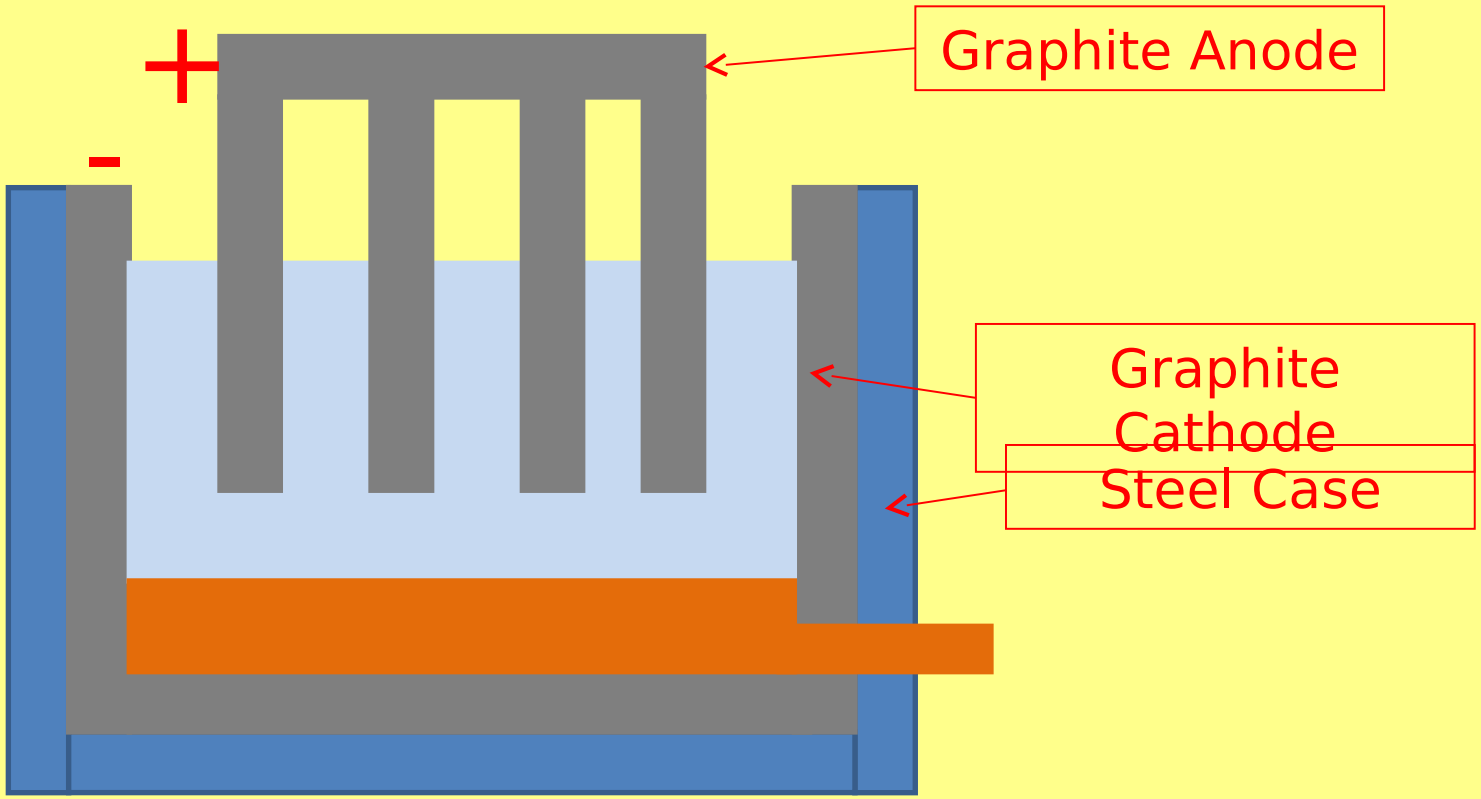
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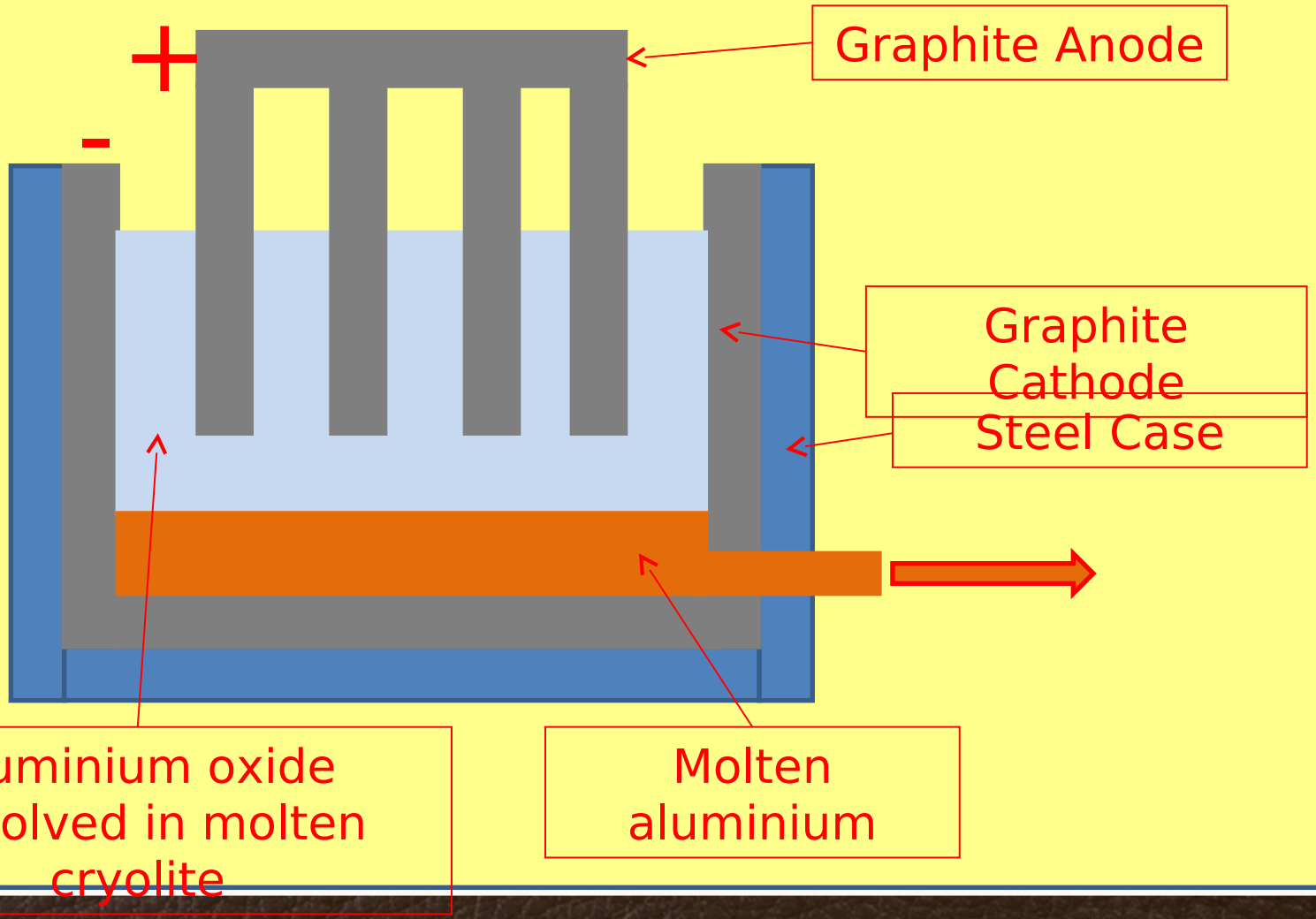
This reduces the temperature down to about 900°C which makes the process of electrolysis much cheaper and easier.



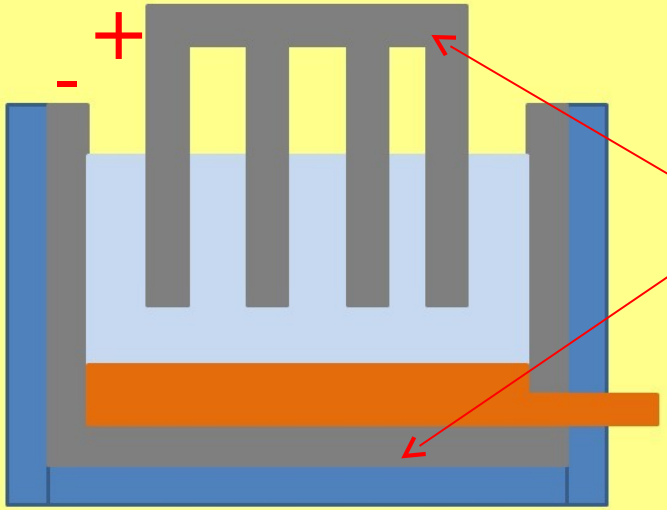
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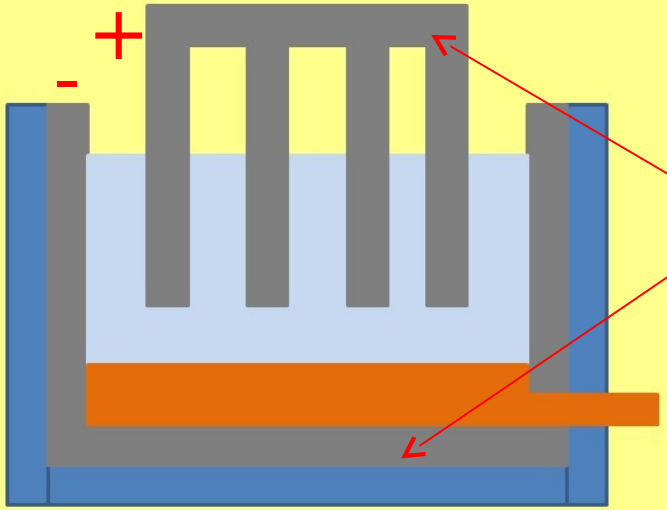


Extracting Aluminium from Bauxite



The electrodes are made of graphite (carbon). The graphite anode reacts with oxygen to form CO_2, so it needs to be replaced quite often.

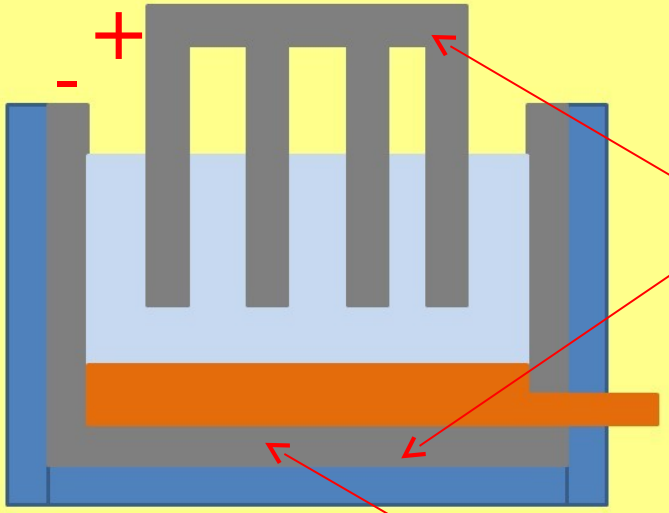
Extracting Aluminium from Bauxite



The electrodes are made of graphite (carbon). The graphite anode reacts with oxygen to form CO_2, so it needs to be replaced quite often.

When molten, the Al_2O_3 dissociates into the ions, Al^{3+} and O^{2-}

Extracting Aluminium from Bauxite

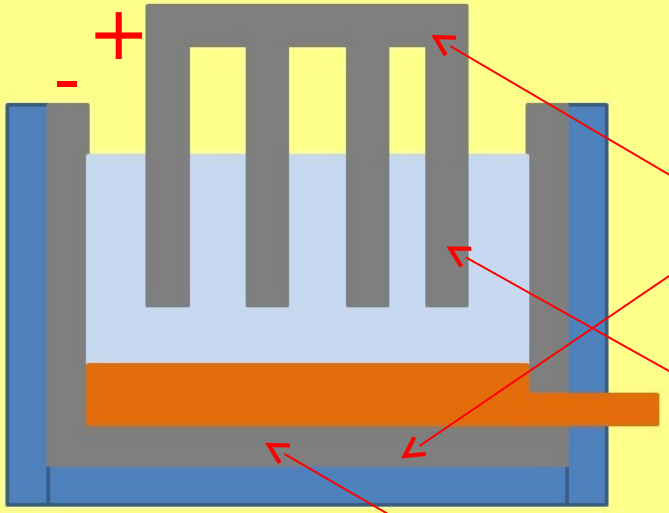


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The positive ion, Al^{3+}, will be attracted towards the negative cathode.

Extracting Aluminium from Bauxite



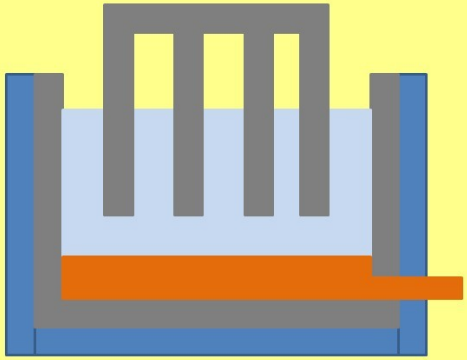
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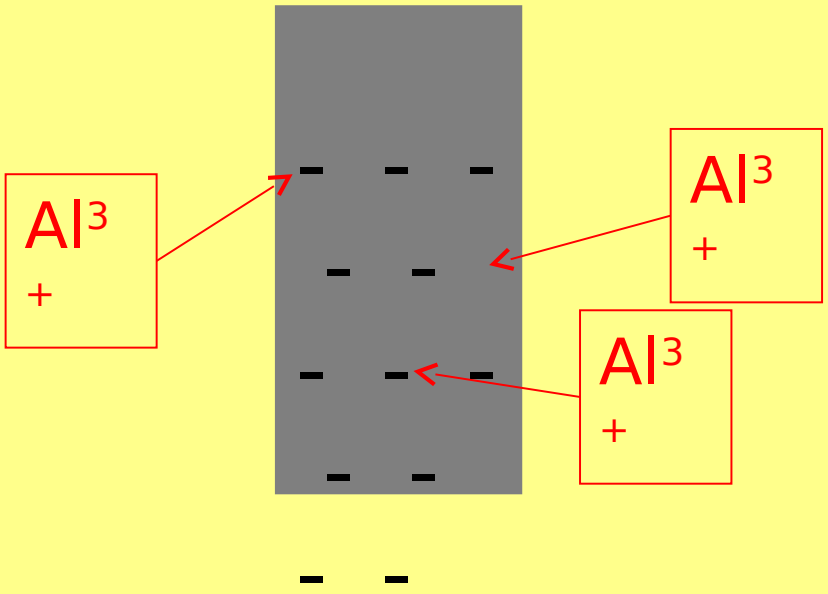
When molten, the Al_2O_3 dissociates into the ions, Al^{3+} and O^{2-}

The positive ion, Al^{3+}, will be attracted towards the negative cathode.

The negative ion, O^{2-}, will be attracted towards the positive anode.

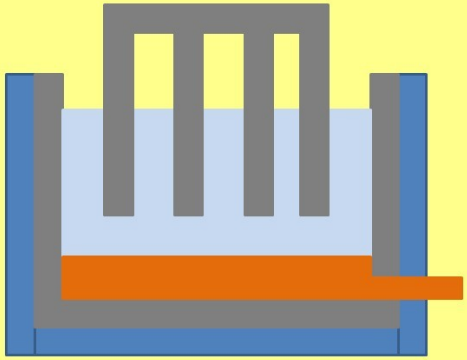
Extracting Aluminium from Bauxite

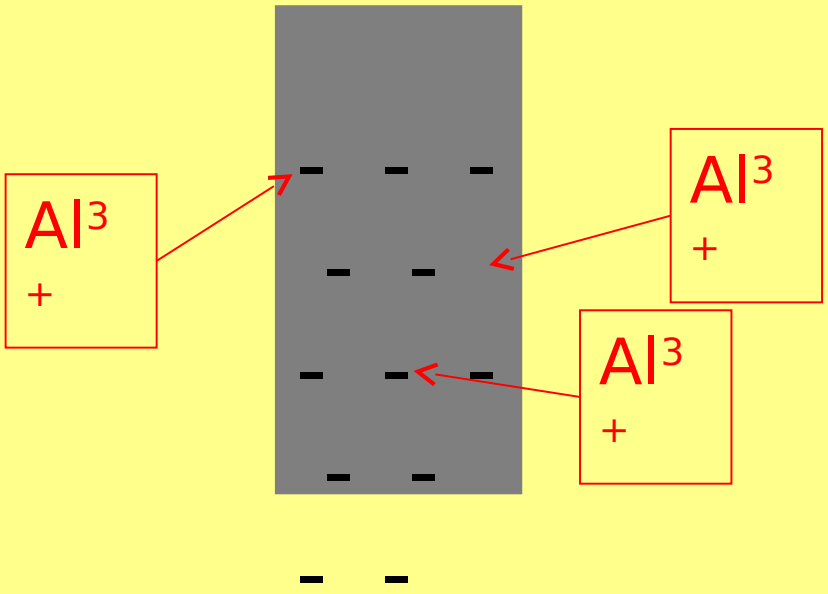




At the cathode (-ve)

Extracting Aluminium from Bauxite

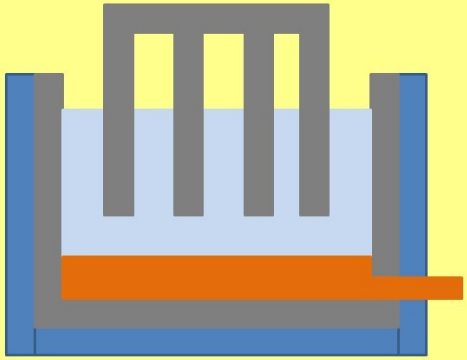


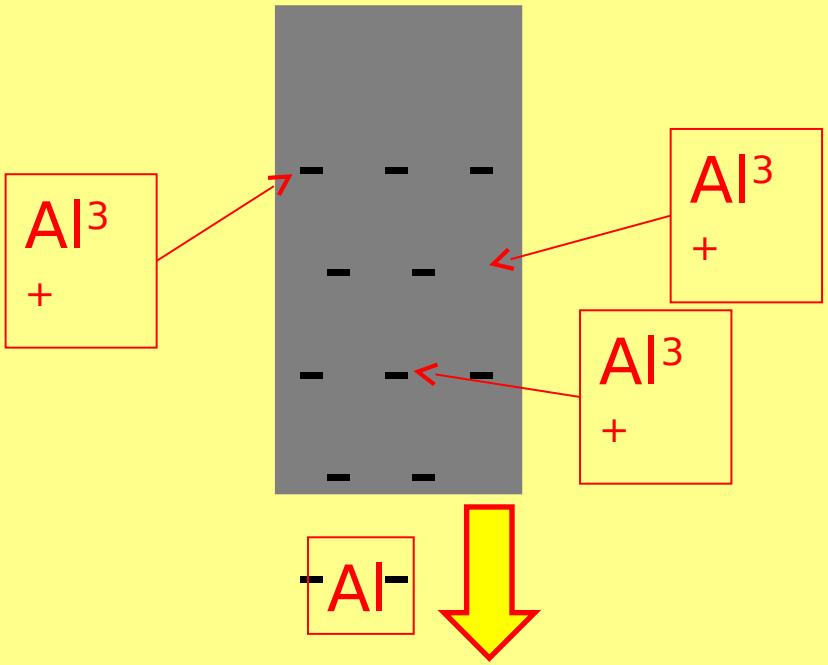


At the cathode (-ve)

$Al^{3+} + 3e^- \rightarrow Al$

Extracting Aluminium from Bauxite

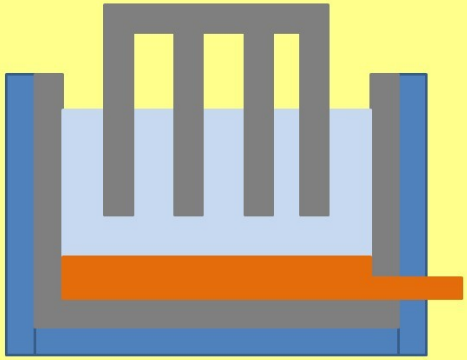


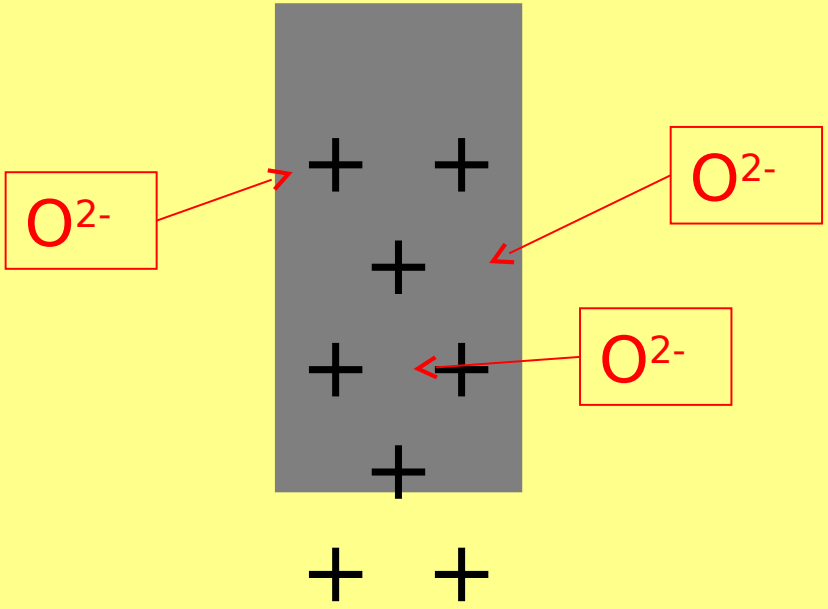


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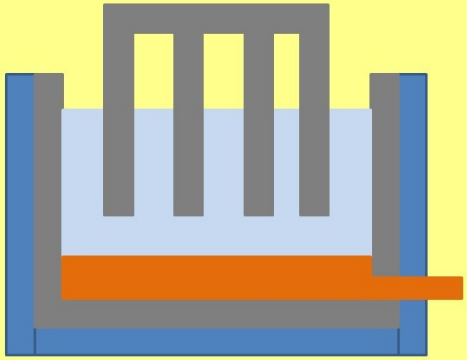
Extracting Aluminium from Bauxite

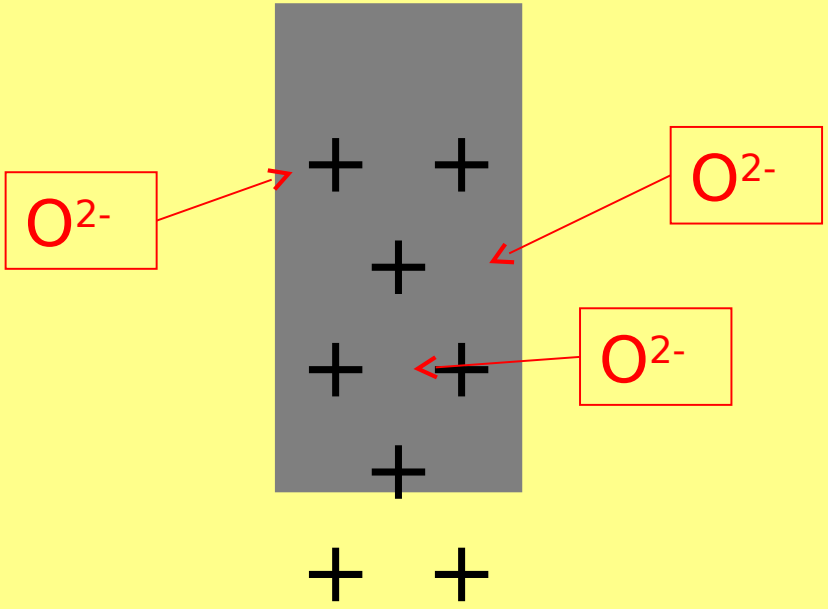




At the anode (+ve)

Extracting Aluminium from Bauxite

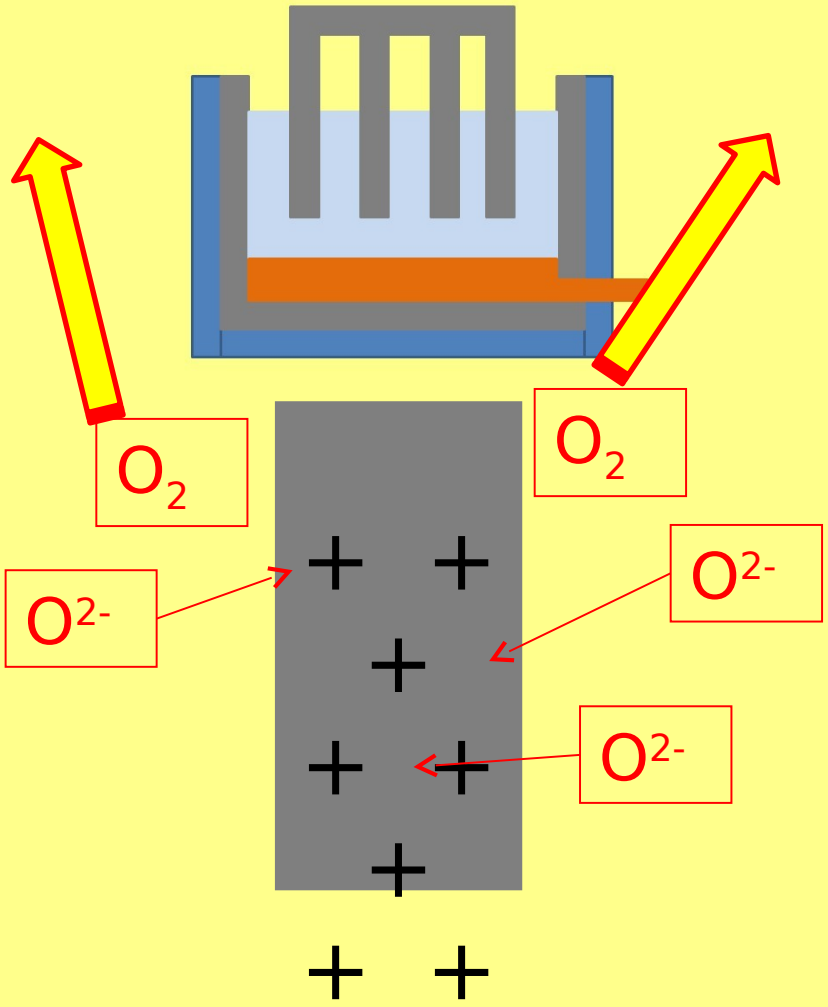




At the anode (+ve)

$2O^{2-} - 4e^{-} \rightarrow O_2$

Extracting Aluminium from Bauxite



At the anode (+ve)

$2O^{2-} - 4e^- \rightarrow O_2$

The Reactivity Series of Metals

Very reactive	POTASSIUM K
	SODIUM Na
	CALCIUM Ca
Fairly reactive	MAGNESIUM Mg
	ALUMINIUM Al
	(CARBON)
	ZINC Zn
	IRON Fe
Not very reactive	LEAD Pb
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	SILVER Ag
	GOLD Au
Not at all reactive	PLATINUM Pt

Metals above carbon must be extracted from their ores by electrolysis

Metals below [illegible] extract[illegible] ores [illegible] with coke or charcoal

eg. Iron

Metals below hydrogen don't react with water or acid. They don't easily tarnish or corrode.

Extracting Iron in a Blast Furnace

Extracting Iron in a Blast Furnace



Extracting Iron in a Blast Furnace



Because iron is below CARBON in the reactivity series, it can be removed from the ore by heating with carbon in a BLAST FURNACE. This is a REDUCTION reaction.

POTASSIUM K
SODIUM Na
CALCIUM Ca
MAGNESIUM Mg
ALUMINIUM Al
(CARBON)
ZINC Zn
IRON Fe
LEAD Pb
(HYDROGEN)
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SILVER Ag
GOLD Au
PLATINUM Pt

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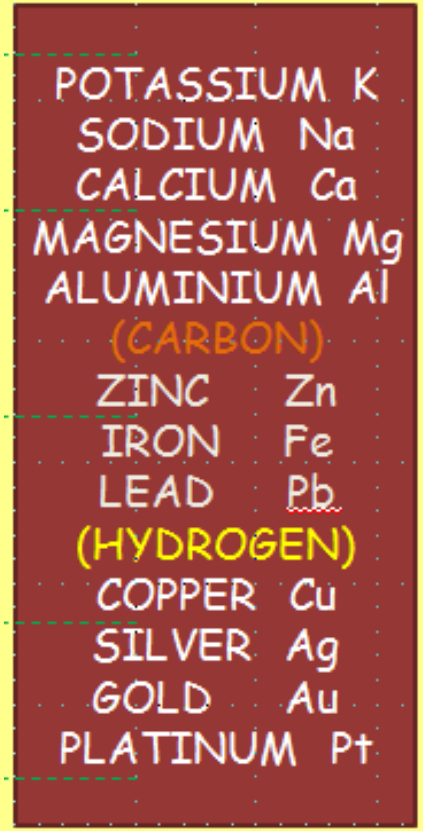
K	
…M	Al
(CARBON)	
ZINC	Zn
IRON	Fe
LEAD	Pb
(HYDROGEN)	
COPPER	Cu
SILVER	Ag
GOLD	Au
PLATINUM	Pt

Remember that in a reduction reaction oxygen is removed

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The raw materials in the blast furnace are iron ore, coke and limestone.



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Coke is almost pure carbon – it will reduce the iron oxide

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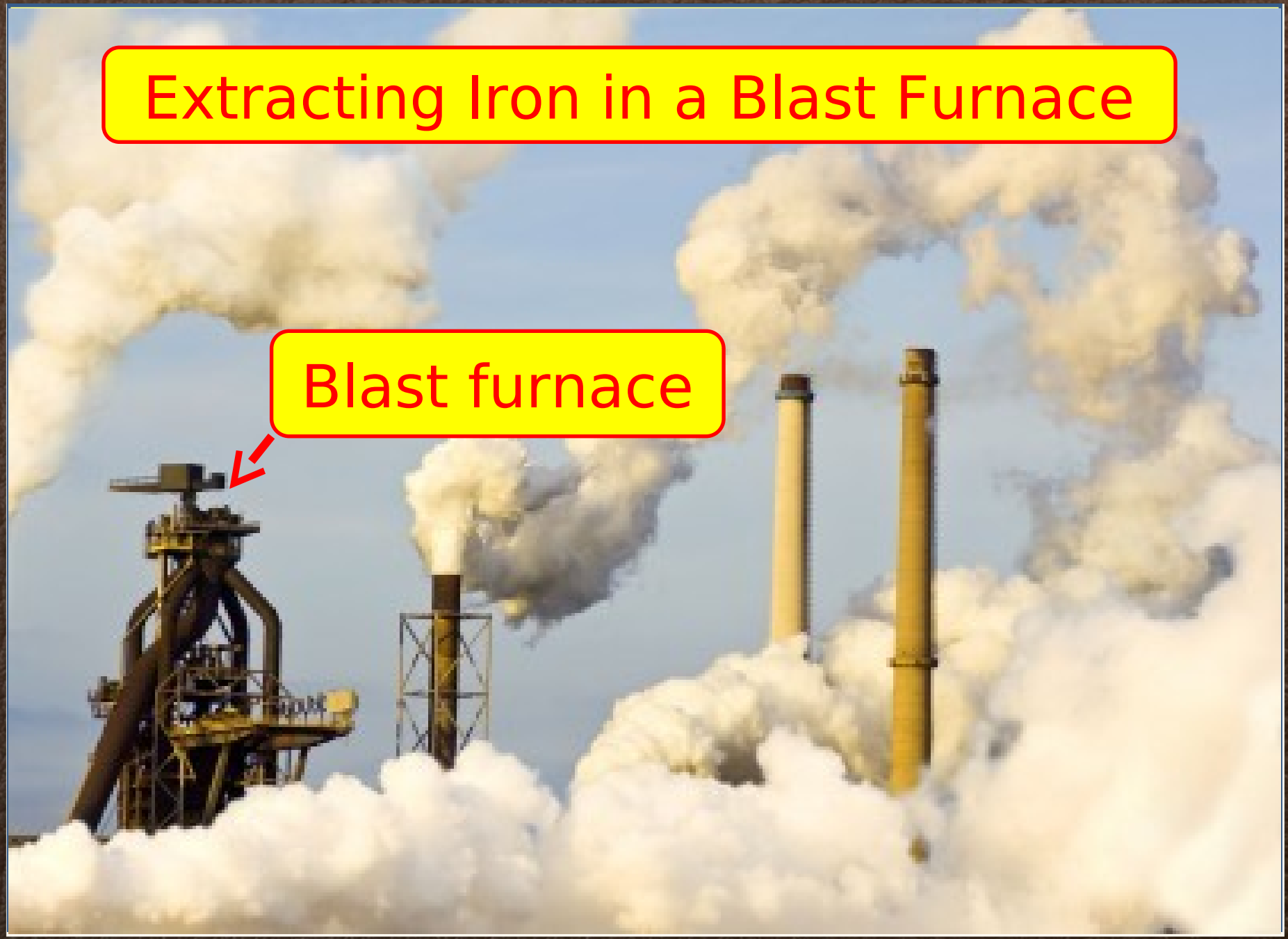
Iron ore is iron oxide, Fe_2O_3

Coke is almost pure carbon – it will reduce the iron oxide

Limestone is calcium carbonate, $CaCO_3$, and removes the impurities.

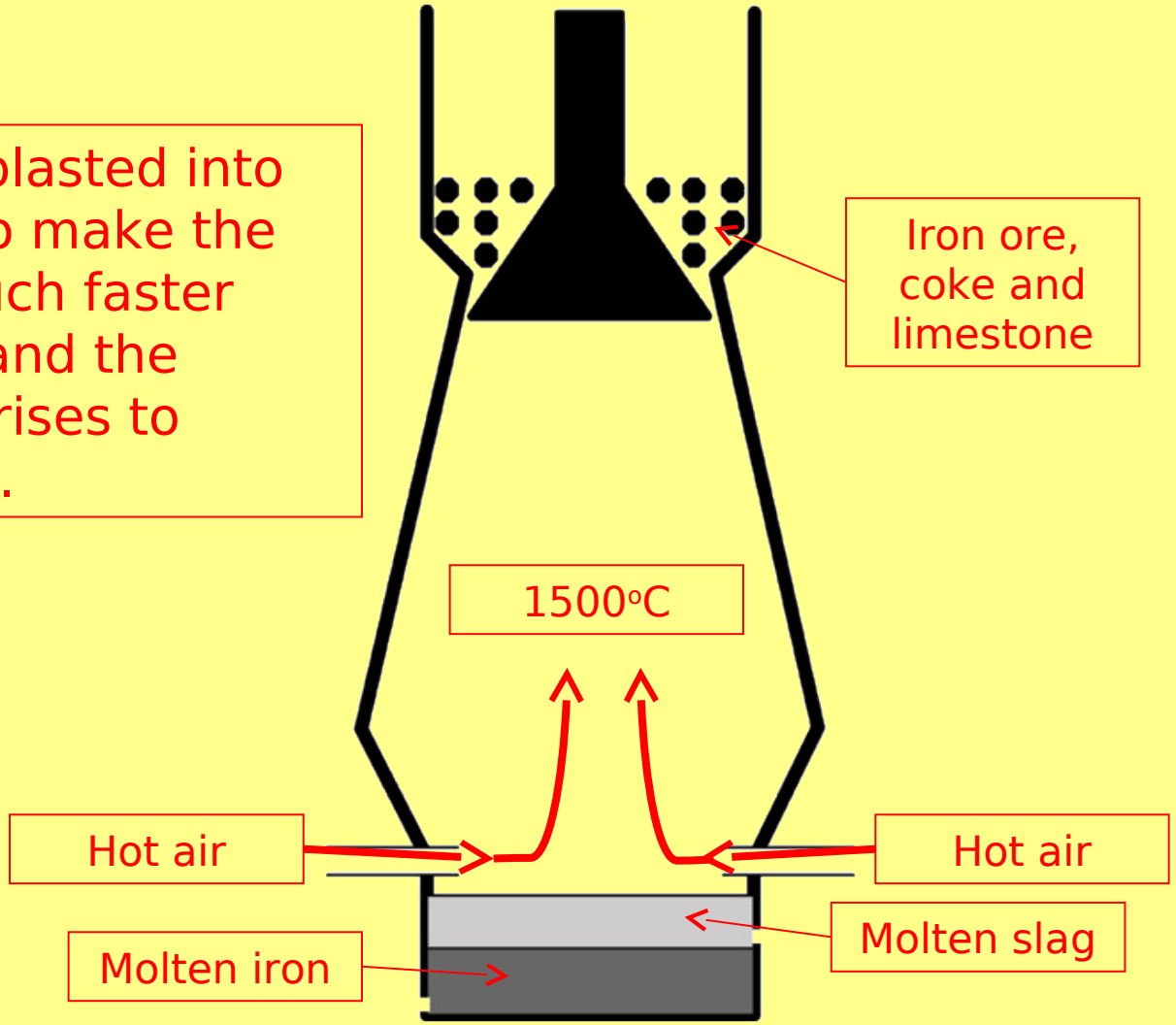
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COPPER Cu
SILVER Ag
GOLD Au
PLATINUM Pt

Extracting Iron in a Blast Furnace



Extracting Iron in a Blast Furnace

1. Hot air is blasted into the furnace to make the coke burn much faster than normal and the temperature rises to about 1500°C.



© http://www.micromountain.com

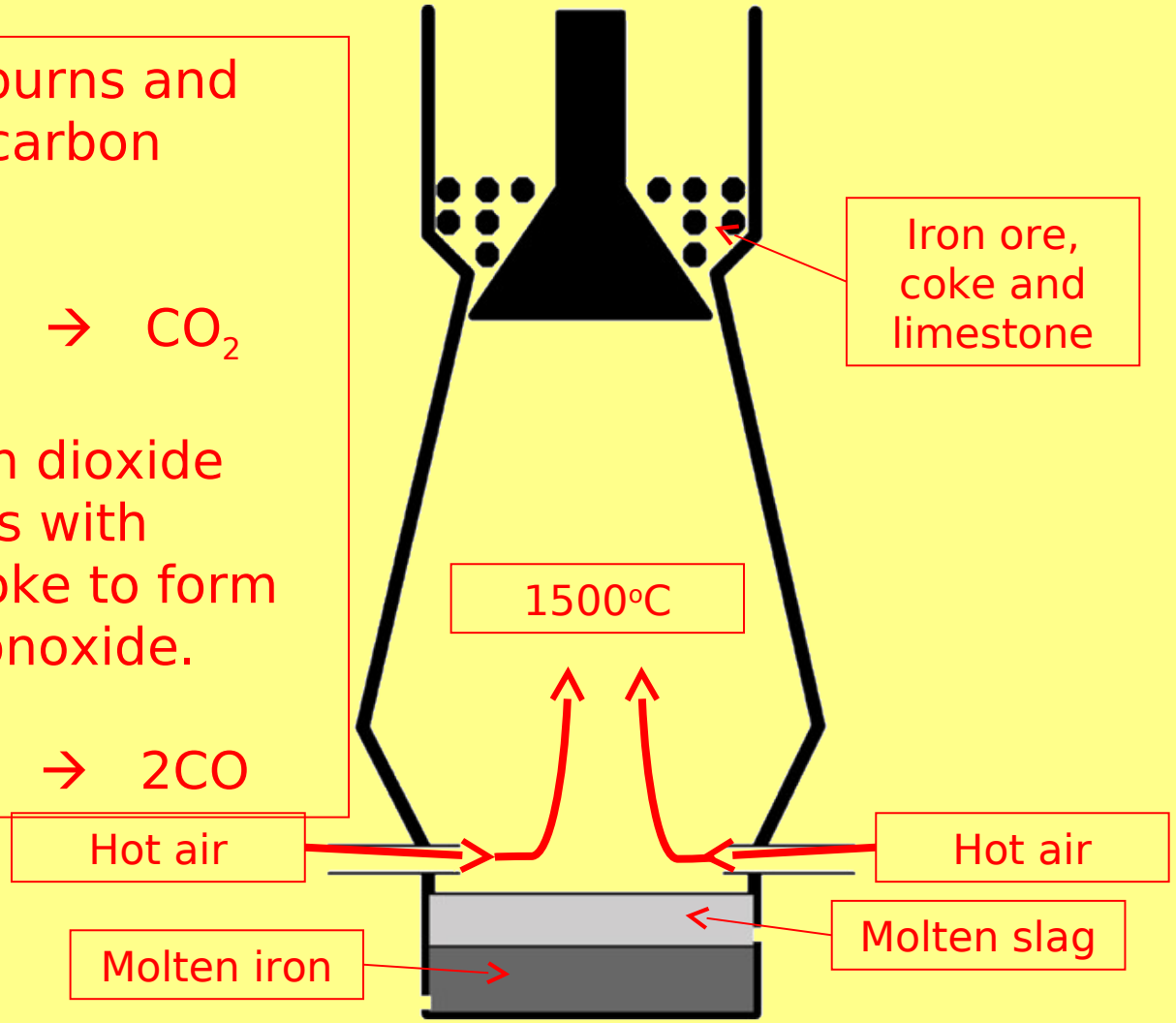
Extracting Iron in a Blast Furnace

2. The coke burns and produces carbon dioxide:

$$C + O_2 \rightarrow CO_2$$

3. The carbon dioxide then reacts with unburnt coke to form carbon monoxide.

$$CO_2 + C \rightarrow 2CO$$



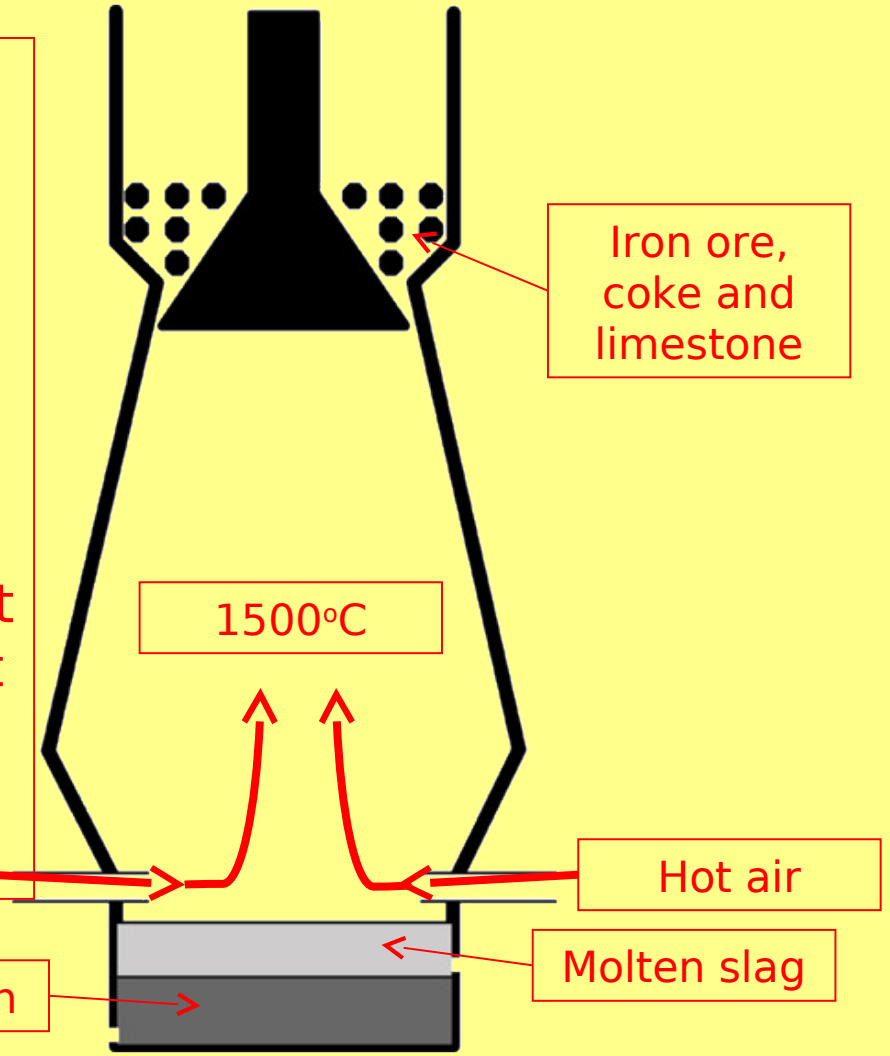
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Extracting Iron in a Blast Furnace

4. The carbon monoxide then reduces the iron ore to iron:

$$3CO + Fe_2O_3 \rightarrow 3CO_2 + 2Fe$$

5. The iron is molten at this temperature and it is also very dense so it runs straight to the bottom of the furnace where it is tapped off.



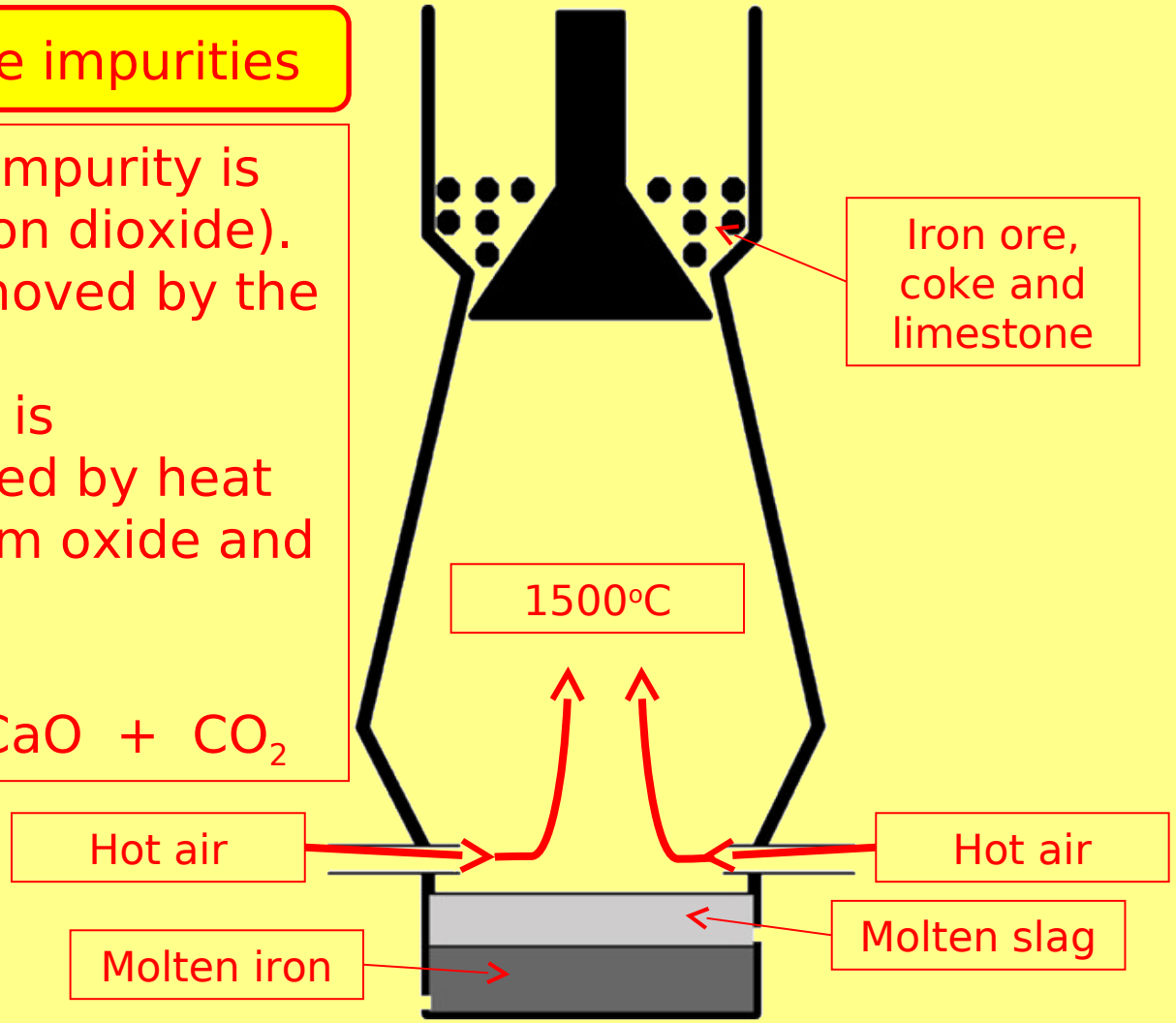
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Extracting Iron in a Blast Furnace

Removing the impurities

1. The main impurity is sand (silicon dioxide). This is removed by the limestone.
2. Limestone is decomposed by heat into calcium oxide and CO_2.

$CaCO_3 \rightarrow CaO + CO_2$



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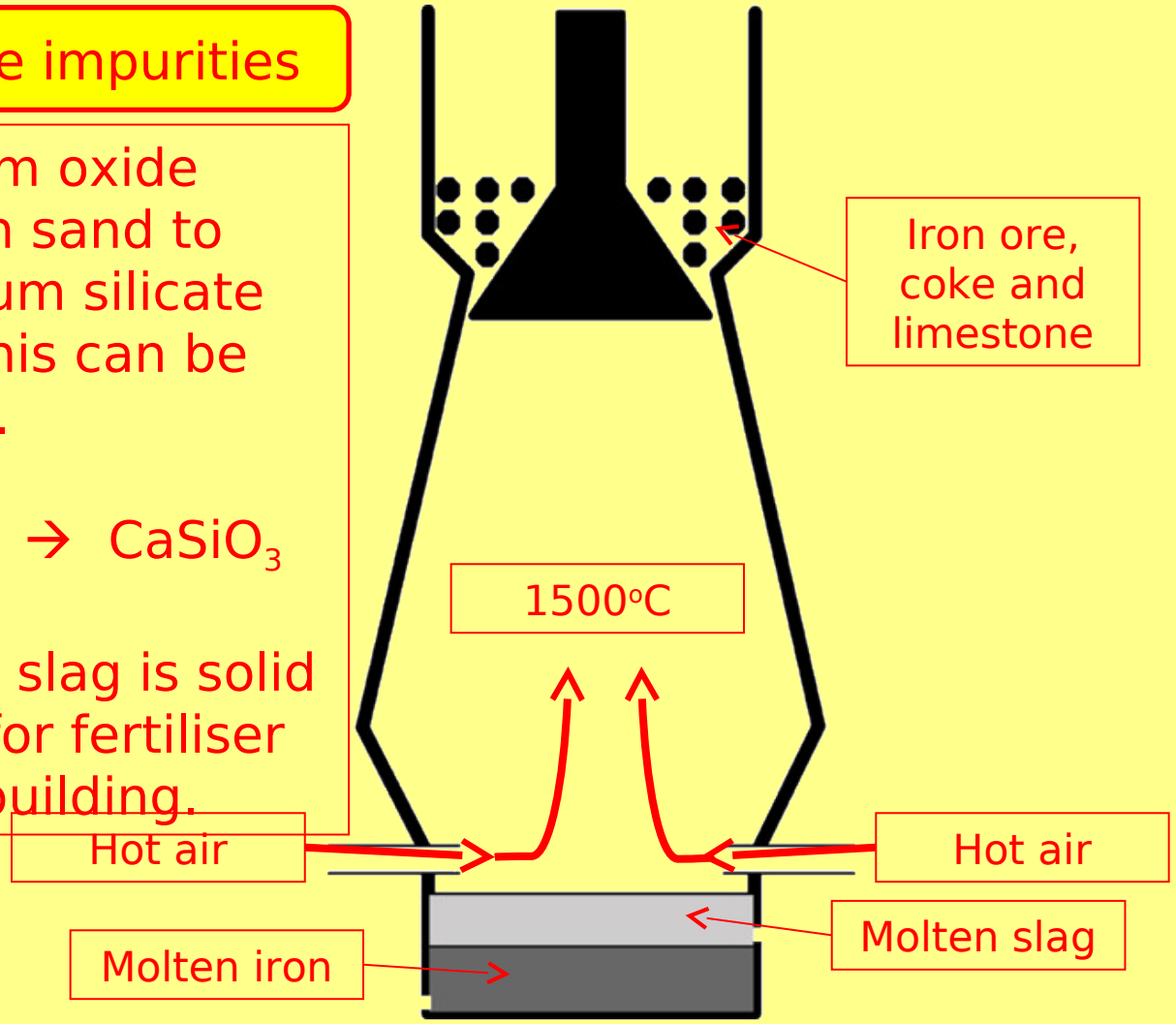
Extracting Iron in a Blast Furnace

Removing the impurities

3. The calcium oxide reacts with sand to form calcium silicate or slag. This can be tapped off.

$$CaO + SiO_2 \rightarrow CaSiO_3$$

4. The cooled slag is solid and used for fertiliser and road building.



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Properties and uses of Aluminium

Property	Uses
Strong, malleable Low density Resistant to corrosion Good conductor of heat and electricity Can be polished to a highly reflective surface	

Properties and uses of Aluminium

Property	Uses
Strong, malleable	Low density and strength make it an ideal metal for the construction of aircraft, ladders and lightweight vehicles (alloy called duralumin often used)
Low density	
Resistant to corrosion	Easily shaped and corrosion-free makes it ideal for drinks cans and roofing material.
Good conductor of heat and electricity	Greenhouses and window frames. Heat conduction good for boilers, cookers and cookware
Can be polished to a highly reflective surface	Overhead power cables (good conductor, low density) Ideal for reflecting surfaces such as mirrors, and also heat resistant clothing for fire fighters.

Properties and uses of Iron

Most iron is used to manufacture steel. Carbon is added, along with small amounts of other elements

Properties and uses of Iron

Most iron is used to manufacture steel. Carbon is added, along with small amounts of other elements

Name and melting point	Property	Uses
Cast iron 1200°C	Hard skin, softer underneath, brittle, corrodes by rusting	Parts with complex shapes can be made by casting
Mild steel 1600°C	Tough, ductile, malleable, good tensile strength, corrodes	General purpose engineering material
High carbon steel 1800°C	Can be heat-treated to make it harder and tougher	Cutting tools, ball bearings
Stainless steel 1400°C	Hard and tough, resistant to wear and corrosion	Cutlery, kitchen equipment

End of Section 5 Lesson 1

In this lesson we have covered:

The Reactivity Series

Extraction of Aluminium

Extraction of Iron

Properties and Uses of Aluminium and Iron

END