

9 Metals

9.1 Properties of metals

1 Compare the general physical properties of metals and non-metals, including:

(a) thermal conductivity

- Metals are good conductors and non-metals are insulators(do not conduct electricity).

(b) electrical conductivity

- Metals are good conductors and non-metals are insulators(do not conduct heat).

(c) malleability and ductility

- Metals are both malleable and ductile but non-metals are neither malleable nor ductile.

(d) melting points and boiling points

- Metals have high melting and boiling points unlike non-metals which have low melting and boiling points.

2 Describe the general chemical properties of metals, limited to their reactions with:

(a) dilute acids

- React with acid to produce a salt and hydrogen bubbles.

(b) cold water and steam

- React with cold water or steam to produce the hydroxide salt of that metal and hydrogen bubbles.

(c) Oxygen

- React with oxygen to produce metal oxide.

9.2 Uses of metals

1 Describe the uses of metals in terms of their physical properties, including:

(a) aluminium in the manufacture of aircraft because of its low density

(b) aluminium in the manufacture of overhead electrical cables because of its low density and good electrical conductivity

(c) aluminium in food containers because of its resistance to corrosion

(d) copper in electrical wiring because of its good electrical conductivity and ductility

9.3 Alloys and their properties

1 Describe an alloy as a mixture of a metal with other elements, including:

(a) brass as a mixture of copper and zinc

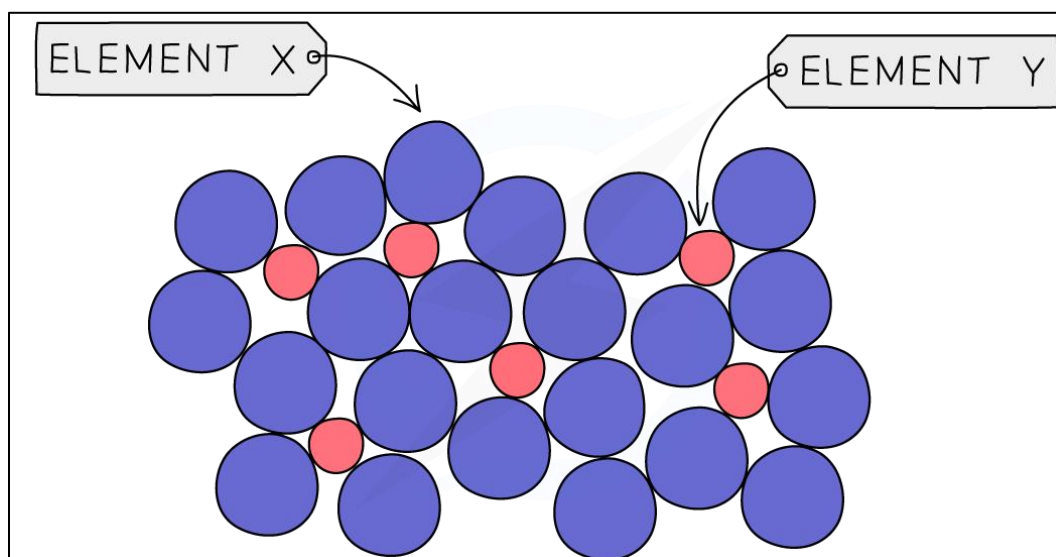
(b) stainless steel as a mixture of iron and other elements such as chromium, nickel and carbon

2 State that alloys can be harder and stronger than the pure metals and are more useful

3 Describe the uses of alloys in terms of their physical properties, including stainless steel in cutlery because of its hardness and resistance to rusting

- Brass is used in musical instruments as it is hard and resists corrosion.
- Bronze(copper+tin) is used in coins as it is hard, sonorous and resists corrosion.

4 Identify representations of alloys from diagrams of structure AND 5 Explain in terms of structure how alloys can be harder and stronger than the pure metals because the different sized atoms in alloys mean the layers can no longer slide over each other



9.4 Reactivity series

1 State the order of the reactivity series as: potassium, sodium, calcium, magnesium, aluminium, carbon, zinc, iron, hydrogen, copper, silver, gold

2 Describe the reactions, if any, of:

(a) potassium, sodium and calcium with cold water

- Reaction with potassium and cold water is the most violent. This means that potassium is the most reactive and calcium is the least reactive out of the 3.

Metal	Observations	Products
Potassium (K)	Reacts very vigorously; moves rapidly on surface; hydrogen ignites with a lilac flame	Potassium hydroxide (alkaline), Hydrogen gas
Sodium (Na)	Reacts vigorously; melts into a ball; skates on surface; hydrogen may ignite with a yellow flame	Sodium hydroxide (alkaline), Hydrogen gas
Calcium (Ca)	Reacts moderately; bubbles of hydrogen; water turns cloudy/milky due to Ca(OH)_2	Calcium hydroxide (slightly soluble, alkaline), Hydrogen gas

(b) magnesium with steam

- When reacted with, magnesium glows and reaction is vigorous. This produces hydrogen and magnesium oxide. It reacts slow with cold water so it is below calcium.

(c) magnesium, zinc, iron, copper, silver and gold with dilute hydrochloric acid

- Magnesium reaction is the most vigorous so it is the most reactive out of all the elements mentioned. It is in the reactivity series above these elements.

Metal	Reaction with Dilute HCl	Observations
Magnesium (Mg)	Reacts rapidly	Vigorous fizzing, hydrogen gas released, solution warms
Zinc (Zn)	Reacts moderately	Steady bubbling, hydrogen gas produced
Iron (Fe)	Reacts slowly	Gentle bubbling, slower reaction
Copper (Cu)	No reaction	Copper is below hydrogen in reactivity series, does not displace hydrogen
Silver (Ag)	No reaction	Silver is below hydrogen, no displacement
Gold (Au)	No reaction	Gold is very unreactive, does not react with dilute acids

and explain these reactions in terms of the position of the metals in the reactivity series

3 Deduce an order of reactivity from a given set of experimental results AND AND 4 Describe the relative reactivities of metals in terms of their tendency to form positive ions, by displacement reactions, if any, with the aqueous ions of magnesium, zinc, iron, copper and silver

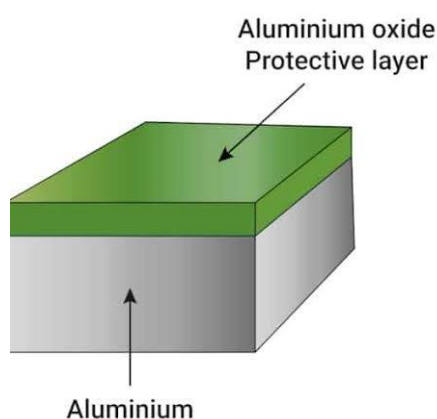
- Example: magnesium displaces zinc when added to aqueous salt of zinc. zinc displaces iron when added to aqueous salt iron. What is the order(most reactive to least reactive).
 - Zinc is more reactive than iron so it is placed higher than iron in the reactivity series as it displaces it.

Magnesium is more reactive than zinc as it displaces it; it is placed at the top,

Magnesium (most reactive)
↓
zinc
↓
iron(least reactive)

- The more the reactive the metal is, the higher the tendency it has to form ions. Magnesium displaces the zinc ion in the salt. Giving magnesium ions and zinc METAL.

5 Explain the apparent unreactivity of aluminium in terms of its oxide layer



9.5 Corrosion of metals

1 State the conditions required for the rusting of iron and steel to form hydrated iron(III) oxide

- Conditions are oxygen and water. Rusting occurs when iron or steel corrode

2 State some common barrier methods, including painting, greasing and coating with plastic AND 3 Describe how barrier methods prevent rusting by excluding oxygen or water

- These prevent air and water from reaching the steel and iron and reacting with it. Preventing rust formation. If this layer is scratched, iron will rust.

4 Describe the use of zinc in galvanising as an example of a barrier method and sacrificial protection AND 5 Explain sacrificial protection in terms of the reactivity series and in terms of electron loss

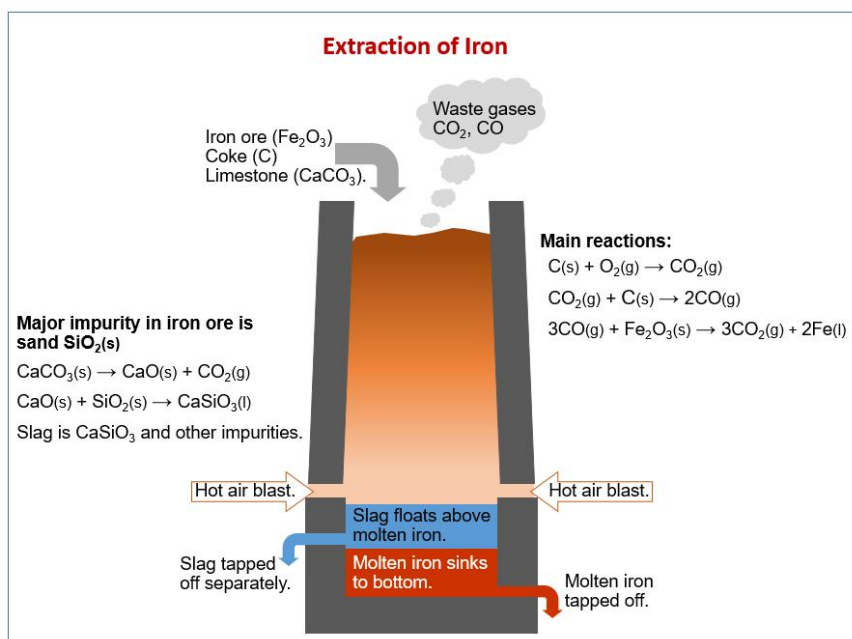
- A layer of zinc is added on top of iron or steel. Zinc reacts with the water and oxygen and corrodes instead. It gets oxidized; loses electrons and forms zinc ions, instead of iron.
- Unlike common barrier methods, if the zinc layer is scratched and the iron is exposed, zinc will corrode instead as it is more reactive than iron. This means it has a higher tendency to lose electrons and form ions.

9.6 Extraction of metals

1 Describe the ease in obtaining metals from their ores, related to the position of the metal in the reactivity series

- The higher the reactivity of the metal, the harder it is to extract from its ore.

2 Describe the extraction of iron from hematite in the blast furnace, limited to: AND 4 State the symbol equations for the extraction of iron from hematite



(a) the burning of carbon (coke) to provide heat and produce carbon dioxide $\text{C} + \text{O}_2 \rightarrow \text{CO}$ [step 1]

(b) the reduction of carbon dioxide to carbon monoxide

$\text{C} + \text{CO}_2 \rightarrow 2\text{CO}$ [step 2]

(c) the reduction of iron(III) oxide by carbon monoxide

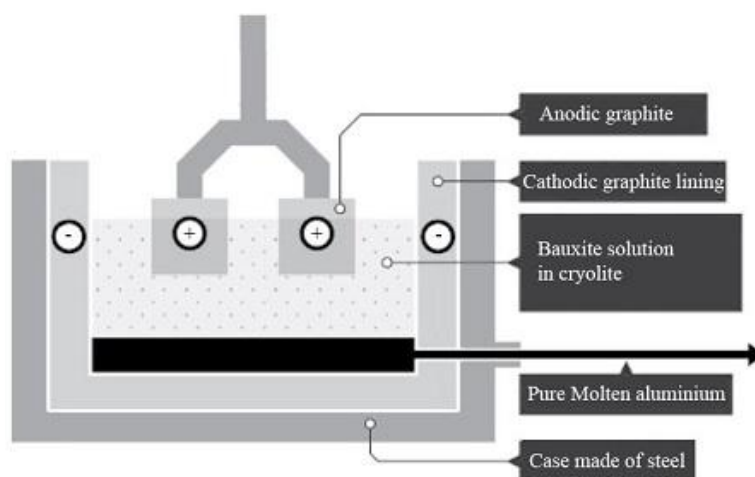
$\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$ [step 3]

(d) the thermal decomposition of calcium carbonate/limestone to produce calcium oxide

$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ [step 4]

(e) the formation of slag $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$ [step 5]

3 State that the main ore of aluminium is bauxite and that aluminium is extracted by electrolysis AND 5 Describe the extraction of aluminium from purified bauxite/aluminium oxide, including:



(a) the role of cryolite

- Cryolite is a solvent for molten aluminium oxide. It lowers the melting point of aluminium oxide, and increases its electrical conductivity. This reduces cost.

(b) why the carbon anodes need to be regularly replaced

- Oxygen forms at the anode. The oxygen burns the carbon anode, forming carbon dioxide and destroying the anode.

(c) the reactions at the electrodes, including ionic half-equations $[2\text{Al}_2\text{O}_3 \rightarrow 4\text{Al} + 3\text{O}_2]$

- At the cathode: $4\text{Al}^{3+} + 12\text{e}^- \rightarrow 4\text{Al}$
- At the anode: $6\text{O}^{2-} \rightarrow 3\text{O}_2 + 12\text{e}^-$

Details of the purification of bauxite are not required

END OF CHAPTER