

Obtaining Metals and Equilibria

4.1—Deduce the relative reactivity of metals*

Use the following information to determine the reactivity of the metals.

- Copper: does not react with water or acid.
- Magnesium: reacts slowly with water, quite quickly with acid.
- Potassium: a flame appears when it reacts with water.
- Sodium: reacts vigorously with water.
- Zinc: reacts slowly with acid, and extremely slowly with water.

Most reactive	----->	Least reactive
Potassium	Sodium Magnesium Zinc	Copper

4.2—Displacement reactions as redox reactions (HT only) *

Recall the definitions of reduction and oxidation:

Oxidation is the **loss** of electrons.

Reduction is the **gain** of electrons.

Displacement reactions are ones in which a **more** reactive metal replaces a **less** reactive metal in a solution of its salt.

Complete the example displacement reaction equations:

W: Zinc + copper sulfate → **zinc sulfate** + **copper**

S: $\text{Zn (s)} + \text{CuSO}_4 \text{ (aq)} \rightarrow \text{ZnSO}_4 \text{ (aq)} + \text{Cu (s)}$

I: $\text{Zn (s)} + \text{Cu}^{2+} \text{ (aq)} \rightarrow \text{Zn}^{2+} \text{ (aq)} + \text{Cu (s)}$

J: In this example, the **zinc** has been oxidised, as it has **lost** electrons. The **copper** has been reduced, as it has **gained** electrons. These reactions are known as **redox** reactions as both oxidation & reduction occur.

4.3—Explain the reactivity series of metals

The higher up the reactivity series, the more **vigorous** the reaction will be with acid and water.

Some metals are too reactive to react with acids.

Some are too **unreactive**.

The reactivity of metals is linked to their relative tendency to form **cations** by losing electrons.

potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
hydrogen		H
copper		Cu
silver		Ag
gold	least reactive	Au

4.4—Extracting metals

4.4a—Ores

Most metals are found as ores in the ground, as they tend to react with other **elements**, especially **oxygen**. An ore is a rock containing metal **compounds**.

They must be **economically** viable to extract.

4.4b—Pure metals

Metals which are very **unreactive**, such as silver and **gold**, are found in the ground in their pure form.

4.5—Oxidation & reduction in terms of oxygen

Oxidation is the **gain** of oxygen.

Reduction is the **loss** of oxygen.

4.6—Extraction of metals

In the extraction of metals (from ores), the metal is always **reduced**. This is because the metal is part of a compound, normally a metal oxide, and so is a **positively**-charged cation.

To obtain the pure metal, **oxygen** must be lost.

This is true for both **electrolysis** and for heating with **carbon**.

HT: To obtain the pure metal, these cations must **gain** electrons.

4.7—Methods of extraction

The method of extraction used depends on the **reactivity** of the metal, and the **cost** associated with its extraction.

Electrolysis is used to extract metals which are **more** reactive than carbon, as the carbon cannot **displace** the metal from the metal compound.

However, this method requires high amounts of **energy**, as the metal compound has to be **molten** before it is electrolysed. It is therefore only normally used if there is no alternative. Heating with **carbon** is much cheaper, as it is readily available and the energy costs are lower.

potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
hydrogen		H
copper		Cu
silver		Ag
gold	least reactive	Au

4.8—Biological methods of extraction (HT only)

Bioleaching is using **bacteria** to extract metals. The bacterial solution is placed on low-grade ores, and the bacteria break down the compounds to produce an acidic solution containing the metal.

Phytoextraction uses **plants** to extract metal ions from **low**-grade ores. These ions are concentrated in the cells. The **plants** are then burnt, and the ash contains the metal **compounds**.

The advantages of this is that the land containing these ores would be otherwise **useless**. Also, it reduces the need for more **mining**, and helps to **conserve** resources. However, this method is a **batch** process, and is very **time**-consuming.

4.9—Reactivity series and resistance to oxidation

The position of a metal in the reactivity series determines its resistance to oxidation (reacting with, or gain of, oxygen).

Metals that are **low** in the reactivity series are more resistant to oxidation. This is because they are less likely to form **cations** by losing **electrons**.

potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
hydrogen		H
copper		Cu
silver		Ag
gold	least reactive	Au

4.10—Recycling metals

Advantages:

- Less **energy** is needed to recycle metals, as they don't need to be heated as strongly.
- Fewer **mines** are needed, as there is less need for new metal. This means that less **pollution** is produced from mining. This also means less **traffic** on roads, further reducing pollution.
- Recycling conserves raw materials, so they will last **longer**.

Disadvantages:

- There are many steps which need organising, workers, fuel and vehicles. These steps include **collection** and **transportation** of the metals.
- It can be difficult to sort the metals from one another.

4.11—Life cycle assessments

There are four stages that need considering in a life cycle assessment:

1) Obtaining the **raw** materials.

At this stage, we should consider the use of **non-renewable** resources such as oil and metal ores, as well as the damage caused to the **environment** from the extraction of the materials.

2) **Manufacturing** the product.

At this stage, we need to consider the use of **land** for factories, and the use of machines and people.

3) **Using** the product.

This depends on what the product is!

4) **Disposal** of the product.

We should consider the use of **landfill** sites for the waste, or whether the substance can be **recycled** or reused.

4.12—Evaluate a life cycle assessment* (steel oven tray)

Most of the energy use of this item is in the **use**. This is likely from **heating** up **ovens**. We could reduce the amount of energy used at this stage by **using alternative cooking methods**.

Life cycle stage	Energy use (%)
Raw materials	10
Manufacture	15
Use	70
Disposal	5