The content on this sheet is assessed on paper 1 only.
* indicates an example: you may be asked about others.

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:

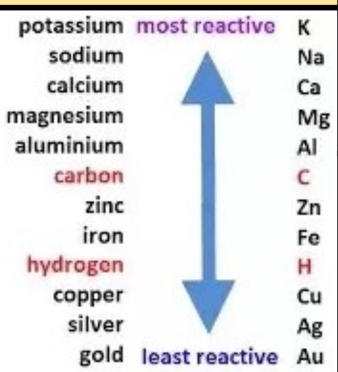
W: Zinc + copper sulfate —> zinc sulfate + copper

S: Zn (s) + $CuSO_4$ (aq) —> $ZnSO_4$ (aq) + Cu (s)

I: Zn (s) + Cu^{2+} (aq) —> Zn^{2+} (aq) + 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.

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.

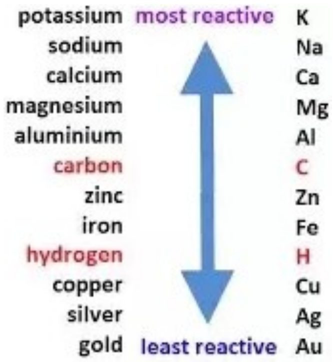
4.5—Oxidation & reduction in terms of oxygen

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

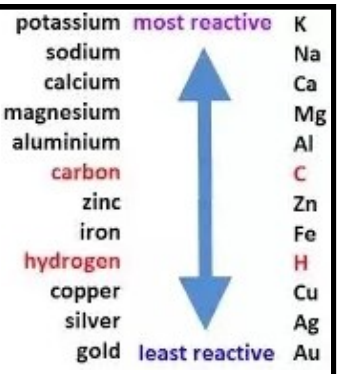


The method of extraction used depends on the reactivity of the metal, and the cost associated with its extraction.
Electrolysis is used to extract metals which are more reactive than carbon, as the carbon cannot displace the metal from the metal compound.
However, this method requires high amounts of 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.

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.

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