Topic 4 – Obtaining and using metals

- **ORES**
- **Metals found as elements:**
- A few metals – e.g gold and platinum – are found naturally in the Earth's crust as elements
- They are found as uncombined elements because they are very unreactive (→don't form compounds)
- **Metals found as compounds:**
- However, most metals are reactive→readily form compounds (the more reactive a metal is, the more easily it reacts with other substances to form compounds)
- Compounds formed are mainly metal oxides
- These metal oxides are found in rocks called ores in the Earth's crust
- →To obtain these metals they must be extracted from ores in the Earth's crust
- Examples:
    - Haematite contains enough iron oxide for it to be profitable to extract iron from it
    - Similarly, aluminium is extracted from bauxite…copper from malachite
- **Extracting metals from ores:**
- Some metals can be extracted by heating their compounds with carbon:
    - E.g iron: iron oxide + carbon → iron + carbon dioxide
    - Chemical equation: $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$
- Other metals are extracted from their compounds by electrolysis of a molten compound:
    - E.g aluminium: aluminium oxide → aluminium + oxygen
    - Chemical equation: $2Al_2O_3 \rightarrow 4Al + 3O_2$
- The method used to extract a metal depends on its reactivity…:
    - The less reactive metals are extracted using carbon (e.g iron, zinc, lead, copper)
    - More reactive metals are more difficult to extract because they form stronger, more stable compounds
    - →The more reactive metals need to be extracted by electrolysis (e.g sodium, calcium, magnesium, aluminium) – a more powerful method
    - *Remember that metals with very low reactivity (e.g gold) are found as elements→don't need to be extracted*
- Extraction using electrolysis is more expensive than with carbon due to the cost of electricity
- →the more reactive the metal, the harder and more expensive it is to extract from its ore
- **OXIDATION AND REDUCTION REACTIONS**
- Reduction reactions: loss of oxygen
- Oxidation reactions: gain of oxygen
- **Metal extraction is reduction:**
- As we've just discussed, the majority of the compounds found in ores (from which metals are extracted) are metal oxides
- In order to obtain metals from their oxides, oxygen is removed
- →the process of extracting metals from their ores is a reduction reaction (the metal oxides lose their oxygen and are therefore 'reduced')

- E.g iron oxide + carbon → iron + carbon dioxide. In this example, the iron oxide is reduced to iron (it has lost its oxygen)
- **Corrosion of metals is oxidation:**
- Corrosion happens when the surface of a metal changes by reaction with oxygen (sometimes with water)**.** E.g when iron corrodes it forms rust
- In this case, the metal gains oxygen→corrosion is an oxidation reaction
- Most metals corrode. The more reactive the metal, the more readily it becomes oxidised→the more rapidly it corrodes
- Exception – aluminium:
    - Aluminium doesn't corrode as much as expected
    - This is because upon reaction with oxygen it forms aluminium oxide, which acts as a protective layer→preventing any further corrosion
- Less reactive metals are more resistant to oxidation→corrode less
- Very unreactive metals – e.g gold - don't corrode at all
- **RECYCLING METALS**
- Metals can be melted down and made into something new in what's referred to as 'recycling'
- **Advantages of recycling:**
- Natural reserves of metal ores will last longer
- For most metals, less energy (→less expensive) is needed to recycle them than to extract them from their ores
- Reduces the need to mine ores (mining can damage the landscape and create dust and noise pollution in the same way as limestone quarrying…see previous topic)
- Less pollution…:
    - Extracting some metals produces greenhouse gases
    - E.g sulphur dioxide is formed when lead is extracted from its ore, galena
- **Disadvantages of recycling:**
- Costs and energy used in collecting, sorting and transporting metals to be recycled
- For some metals, it is more expensive to recycle them than to extract them from their ores
- **How metals are recycled:**
- Iron and steel are easily separated from other metals as they're magnetic
- Others are separated by hand
- **PROPERTIES OF METALS**
- General properties: shiny, conduct heat, conduct electricity, malleable (can be hammered into shape), ductile (can be stretched into wires)
- Different metals, though, have slightly different properties→have different uses…
- **Aluminium:**
- Has a low density and doesn't corrode as a protective layer of aluminium oxide forms quickly on its surface
- →is used to make aeroplanes (the lighter the aircraft, the less fuel it needs to fly)
- **Copper:**
- Good electrical conductor→copper is used to make electrical cables
- Has low reactivity and doesn't react with water→also used in water pipes
- **Gold:**
- Very unreactive, doesn't corrode, easily worked into shapes→used for jewellery
- It's also a very good electrical conductor→tiny amounts are used inside most electronic devices, including mobile phones and computers

- **Iron and steel:**
- Iron is fairly cheap to extract from iron ore by heating with carbon
- However, pure iron is too soft→it is often made into steel (a mixture of iron, carbon and other metals), which is stronger and harder
- Steel is used to make bridges, cars, electrical goods and frames for buildings
- However, both iron and steel rust because the iron readily reacts with air and water
- **ALLOYS**
- Many metals are mixed with small amounts of other metals to improve their properties for a particular use
- Such a mixture of metals is called an alloy
- **Converting pure metals into alloys often increases their strength:**
- In a pure metal structure:
    - All the atoms are the same size and are packed closely together in a regular arrangement
    - →When a force is applied, the layers of atoms slide over each other, making the metal soft
- In an alloy:
    - Each metal in the mixture has different sized atoms
    - →When force is applied, the atoms can't slide past each other as easily
    - →the alloy is harder and stronger
- **Examples of alloys:**
- Iron:
    - A big problem with iron is that it rusts
    - However, iron can be made into the alloy stainless steel (mixture of iron and small amounts of chromium and nickel) which doesn't corrode
- Gold:
    - Pure gold is too soft to be used in jewellery
    - →other metals, e.g copper and silver, are added to make a harder and stronger alloy
    - The purity of gold is measured in carats, or as fineness:
        - Pure gold is 24-carat and has a fineness of 1000 parts per thousand
        - The lower the carat and fineness, the lower the purity of gold
- **Shape memory alloys:**
- Nitinol is an alloy of nickel and titanium
- It's a smart material – i.e it has a property that changes with a change in conditions (usually temperature)
- Nitinol is a shape memory alloy…:
    - In other words, if the shape of something made of nitinol is altered, it returns to its original shape when heated
    - Nitinol is used in the repair of a collapsed artery:
        - Doctors slide a squashed nitinol tube into the damaged artery
        - As it warms up in the body, the nitinol returns to its original size
        - →holding the artery open