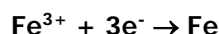


## Topic 13 – Metal Extraction Revision Notes

### 1) Introduction

- Rocks that contain a high enough percentage of a metal for commercial extraction are known as ores
- Ores usually contain metal compounds, mainly oxides and sulphides
- Sulphide ores are usually converted into oxides by roasting in air. This produces SO<sub>2</sub> that would cause acid rain if released into the atmosphere. However, the SO<sub>2</sub> can be captured and used to make sulphuric acid, H<sub>2</sub>SO<sub>4</sub>
- Extraction of metals involves reduction of metal ions e.g.

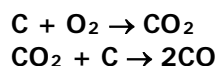


### 2) Reduction with carbon & carbon monoxide

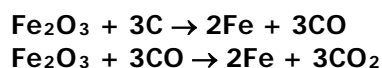
- C and CO are cheap and effective reducing agents. They can be made from coke, which is purified coal. They are used in the extraction of iron, manganese and copper from their oxides

#### a) **Iron, Fe**

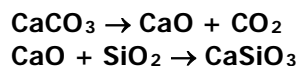
- Fe is extracted by heating Fe<sub>2</sub>O<sub>3</sub> with carbon in a blast furnace
- This is a continuous process that needs a high temperature. The high temperature is produced by burning the carbon in a blast of hot air



- The Fe<sub>2</sub>O<sub>3</sub> is reduced by both C and CO

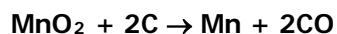


- Limestone (calcium carbonate) is added to the blast furnace to remove sandy impurities (SiO<sub>2</sub>)
- Calcium silicate (slag) is produced which can be used in the construction industry (for road building, to make breeze blocks)



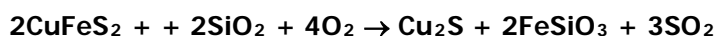
#### b) **Manganese, Mn**

- Manganese is extracted by the reduction of manganese dioxide

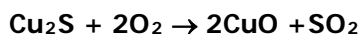


### c) Copper, Cu

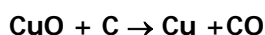
- Cu is extracted from the ore chalcopyrite,  $\text{CuFeS}_2$ , in a three stage process
- In the first stage chalcopyrite is heated with silicon dioxide and oxygen



- The  $\text{SO}_2$  produced would cause acid rain if released into the atmosphere. However, the  $\text{SO}_2$  can be captured and used to make sulphuric acid,  $\text{H}_2\text{SO}_4$
- In stage 2, the copper(I) sulphide is roasted with oxygen at a high temperature



- In stage 3, the copper(II) oxide is reduced by heating with carbon

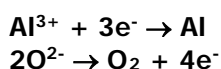


### d) Ti, Al and W

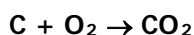
- Titanium and tungsten are not extracted by heating their oxides with carbon because the carbide would be formed as well as the metal. The carbide (e.g.  $\text{TiC}$ ) makes the metal brittle and useless
- Aluminium is not extracted by heating with carbon because the temperature required is too high

## 3) Reduction by electrolysis

- Aluminium is useful because it resists corrosion and has a low density
- Al is extracted from purified bauxite (aluminium oxide) by electrolysis
- Electrolysis is more expensive than heating with carbon because electricity is expensive
- $\text{Al}_2\text{O}_3$  is dissolved in molten cryolite. The cryolite needs to be molten so that ions are free to move
- A high temperature is needed to keep the cryolite molten but the temperature is less than that required to melt  $\text{Al}_2\text{O}_3$  thus saving energy costs
- The electrode equations are as follows:

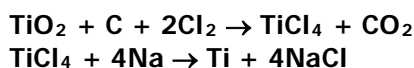


- Carbon electrodes are used which have to be replaced from time to time. The positive electrode burns away as the carbon reacts with the oxygen produced there



## 4) Reduction with reactive metals

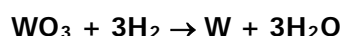
- Ti is extracted from  $\text{TiO}_2$  by conversion to  $\text{TiCl}_4$  then displacement by a more reactive metal (Na or Mg) which acts as the reducing agent
- This is a batch process (which involves stopping and starting)



- Both stages need a high temperature to increase the reaction rate
- The second stage needs an atmosphere of argon (which is unreactive). This prevents Ti and Na reacting with air and prevents TiCl<sub>4</sub> and Na reacting with water
- Extracting Ti by this process is expensive because: Na and Cl<sub>2</sub> are expensive because they have to be made by electrolysis, it is a batch process (inefficient), an argon atmosphere is needed, both stages need a high temperature

## 5) Reduction with hydrogen

- Tungsten is extracted from its oxide using hydrogen gas as the reducing agent



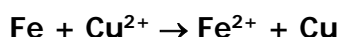
- Tungsten is heated to around 700°C in a stream of hydrogen
- Air has to be excluded from the system as there is a risk of explosion using hydrogen at this sort of temperature

## 6) Recycling

- In economic terms, recycling uses less energy than extraction from an ore. In environmental terms, recycling reduces landfill, reduces mining, reduces acid rain and reduces greenhouse gas emission
- Recycling aluminium is viable because expensive electricity is needed to produce the new aluminium by electrolysis
- There are costs involved with recycling: collection of scrap and separation of the pure metal

## 7) Extraction of copper from low grade ores

- Aqueous solutions of copper compounds can be made by leaching from low grade ores
- The copper can then be extracted by displacement using scrap iron as the reducing agent



- This is a low cost method of extracting copper because it uses scrap iron as the reducing agent and it has a low energy requirement