Edexcel GCSE Chemistry

Topic 4: Extracting metals and equilibria

Obtaining and using metals

Notes

4.1 Deduce the relative reactivity of some metals, by their reactions with water, acids and salt solutions

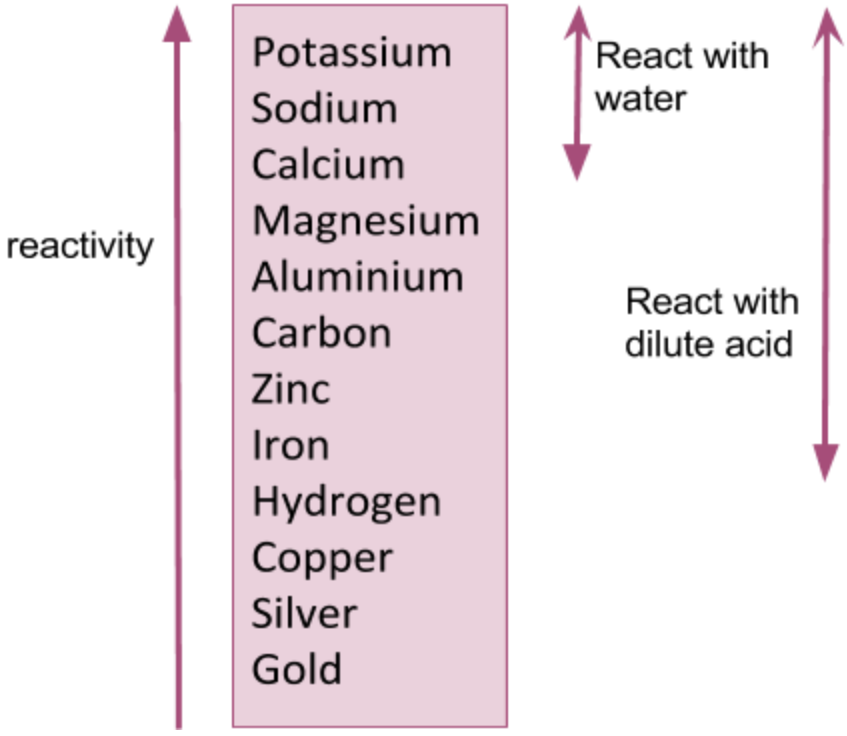
- The most reactive metals will react with cold water:
    - Products are a metal hydroxide (forming an alkaline solution) and hydrogen gas
    - E.g. with potassium: $2K + 2H_2O \rightarrow 2KOH + H_2$
- Fairly reactive metals react with acids: acid + metal ⟶ salt + hydrogen
- Almost all metals react with oxygen: metal + oxygen -> metal oxide, though more reactive metals will react with oxygen more quickly
- Only metal that does not react with any of the above is gold, because it is extremely unreactive
- You can therefore deduce the relative reactivity of some metals by seeing if they react with water (i.e. VERY reactive), acid (reactive), and oxygen (not that reactive). For these reactions, you can see if they have taken place by looking for bubbles (if hydrogen is produced)
- You can see if one metal is more reactive than another by using displacement reactions...
    - Easily seen when a salt of the less reactive metal is in the solution
        - More reactive metal gradually disappears as it forms a solution
        - Less reactive metal coats the surface of the more reactive metal

4.2 (HT only) Explain the displacement reactions as redox reactions, in terms of gain or loss of electrons

- More reactive metals form a cation (+) as they displace the less reactive metal, losing electrons and therefore being OXIDISED (Oxidation Is Loss of electrons), it forms an ion as it replaces the less reactive metal in the salt solution
- Less reactive metals form atoms from negative ions as they are displaced, gaining electrons and therefore being REDUCED (Reduction Is Gain of electrons), it forms an atom as it is replaced in the salt solution

4.3 Explain the reactivity series of metals (potassium, sodium, calcium, magnesium, aluminium, (carbon), zinc, iron, (hydrogen), copper, silver, gold) in terms of the reactivity of the metals with water and dilute acids and that these reactions show the relative tendency of metal atoms to form cations

- When metals react with other substances, metal atoms form positive ions
- Reactivity of a metal is related to its tendency to form positive ions- more reactive metals can form positive ions more easily
- Metals can be arranged in order of their reactivity in a reactivity series
    - Metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids
    - Non-metals hydrogen and carbon are often included in the reactivity series
- A more reactive metal can displace a less reactive metals from a compound (think about how this is similar as well to halogens)



4.4 Recall that: most metals are extracted from ores found in the Earth's crust, and unreactive metals are found in the Earth's crust as the uncombined elements

- You will notice that the last element is gold, since it is very unreactive, it is found in the Earth as the metal itself (unreacted with anything)
- But, most metals are found as compounds that require chemical reactions to extract the metal, since they have reacted with other compounds/elements

4.5 Explain oxidation as the gain of oxygen and reduction as the loss of oxygen

- As well as describing oxidation and reduction in terms of electrons, you can also describe them in terms of oxygen
- OXidation is GAIN of OXygen
- reduction is LOSS of oxygen

4.6 Recall that the extraction of metals involves reduction of ores

- Metals less reactive than carbon:
    - Can be extracted from their oxides by reduction with carbon
        - Don't forget: reduction involves the loss of oxygen, so you are reducing the ores to remove the oxygen to obtain the pure metal

4.7 Explain why the method used to extract a metal from its ore is related to its position in the reactivity series and the cost of the extraction process, illustrated by heating with carbon (including iron) and electrolysis (including aluminium) (knowledge of the blast furnace is not required)

- Can only be extracted by reduction of carbon if metal is less reactive so that carbon displaces the metal from the ore…
- If more reactive than carbon, electrolysis can be used (metals less reactive than carbon can also be extracted this way)
- Electrolysis is expensive due to the use of large amounts of energy to melt the compounds and to produce the electrical current (so you wouldn't extract a metal using electrolysis if it could be done more cheaply using carbon)
- Extraction by heating with carbon (including iron):
    - Iron oxide loses oxygen, and is therefore reduced. The carbon gains oxygen, and is therefore oxidised.
    - $2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(l) + 3CO_2(g)$
    - For iron, this is carried out at high temperatures in a blast furnace
- Extraction by electrolysis (including aluminium):
    - Metals that are more reactive than carbon e.g aluminium are extracted by electrolysis of molten compounds.
        - Too reactive to be extracted by reduction with carbon

        - Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite using carbon as the positive electrode (anode).
    - Metals that react with carbon can be extracted by electrolysis as well

4.8 (HT only) Evaluate alternative biological methods of metal extraction (bacterial and phytoextraction)

- Phytoextraction:
    - Some plants absorb metal compounds through their roots
    - They concentrate these compounds into their shoots and leaves
    - The plants can be burned to produce an ash that contains the metal compounds
- Bacterial extraction:
    - Some bacteria absorb metal compounds
    - Produce solutions called leachates which contain them
    - scrap iron can used to be obtain the metal from the leachate

4.9 Explain how a metals' relative resistance to oxidation is related to its position in the reactivity series

- Relative resistance to oxidation is the same as relative resistance to losing electrons / forming positive metal ions
    - less reactive a metal is, the more resistant it is to oxidation, because for a metal to react, it forms a positive metal ion by losing electrons (loss of electrons=oxidation)

4.10 Evaluate the advantages of recycling metals, including economic implications and how recycling can preserve both the environment and the supply of valuable raw materials

- Recycling is important to achieve sustainable development
    - Requires less energy to melt and remould metals than it does to extract new metals from their ores
    - Mining ores is bad for the environment as large quarries are created, which produce noise pollution and dust
    - Also, recycling allows for waste metals to be reused, saving money, helping the environment and the supply of valuable raw materials (meaning metal ores will last longer)

4.11 Describe that a life time assessment for a product involves the consideration of the effect on the environment of obtaining the raw materials, manufacturing the product, using the product and disposing of the product when it is no longer useful

- These are carried out to assess the environmental impact of products in each of these stages:
    - Extracting and processing raw materials
    - Manufacturing and packaging
    - Use and operation during its lifetime
    - Disposal at the end of its useful life, including transport and distribution at each stage
- Use of water, resources, energy sources and production of some wastes can be fairly easily quantified
- Allocating numerical values to pollutant effects is less straightforward and requires value judgements, so LTA (life time assessment) is not a purely objective process
- Selective or abbreviated LTAs can be devised to evaluate a product but these can be misused e.g. in support of claims for advertising purposes

4.12 Evaluate data from a life cycle assessment of a product

- Use 4.11 to do so