OCR A GCSE Chemistry

Topic 6: Global challenges

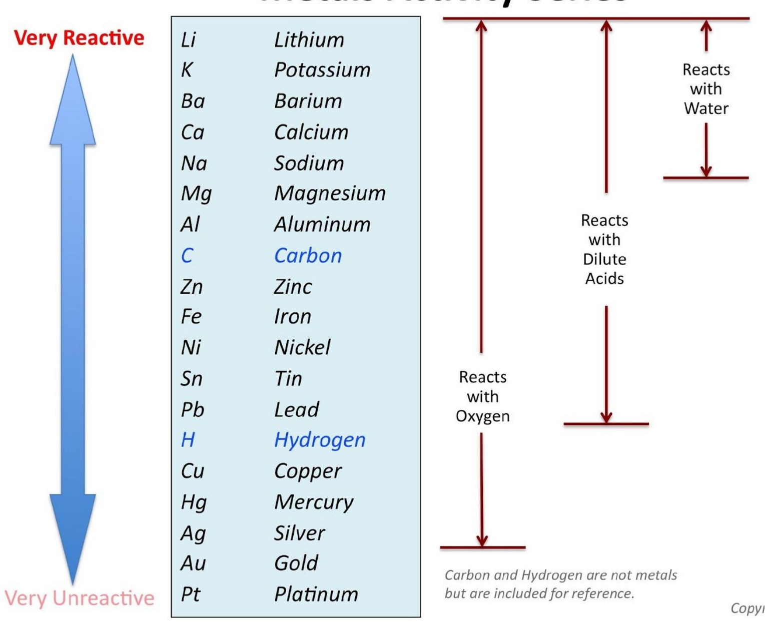
Improving processes and products

Notes

C6.1a explain, using the position of carbon in the reactivity series, the principles of industrial processes used to extract metals, including extraction of a non-ferrous metal

- 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)

Metals Activity Series



- The second to last element is gold, since it is very unreactive, it is found in the Earth as the metal itself
- But, most metals are found as compounds that require chemical reactions to extract the metal
- Metals less reactive than carbon
    - Can be extracted from their oxides by reduction with carbon
        - Don't forget: reduction involves the loss of oxygen

C6.1b explain why and how electrolysis is used to extract some metals from their ores

- 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
- Large amounts of energy are used in the extraction process to melt the compounds and to produce the electrical current

C6.1c (HT only) evaluate alternative biological methods of metal extraction

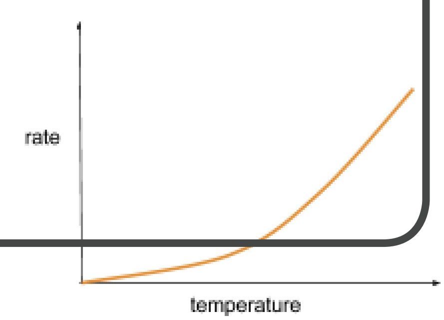
- Phytoextraction
    - Some plants absorb metal compounds through their roots
    - They concentrate these compounds as a result of this
    - The plants can be burned to produce an ash that contains the metal compounds
- Bacterial extraction
    - Some bacteria absorb metal compounds
    - Produce solutions called leachates which contain the metals

C6.1d (HT only) explain the trade-off between rate of production of a desired product and position of equilibrium in some industrially important processes

- Compromise is needed for a large yield (position of equilibrium) and a fast rate of reaction (rate of a desired product)
- a lower temperature/pressure may give a favourable position of equilibrium, but this will also lead to a slow rate of reaction, meaning you will end up with a lower yield of product. In these cases, generally a moderate temperature/pressure is used
- However, if a high temperature or high pressure favour the position of equilibrium as well – you still must put a limit to these two things to save money and also, if they are too high – this could be dangerous

C6.1e (HT only) interpret graphs of reaction conditions versus rate

- as an example, in this graph of rate against temperature, you can see that the rate increases with temperature



C6.1f (HT only) explain how the commercially used conditions for an industrial process are related to the availability and cost of raw materials and energy supplies, control of equilibrium position and rate

- see C6.1d
- energy supplies: high temperatures and pressures use massive amounts of energy
- almost all industrial processes will use a catalyst

C6.1g explain the importance of the Haber process in agricultural production

- Used to manufacture ammonia, which is used to produce nitrogen-based fertilisers
- The raw materials for the Haber process are nitrogen and hydrogen.
- Nitrogen is obtained from the air and hydrogen may be obtained from natural gas/hydrocarbons or steam
- The purified gases are passed over a catalyst of iron at a high temperature (about 450 °C) and a high pressure (about 200 atmospheres).
- Some of the hydrogen and nitrogen reacts to form ammonia.
- The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen.

nitrogen +hydrogen ⇌ ammonia

- On cooling, the ammonia liquefies and is removed.
- The remaining nitrogen and hydrogen are recycled.

C6.1h compare the industrial production of fertilisers with laboratory syntheses of the same products

- In the lab:
  - reactants: ammonia solution and dilute sulfuric acid (bought from chemical manufacturers)
  - SMALL scale (very little is produced)
  - only involves a few stages (titration then crystallisation)

- In industry:
  - reactants: natural gas, air, water (to make ammonia) and sulfur, air, water (to make sulfuric acid)
  - LARGE scale (produces a lot)
  - Many stages required (need to make ammonia and sulfuric acid, react accurate volumes then evaporate)

C6.1i recall the importance of nitrogen, phosphorous and potassium compounds in agricultural production

- Compounds of nitrogen, phosphorus and potassium are used as fertilisers to improve agricultural productivity
- in order for plants to be able to absorb these elements, they must be supplied in soluble compounds which can be taken in through the plant's roots

C6.1j describe the industrial production of fertilisers as several integrated processes using a variety of raw materials

- NPK fertilisers are formulations of various salts containing appropriate percentages of the elements
- Ammonia can be used to manufacture ammonium salts (such as ammonium nitrate and ammonium sulfate) and nitric acid
  - ammonia + nitric acid → ammonium nitrate
  - ammonia + sulfuric acid → ammonium sulfate
- Potassium chloride, potassium sulfate and phosphate rock are obtained by mining, but phosphate rock cannot be used directly as a fertiliser
  - Phosphate rock is treated with nitric acid or sulfuric acid to produce soluble salts that can be used as fertilisers

C6.1k describe the basic principles in carrying out a life-cycle assessment of a material or product

- 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 LCA (life cycle assessment) is not a purely objective process

C6.1l interpret data from a life-cycle assessment of a material or product

- use C6.1k as shown above

C6.1m describe a process where a material or product is recycled for a different use, and explain why this is viable

- Reduction in use, reuse and recycling of materials by end users reduces the use of limited resources, use of energy sources, waste and environmental impacts
- Metals, glass, building materials, clay ceramics and most plastics are produced from limited raw materials.
  - Much of the energy for the processes comes from limited resources
  - Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts
  - Some products, such as glass bottles, can be reused
    - Glass bottles can be crushed and melted to make different glass products
  - Other products cannot be reused and so are recycled for a different use
  - Metals can be recycled by melting and recasting or reforming into different products
  - Amount of separation required for recycling depends on the material and the properties required of the final product
    - E.g. some scrap steel can be added to iron from a blast furnace to reduce the amount of iron that needs to be extracted from iron ore

C6.1n evaluate factors that affect decisions on recycling

- advantages of recycling:
  - preserves materials
  - requires less energy than obtaining some materials e.g. extracting metals and can also produce less noise/dust pollution than this
- disadvantages of recycling:
  - energy costs of collecting and transporting items to recycling centre
  - must be sorted into different types
  - saves different amounts of energy for different materials

C6.1o describe the composition of some important alloys in relation to their properties and uses

- Most metals in everyday uses are alloys. Pure copper, gold, iron and aluminium are all too soft for everyday uses and so are mixed with small amounts of similar metals to make them harder for everyday use.
  - Gold in jewellery is usually an alloy with silver, copper and zinc
- Brass (copper and zinc)
  - Hinges, electrical plugs
- Solder (lead and tin)
  - Joining metals
- Bronze (copper and tin)
  - Castings and bearings
- Duralumin (aluminium, copper and other metals)
  - Aircraft manufacture
- Most iron is converted into steels.
    - Steels are alloys since they used mixtures of carbon and iron
    - Some steels contain other metals. Alloys can be designed to specific uses.
    - Low-carbon steels are easily shaped, high carbon steels are hard, and stainless steels are resistant to corrosion.

C6.1p describe the process of corrosion and the conditions which cause corrosion

- Corrosion = destruction of materials by chemical reactions with substances in the environment
- rusting requires both oxygen and water to be present

C6.1q explain how mitigation of corrosion is achieved by creating a physical barrier to oxygen and water by sacrificial protection

- rusting can be prevented by excluding oxygen and water e.g. by:
  - painting
  - coating with plastic
  - using oil or grease
- Aluminium has an oxide coating that protects the metal from further corrosion – exclusion of oxygen and water
- water can be kept away using a desiccant in the container (absorbs water vapour)
- oxygen can be kept away by storing the metal in a vacuum container
- Sacrificial protection: where the metal you want to be protected from rusting is galvanised with a more reactive metal, which will rust first and prevent water and oxygen reaching the layer underneath
  - E.g. zinc is used to galvanise iron

C6.1r compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals

- glass ceramics: transparent, hard, brittle, poor heat and electrical conductors
    - uses: windows, bottles
- clay ceramics: opaque, hard, brittle, poor heat and electrical conductors
    - uses: bricks and porcelain
- polymers: can be made transparent/translucent/opaque, poor heat and electrical conductors, can be tough or ductile
    - uses: plastic bags, bottles
- metals: shiny, good heat and electrical conductors, hard, tough
    - uses: cars, bridges, electrical cables

C6.1s explain how the properties of materials are related to their uses and select appropriate materials given details of the usage required

- see C6.1r above