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Chemistry Topic 15
Using our resources (triple only)

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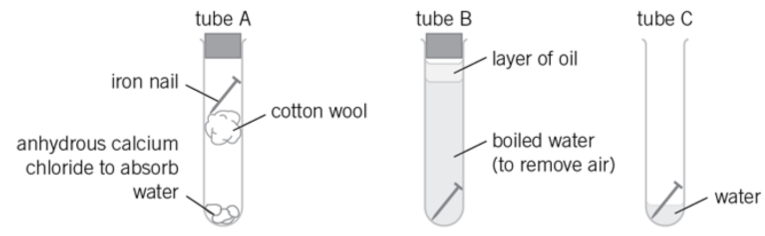
Section 1: Key Terms

Corrosion	**Breakdown of materials** due to chemical reactions. It is a form of **erosion**.
Rusting	The **corrosion** of **iron**.
Rust	Rust is hydrated Iron(III)oxide.
Sacrificial protection	An effective way to **prevent rusting** whereby a metal **more reactive than iron** is attached to or coated on an object.
Galvanised	Iron or steel objects that have been **protected from rusting** by a thin layer of **zinc metal** at their surface.
Oxidation	**Loss** of electrons.
Reduction	**Gain** of electrons.
Reducing agent	Tend to get **oxidised themselves** (and hence reduce other species).
Alloy	A mixture of two or more elements, at least one of which is a metal. For e.g. Steel is an alloy of Iron and carbon.
Bronze	Alloy of copper and tin.
Brass	Alloy of copper and zinc.
Steels	Alloys of iron containing specific amounts of carbon and/or other metals.
Hydrated	A substance that contains water in its crystals.
Polymers	A substance made from very large molecules, polymers are made up of many repeating units.
Thermosoftening polymers	Soften and melt when they are heated. Can be remoulded.
Thermosetting polymers	Do not melt when they are heated. Cannot be remoulded.
Composites	Two materials combined to make a material with useful properties.
Ceramics	Materials made by heating clay to high temperatures making hard materials which are excellent insulators.

Section 2: Rusting

For iron to rust, both **air** and **oxygen** are needed. Providing a barrier between iron either air (oxygen) and water protects the iron from rusting.

Iron + oxygen + water → hydrated iron(III)oxide



Tube A tests to see if air alone makes iron rust. Tube B tests to see if water alone will make iron rust. Tube 3 tests to see if air and water will make iron rust. **Rusting is only observed** in **tube 3** illustrating that both **air and water** are **needed** for iron to rust.

Sacrificial protection provides **protection against rusting**. The iron needs to be attached to a more **reactive metal** (**galvanising** it) for e.g. Zinc, magnesium or aluminium. The zinc is a **stronger reducing agent** than iron, so it has a stronger **tendency to form positive ions** by giving away electrons. As the zinc atoms lose electrons they become **oxidised**. Therefore any water or oxygen reacts with the zinc instead of the iron (protecting the iron from oxidation).

Section 3: Useful alloys

Alloys are **harder** than **pure** metals because the **regular layers** are **distorted** by **differently sized atoms** and hence **cannot slide**.

Pure iron is too **soft** for it be useful in its pure form. Steel is an alloy of iron which contains **carefully controlled quantities of carbon** so that it's hardness is controlled.

Steels	Properties	Uses
High carbon steel	Very hard but brittle	Cutting tools (chisels)
Low carbon steel	Softer but easily shaped	Bodies of cars
Stainless steel	Chromium-nickel steels resistant to corrosion	Cooking utensils, cutlery
Nickel steel alloys	Resistant to stretching	Bridges, bicycle chains

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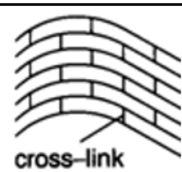
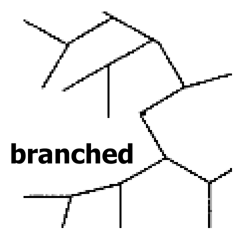
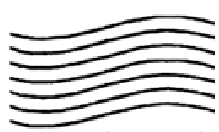
Section 4: The properties of polymers

The properties of polymers depends on what monomers they are made from the conditions under which they are made.

Thermosoftening polymers	Soften or melt easily when heated because their **intermolecular forces** between the chains are **weak**.	
Thermosetting polymers	Contain **crosslinks** (strong covalent bonds) between chains so they do not soften or melt easily.	
High density polyethene	Made using very high pressures and trace of oxygen. Polymer chains are randomly **branched, can't pack closely** together resulting in a **low density.**	
Low density polyethene	Made using a catalyst at 50°C and a slightly raised pressure. Made of **straight chain** molecules which are **closely packed,** stronger and more **dense.**	**Straight chain** 

Section 5: Glass, ceramic and composites

Glass	The most common form of glass is Soda Glass which is made by heating a mixture of sand (SiO_2), limestone ($CaCO_3$) and sodium carbonate (soda) at 1500°C. As it cools down the glass turns into a solid. Different types of glass exist depending on amounts of each of the reactants; borosilicate glass involves an extra compound- B_2O_3. • Atoms arranged irregularly • Transparent, brittle, high melting point, keeps its shape (not flexible)
Ceramics	Wet clay is moulded into a desired shape, then heated in a furnace to 1000°C • Used in bricks, tiles, crockery, bathroom furniture • Atoms are held together in a giant covalent lattice, generally in a regular pattern • Hard but brittle, electrical insulators
Composites	Materials made from two or more different materials, with one material acting as a binder for the other material, **reinforcing it.** Usually fibres or fragments of one material are held in a 'matrix' (network of atoms) by the other. • Glass-ceramic composites are very hard and tough (not brittle) • Fibreglass (polymer-ceramic) is a low density, tough, flexible material- e.g. used in kayaks • Plywood, carbon fibres and cement are other examples

Section 6: The Haber process

The Haber process is used to manufacture ammonia, which can be used to produce nitrogen-based fertilisers. The **raw materials** are **nitrogen** (from the air) and **hydrogen** (from natural gas, mainly **methane**).

The nitrogen and hydrogen are purified then passed over an **iron catalyst** at a **high temperature** of 450°C and a **high pressure** (200 atmospheres) to make **ammonia** NH_3.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

The reaction is **reversible** so ammonia can break down again into nitrogen and hydrogen. The ammonia is removed by cooling the gases so that the ammonia liquefies. It can then be separated from the unreacted nitrogen and hydrogen gas.

The unreacted nitrogen and hydrogen gases are recycled back into the reaction mixture so that they can react again on the surface of the iron catalyst.

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Section 7: The Haber process key terrms

Reversible reaction	A reaction in which the **products can also form the reactants.** Its symbol is ⇌ Shown as: A + B ⇌ C + D
Exothermic	A reaction that **transfers energy to** the **surroundings**
Endothermic	A reaction that **takes in energy from** the **surroundings**
Equilibrium (HT)	Equilibrium is reached when the **forward and backwards reactions** occur at **exactly the same rate**. The **amounts of reactants and products present remain constant**. Requires a **sealed container**.
Le Chatelier's Principle (HT)	When a **change in conditions** is introduced to a system at equilibrium, the **position of equilibrium shifts** so as **to cancel out the change.**

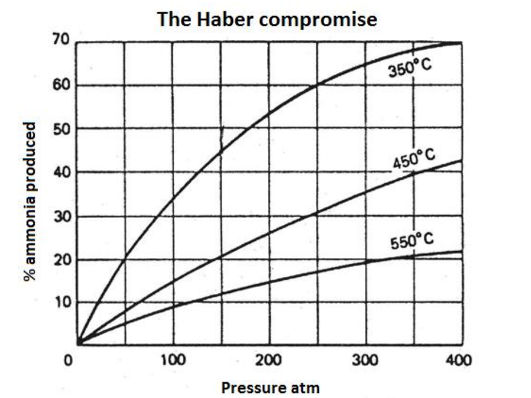
Section 8: Changing conditions in the Haber Process

Equation for the Haber process: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
ΔH is negative (exothermic in forwards direction).

Changing temperature	The Haber process is an **exothermic** process (ΔH is negative). If the temperature is **decreased**, the equilibrium moves to the **exothermic side** and **more NH_3** is made.
Changing the pressure	**Increasing the pressure** results in the equilibrium moving to the right hand side as there are **less gas molecules**.
Catalyst	The iron catalyst speeds up the rate of the forwards and backwards reaction **equally**, hence it **doesn't affect the yield** of ammonia but does result in ammonia being produced **quicker**.

Section 9: The Haber compromise (HT)

Lowering the temperature **slows** down the rate of reaction, taking **longer** for ammonia to be produced.
Increasing the pressure means stronger, more **expensive equipment** is needed. This **increases** the **cost** of producing ammonia.
Hence a **compromise** is reached achieving an **acceptable yield** in a **reasonable timeframe** while keeping **costs down.**
A pressure of **200 atmospheres** and a temperature of **450°C.**



Section 10: Fertilisers

Compounds of nitrogen, phosphorus and potassium are used as fertilisers to improve agricultural productivity.

NPK fertilisers	NPK fertilisers contain compounds of all three elements. **Nitrogen** for cell growth and making proteins in plants **Phosphorus** needed to make DNA **Potassium** needed to make enzymes involved in respiration and photosynthesis.
Synthesis	Fertilisers are made by reacting an **acid** and **base** together e.g. Ammonia + nitric acid → ammonium nitrate Ammonia + phosphoric acid → ammonium phosphate Ammonia + sulphuric acid → ammonium sulfate
Obtaining raw materials	Phosphates are obtained from **phosphate rocks**. Phosphate rocks all contains the phosphate ion PO_4^{3-}. The rocks are **insoluble so cant be used directly as fertilisers,** but react with **acids** to make the **soluble phosphate** compounds. Potassium chloride and potassium sulfate are obtained by **mining** and are **soluble** so **can be directly used** as fertilisers. Nitric acid is required to make nitrate fertilisers (ammonia from the Haber process is oxidised to make nitric acid).
Phosphate rock fertilisers	Phosphate rock + nitric acid → phosphoric acid + calcium nitrate Phosphate rock + sulphuric acid → calcium phosphate + calcium sulfate Phosphate rock + phosphoric acid → calcium phosphate