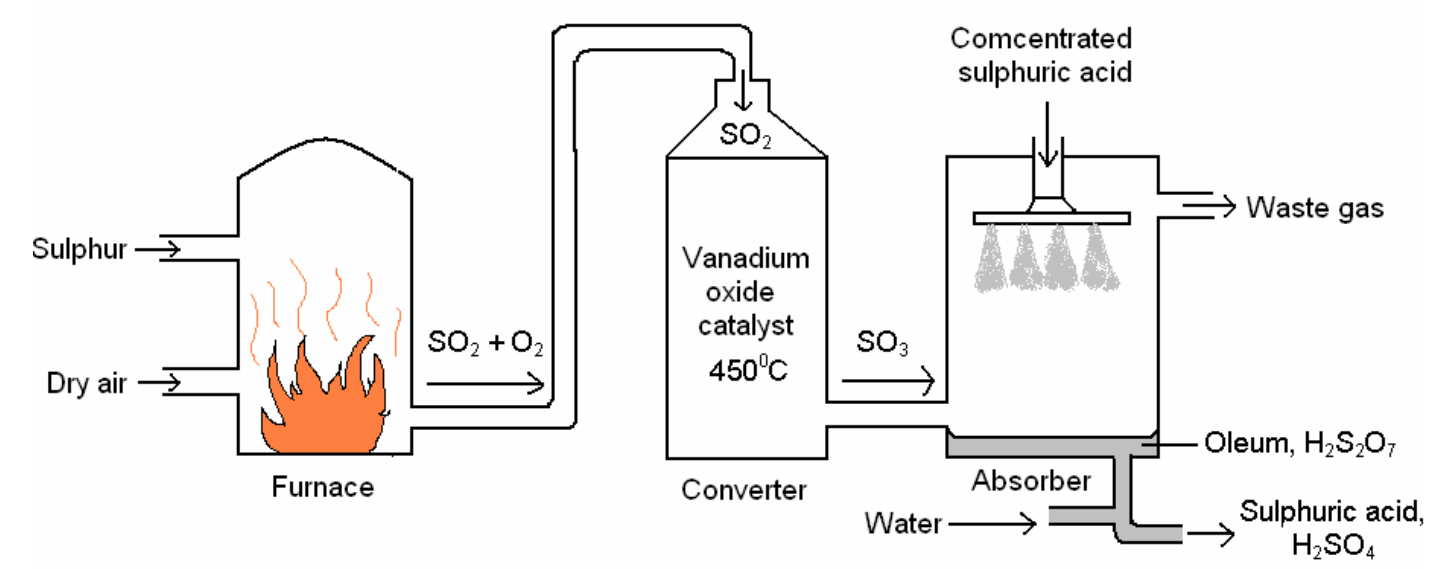
Chapter 9: Manufactured Substances in Industry



The manufacture of sulphuric acid, H_2SO_4 through the Contact Process

Stage 1: Combustion of Sulphur

In the furnace, molten sulphur is burnt in dry air to produce sulphur dioxide, SO_2. The gas produced is purified and cooled.

$$S(l) + O_2(g) \rightarrow SO_2(g)$$

Stage 2:

In the converter, sulphur dioxide, SO_2 and excess oxygen gas, O_2 are passed over a few plates of vanadium (V) oxide, V_2O_5 catalyst at 450^0C to produce sulphur trioxide, SO_3.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

About 99.5% of the sulphur dioxide, SO_2 is converted into sulphur trioxide, SO_3 through this reversible reaction.

Stage 3:

In the absorber, the sulphur trioxide, SO_3 is first reacted with concentrated sulphuric acid, H_2SO_4 to form a product called oleum, $H_2S_2O_7$.

$$SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7$$

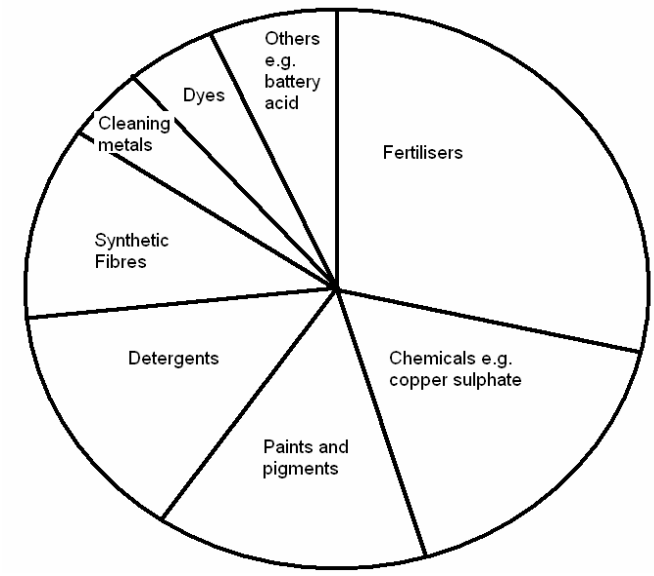
The oleum, $H_2S_2O_7$ is then diluted with water to produced concentrated sulphuric acid, H_2SO_4 in large quantities.

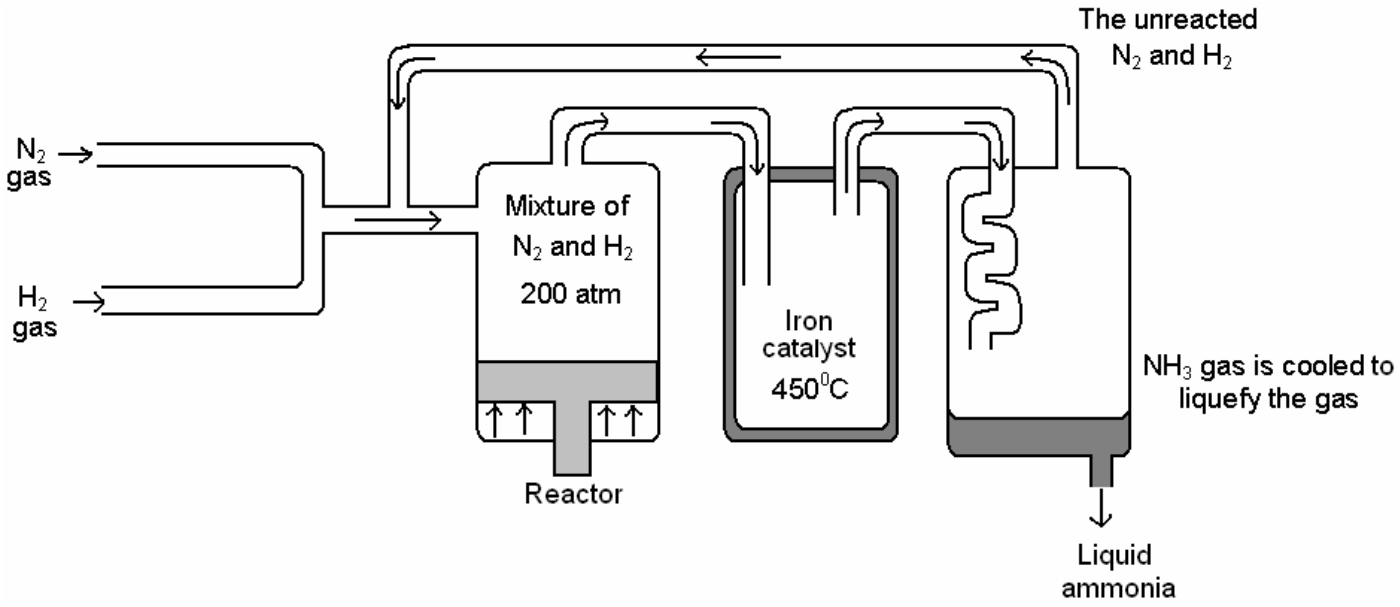
$$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$$

The two reactions in the third stage are equivalent to adding sulphur trioxide, SO_3 directly to water.

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$$

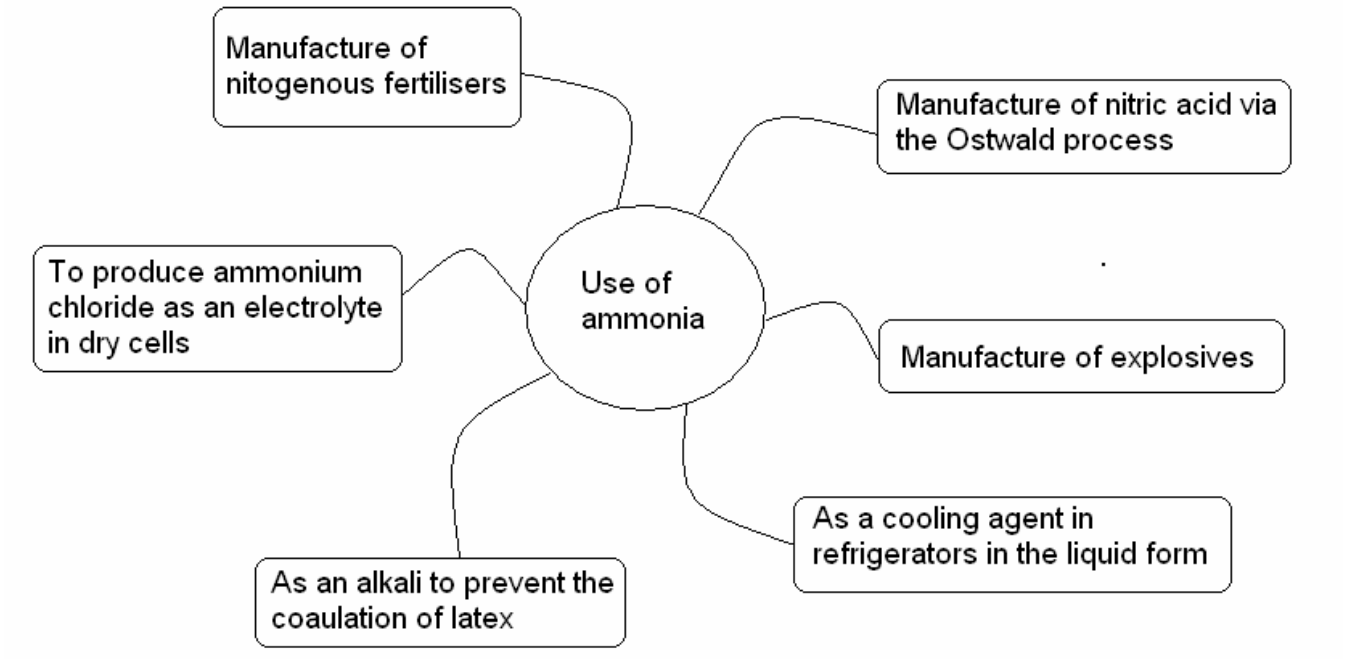
Uses of Sulphuric Acid





*The manufacture of ammonia, NH_3 through the **Haber Process***

1. Gases mixed and scrubbed	**3. Converter**
Haber process combines N_2 gas from the air with H_2 gas from natural gas to form NH_3. The two gases are mixed. The mixture is scrubbed to get rid of impurities.	Then, it goes to the converter. It is then passed through layers of iron catalyst with aluminium oxide as a promoter at a temperature of 450^{0}C – 500^{0}C
2. Compressor	**4. Cooler**
One volume of N_2 gas and three volume of H_2 gas is compressed to a pressure of 200 – 500 atm $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	A mixture of three gases leaves the converter. It is cooled until the ammonia condenses. The nitrogen and hydrogen are pumped back to the converter for another chance to react.
	5. storage tanks
	NH_3 is formed and then liquefy and separated to get a better yield. The NH_3 is run into tanks and stored as a liquid under pressure.



Metals

- Most metals are solid
- Pure metals are made up of the same type of atoms and are of the same size.
- The arrangement of the atoms in metals gives the metals their ductile and malleable properties.
- The orderly arrangement of atoms in metals enables the layers of atoms to slide on one another when force is applied.
- Thus, metals are ductile or can be stretched.

Alloys

- A mixture of two or more elements with a certain fixed composition in which the major components is a metal.
- The aim of making alloys is to make them stronger, harder, resistant to corrosion, have a better furnish and luster.
- The presence of atoms of other metals that are of different sizes disturb the orderly arrangement of atoms in the metal.
- This reduces the layer of atoms from sliding.
- Thus, an alloy is stronger and harder than its pure metals.

Alloy	Composition	Properties	Uses
Bronze	- 90% copper - 10% tin	- Hard and strong - Does not corrode easily - Has shiny surface	- In building of statues or monuments - In the making of medals, swords and artistic materials.
Brass	- 70% copper - 30% zinc	- Harder than copper	- In the making of musical instruments and kitchenware
Steel	- 99% iron - 1% carbon	- Hard and strong	- In the construction of buildings and bridges - In the building of the body of cars and railways tracks
Stainless Steel	- 74% iron - 8% carbon - 18% chromium	- Shiny - Strong - Does not rust	- In the making of cutlery - In the making of surgical instruments
Duralumin	- 93% aluminium - 3% copper - 3% magnesium - 1% manganese	- Light - Strong	- In the building of the body of aeroplanes and bullet train
Pewter	- 96% tin - 3% copper - 1% antimony	- Luster - Shiny - Strong	- In the making of souvenirs

Polymers

- Polymers are large molecules made up of many identical repeating sub-units called monomers which are joined together by covalent bonds.
- Monomers are joined into chains by a process of repeated linking known as polymerization.
- A polymer may consists of thousands of monomers.
- Naturally occurring polymers: starch, cellulose, wool, protein. Silk and natural rubber

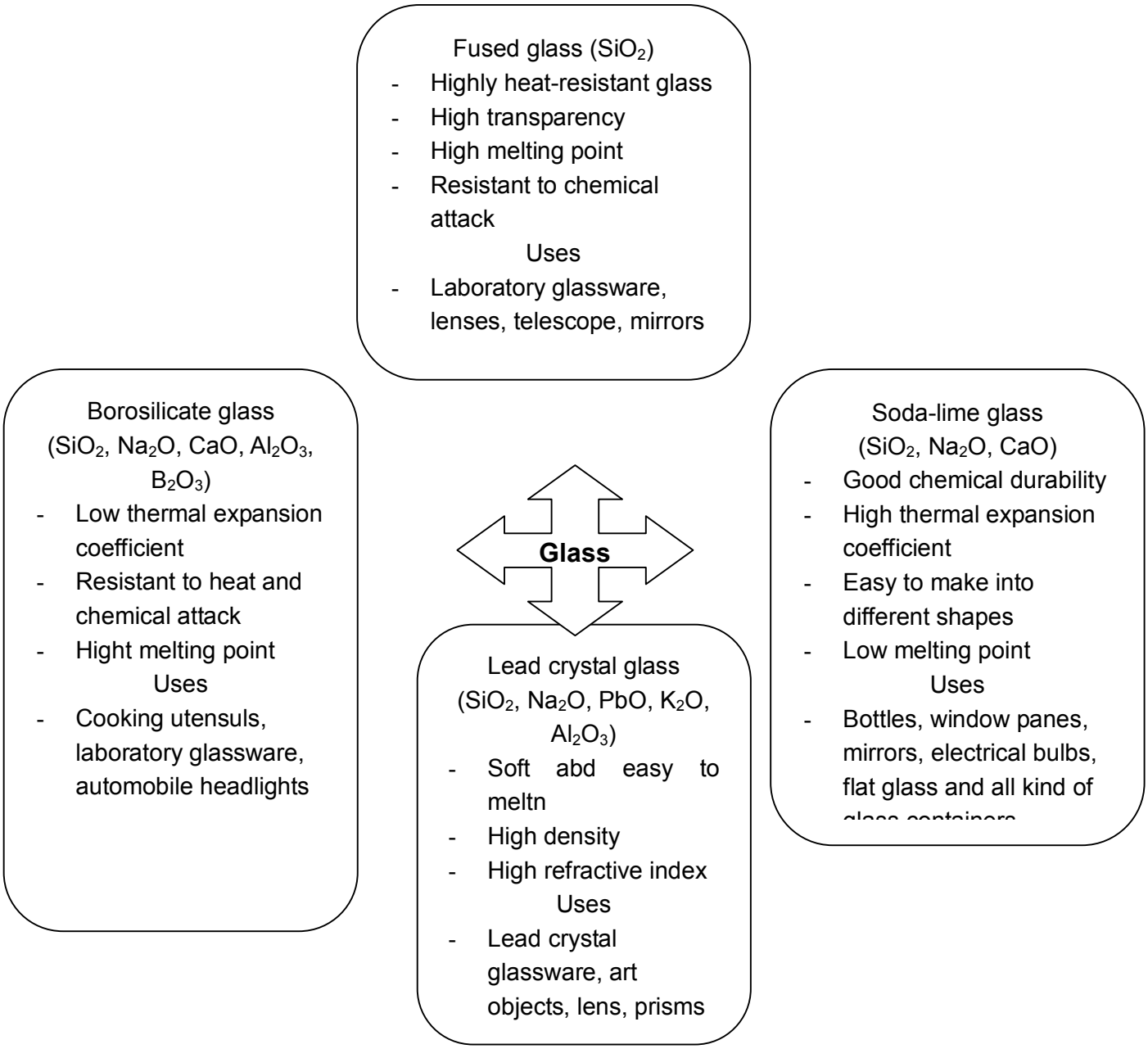
Synthetic Polymers

- Synthetic polymers are man-made polymers.
- The monomers used are usually obtained from petroleum after going through the refining cracking processes.
- Examples: polythene, polyvinyl chloride (PVC), polypropene, perspex, nylon and terylene.
- Synthetic polymers are very stable and do not corrode or decay, and also difficult to dispose.
- They may cause pollution, blockage of drainage systems and flash floods.

Synthetic polymer	Monomer	Uses
Polythene	Ethene	Plastic bags, shopping bags, plastic containers and insulation for electrical wiring
Polypropene	Propene	Piping, bottle crates, carpets, car batteries and ropes
Polyvinyl chloride, PVC	Chloroethene	Artificial leather, water pipes and records
Perspex	Methylmethacrylate	Safety glass, reflectors, traffic signs and lens
Terylene	Hexane-1,6-diol Benzene-1,4-dicarboxylic acid	Clothing, sails and ropes
Nylon	Hexane-1,6-diamine Hexane-1,6-dioic acid	Ropes, clothing and carpets.

Glass

- The major component of glass is silica or silicon dioxide, SiO_2 which found in sand.
- Properties of glass: Transparent, hard but brittle, chemically inert, heat insulator, electrical insulator, impermeable to liquid



Ceramics

- Ceramics are made from clay, for example kaolin, a hydrated aluminiumsilicate, $Al_2O_3.2SiO_2.2H_2O$.
- When the clay is heated to a very high temperature, they undergo a series of chemical reaction and are hardened permanently to form ceramics.
- Ceramics are very hard, brittle, have a very high melting point, chemically inert and do not corrode.
- The are good insulators of electricity and heat.
- Uses of ceramics: construction materials – bricks, tiles, cement and pipes
- Ornamental articles – bowls, cups, plates, vase and porcelain
- Electrical insulators – spark plugs, fuses, insulators in electric iron and oven
- Superconductors

Composite Materials

- Composite materials is a structural material that is formed by combining two or more different substance such as metal, alloys, glass, ceramics and polymers.
- The resulting material has properties that are superior than those of the original components.
- Composite materials are created for specific application.

Composite material	Component	Properties of component	Properties of composite	Uses of composites
Reinforced concrete	Concrete	- Hard but brittle - Low tensile strength	- Stronger - Higher tensile strength - Does not corrode easily - Cheaper - Can be moulded into any shape - Can withsatand very high applied forces - Can support very heavy loads	- Construction of roads - Rocket launching pads - High-rise buildings
	Steel	- Strong in tensile strength - Expensive - Can corrode		
Superconductor	- Copper (II) oxide - Tttrium oxide - Barium oxide	Insulators of electricity	- Conducts electricity without resistance when cooled by liquid nitrogen	- Magnetically levitated train - Transformers - Electric cable - Computer parts - Amplifier
Photochromic glass	Glass	- Transparent - Not sensitive to light	- Reduce refraction of light - Control the amount of light passes through it automatically - Has the ability to change colour and become darker when exposed to ultraviolet light -	- Information display panels - Light detector devices - Car windshields - Optical lens
	Silver chloride or silver bromide	- Sensitive to light		
Fibre optics	Glass with low refraction index	- Transparent - Does not reflect light rays	- Low material cost - Reflect light ray and allow to travel along the fibre	- Transmit data using light waves in telecommunications - Instruments for

			- Can transmit electronic data or signals, voice and images in a digital format, in the form of light along the fine glass tubes at great speeds	examining internal parts of the body or inspecting the interiors of manufactured structural products
	Glass with higher refractive index			
Fibre glass	Glass	- High density - Strong but brittle - Non-flexible	- High tensile strength - Moulded and shaped - Inert to chemicals - Light - Strong - Tough - Not inflammable - Impermeable to water - Resilient - Flexible	- Car bodies - Helmets - Skies - Rackets - Furniture - Water storage tanks - Small boats
	Polyester plastic	- Light - Flexible - Inflammable - Elastic but weak		