CHAPTER 9: MANUFACTURED SUBSTANCES IN INDUSTRY

Sulphuric acid

Uses of Sulphuric Acid:
1. Fertilisers (+ NH_4^+, + K^+, + Ca^{2+})
2. Paint pigments (+ Ba^{2+})
3. Detergents (Sulphonation)
4. Synthetic fibres (+ Cellulose + Alkali)
5. Electrolyte (Lead-acid accumulator)
6. Cleaning metals
7. Plastics

Manufacture of Sulphuric Acid (Contact Process):

1. $S \xrightarrow{+O_2} SO_2$ (Sulphur burner, purifier)
2. $SO_2 \xrightarrow{+O_2} SO_3$ (Converter with V_2O_5 at 450°C)
3. $SO_3 \xrightarrow{+H_2SO_4} H_2S_2O_7$ (*Oleum*) $\xrightarrow{+H_2O} 2H_2SO_4$ (Absorber, diluter)
4. $SO_3 \xrightarrow{+H_2O} H_2SO_4$ [unrecommended as it produces too much heat and acidic fume]

Formation of Acid Rain:
1. $SO_2 + H_2O \rightarrow H_2SO_3$
2. $2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$
3. Acid rain: sulphurous acid, sulphuric acid, nitric acid

Corrosion of Acid Rain:
1. $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$
2. $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$

Pollution of Acid Rain:
1. Soil: increases acidity, leaches minerals, destroys plants
2. Water: increases acidity, kills aquatic organisms

Control of Acid Rain:
1. Use low-sulphur fuels
2. Neutralise soil and water
3. Remove sulphur oxide by blowing powdered limestone into the combustion chamber, so that $CaCO_3 \rightarrow CaO \rightarrow CaSO_3 \rightarrow CaSO_4$ for the building industry.

Ammonia

Uses of Ammonia:

1. Fertilisers and urea (+ PO_4^{3-}, + NO_3^-, + SO_4^{2-}, + CO_2)
2. Manufacture of nitric acid
3. Cooling agent
4. Prevention of coagulation of latex
5. Electrolyte (+ Cl^-)
6. Explosives (+ NO_3^-)

Manufacture of Ammonia (Haber Process):

1. 200 atm	(Compressor)
2. $N_2 + 3H_2 \rightarrow 2NH_3$	(Reactor with red hot iron at 450°C)
3. NH_3 (g → l), return unreacted N_2+H_2	(Cooling chamber)

Manufacture of Nitric Acid (Ostwald Process):

1. $NH_3 \xrightarrow{+O_2} NO + H_2O$	(Oxidation converter with platinum)
2. $NO \xrightarrow{+O_2} NO_2$	(Oxidation chamber)
3. $NO_2 \xrightarrow{+O_2+H_2O} HNO_3$	(Absorption chamber)

Alloys (A mixture of > 2 elements with fixed composition in which the major component must be a metal)

Aims of Manufacturing Alloys:

1. Increase strength and hardness
   i. disrupt the orderly arrangement of atoms so that layers are more difficult to slide
2. Increase resistance to corrosion (prevent oxides)
3. Improve appearance (prevent oxides)

Alloys:

1. Bronze	(Cu+Sn)	Medals, statues, art materials
2. Brass	(Cu+Zn)	Musicals, kitchenware, knobs, ornaments, electrics
3. Cupro-Ni	(Cu+Ni)	Coins
4. Steel	(Fe+C)	Buildings, cars, railways
5. S.less steel	(Fe+C+Cr+Ni)	Cutlery, sinks, surgicals
6. Duralumin	(Al+Cu+Mg+Mn)	Aircrafts, trains, bicycles
7. Pewter	(Sn+Cu+Sn)	Art objects, souvenirs
8. Solder	(Sn+Pb)	Wires
9. 9-C gold	(Au+Cu+Ag)	Jewellery

Polymers

(Long chained molecules by joining up identical monomers)

1. Natural polymers: natural rubber (*polyisoprene*), carbohydrates, proteins
2. Synthetic polymers:
   - i. Addition polymerisation

I. Polythene	Bags, cups, toys
II. PVC	Pipes, wire casing, raincoats, bags
III. Polystyrene	Disposable cups, packages, toys, insulators
IV. Perspex	Glass replacement, lenses, optic fibres
V. Teflon	Non-stick pans, insulators
VI. Syn. rubber (*neoprene*)	Rubber host, toys

   - ii. Condensation polymerisation

I. Nylon (*polyamine*)	Toothbrushes, fishlines, textile, parachutes, insulators
II. Terylene (*polyester*)	Textile, stocking, parachutes, fishnets

Glass

Manufacture of Glass (*metal silicates*):

1. $SiO_2 + MCO_3 \rightarrow MSiO_3 + CO_2$
2. Temperature is raised to above 1500°C
3. Every oxygen atom is bonded to 2 silicon atoms to form a gigantic 3D covalent molecule

Types of Glass:

1. Fused glass (pure SiO_2):	Heated and cooled, expensive, 'simplest glass'
2. Soda-lime glass:	(+CaO+NaO) Most common and earliest used glass.
3. Borosilicate glass:	(+CaO+NaO+B_2O_3) High m/p, resistant to chemical attack.
4. Lead crystal glass:	(+PbO+NaO) Denser, more expensive, 'crystal/lead glass'

Ceramics

Types of clay:

1. White clay: *Kaolinite* or hydrated *aluminosilicate*
2. Red clay: Iron (III) oxide

Manufacture of Ceramics:

1. Wet clay is shaped easily due to easy sliding crystals
2. The clay is heated to above 1500°C to pack the mineral crystals together
3. It is glazed and heated again for a waterproof surface
4. This is an irreversible reaction

Glass and Ceramics

Similarities: Brittle, inert to chemicals, good insulator, do not corrode.
Differences: Glass can be heated repeatedly; glass is usually transparent; glass has a lower m/p
Improvements:

1. Glass optical fibre
2. Photochromic glass
3. Conducting glass
4. Smart glass (electrochromic/privacy glass)
5. Bioceramics
6. Glass ceramics
7. Ceramic superconductors (perovskites)
8. Ceramic composites (piezoelectric ceramic)

Composite Materials (material formed by > 2 different substances)

1. Wood (cellulose + lignin)
2. Bones (collagen + apatite)
3. Plywood
4. Reinforced concretes
5. Superconductors
6. Fibre optic
7. Fibreglass
8. Photochromic glass