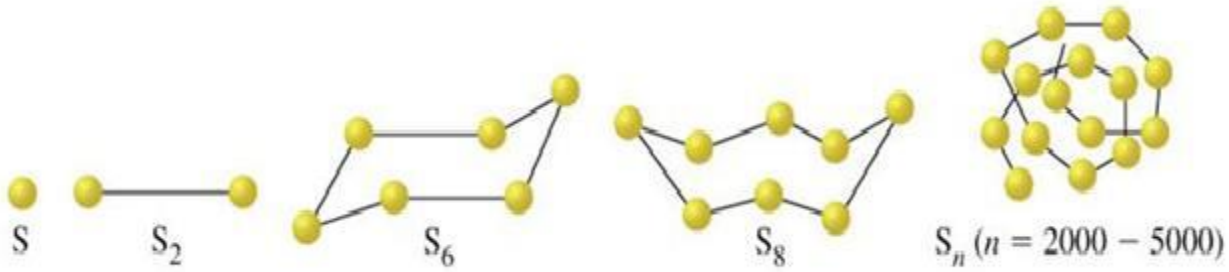
SULPHUR

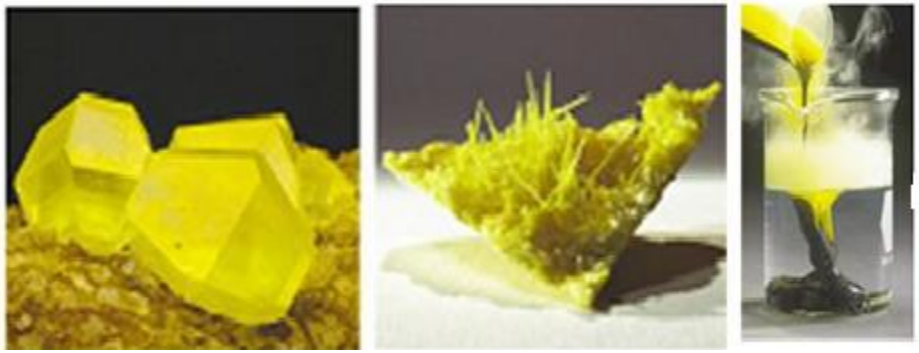
Allotropy and Polymorphism

Sulphur has more allotropic forms than any other element.These forms arise partly from the extent to which S has polymerised.



Most important are Rhombic or octahedral or α form

Monoclinic or prismatic or β form



Rhombic and monoclinic forms undergo reversible changes at 368.5 K (transition temperature)

The S_2 molecule is paramagnetic and blue coloured like O_2

Sulfur & its properties

Sulfur

Crystalline		Amorphous
Rhombic	**Monoclinic**	slowly changes to rhombic form at ambient temperatures
stable at < 204°F	stable at >204°F	
		prepared by rapidly chilling liquid sulfur
Both exists in octatomic crystalline structures		presence not desired

Solid sulfur at ambient temperature

Gaseous sulfur allotropes

S_8

S_6

S_2

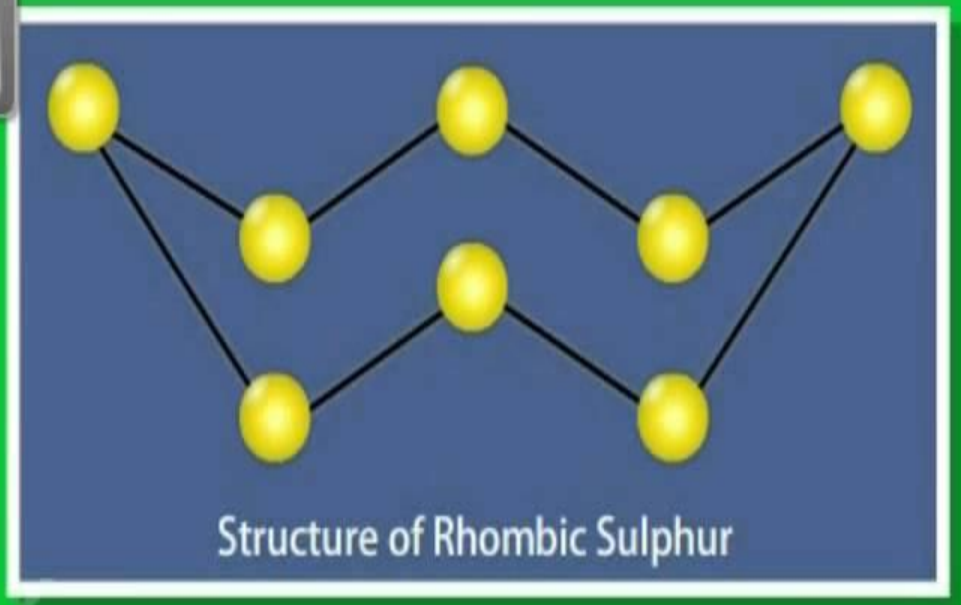
ALLOTROPIC FORMS

- Sulphur forms numerous allotropes of which the yellow rhombic (α-sulphur) and monoclinic (β - sulphur) forms are the most important.
- The stable form at room temperature is rhombic sulphur, transforms to monoclinic sulphur when heated above 369 K.

Allotropic Forms of Sulphur

Rhombic Sulphur (α-sulphur):

This is the most stable form of sulphur. It is obtained by slowly evaporating a solution of roll sulphur in CS_2, when octahedral crystals of rhombic sulphur are formed. This is lemon yellow in colour.

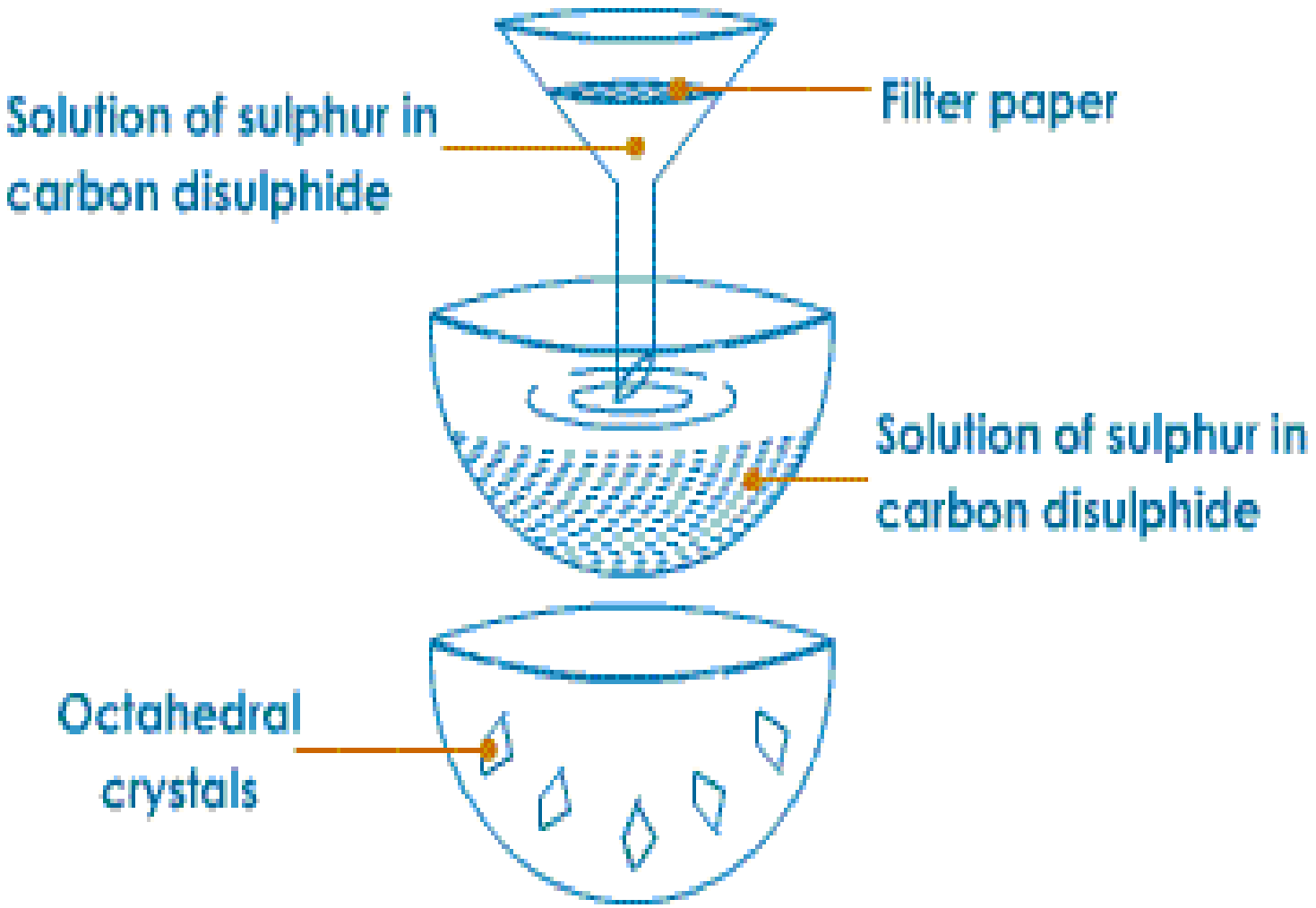


Structure of Rhombic Sulphur

Monoclinic Sulphur (β-sulphur):

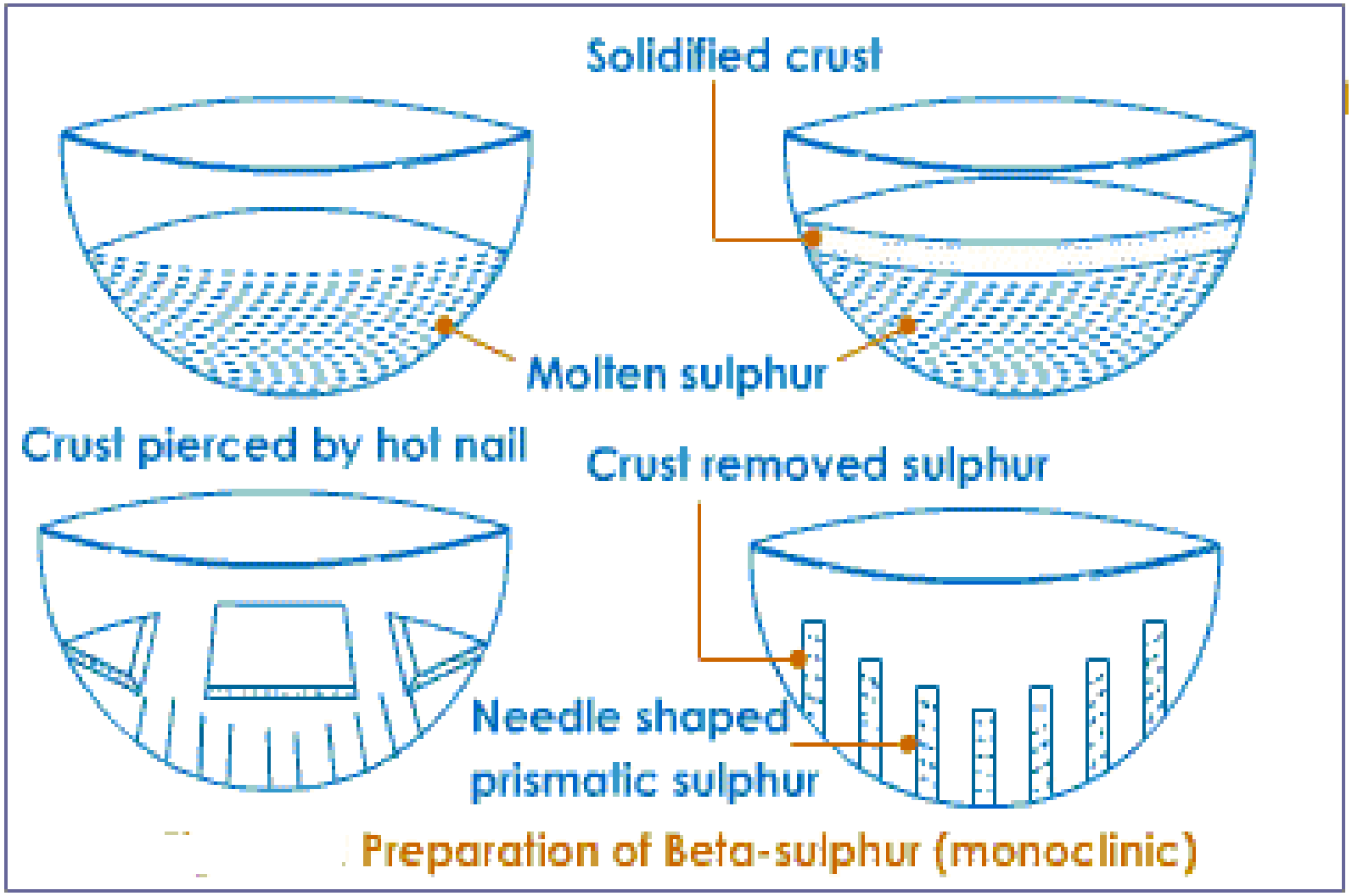
If crystals of rhombic sulphur are slowly heated to 369 K, they slowly change into needle like variety called monoclinic sulphur. This form is stable above 369 K. It has dull yellow colour. It is insoluble in water.

Structure of Monoclinic Sulphur



Preparation of α-sulphur(rhombic)

MONOCLINIC SULPHUR



Rhombic vs Monoclinic Sulphur

More Information Online WWW.DIFFERENCEBETWEEN.COM

	Rhombic Sulphur	Monoclinic Sulphur
DEFINITION	A crystalline allotropic form of Sulphur that has rhombic octahedral crystals.	A crystalline allotropic form of sulphur that has needle-like, long crystals.
DENSITY	Around 2.06 g/mL	About 1.98 g/mL
MELTING POINT	112.8◦C	119◦C
CONVERSION INTO OTHER FORMS	If we heat rhombic sulphur to about 96◦C slowly, it converts into the monoclinic form.	Monoclinic form converts into the rhombic form when heated to about 94.5◦C slowly.
METHOD OF PREPARATION	Preparation starts with the dissolving of sulphur powder in carbon disulphide.	Preparation starts with the evaporation of sulphur powder on an evaporating dish until it melts.

Formation of Plastic Sulphur

USES OF SULPHUR

Preparation of Sulphur Dioxide

- Sulphur dioxide is prepared by burning sulphur in oxygen or air.

$$S + O_2 \rightarrow CO_2$$

- Sulphur dioxide is usually made in the laboratory by heating concentrated sulphuric acid with copper turnings.

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

- Industrially, it is produced as a by-product of the roasting of sulphide ores.

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$$

PHYSICAL PROPERTIES

- Sulphur dioxide is a colourless gas with pungent smell and is highly soluble in water.
- It liquefies at room temperature under a pressure of two atmospheres and boils at 263 K.

Chemical Properties

- Sulphur dioxide, when passed through water, forms a solution of sulphurous acid.

$$SO_2 + H_2O \rightleftharpoons H_2SO_3\,(aq)$$

- It reacts readily with sodium hydroxide solution, forming sodium sulphite, which then reacts with more sulphur dioxide to form sodium hydrogen sulphite.

$$2NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O$$

$$Na_2SO_3 + H_2O + SO_2 \rightarrow 2NaHSO_3$$

- Sulphur dioxide reacts with chlorine in the presence of charcoal (which acts as a catalyst) to give sulphuryl chloride, SO_2Cl_2. It is oxidised to sulphur trioxide by oxygen in the presence of vanadium(V) oxide catalyst.

$SO_2\ (g) + Cl_2\ (g) \rightarrow SO_2Cl_2$

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

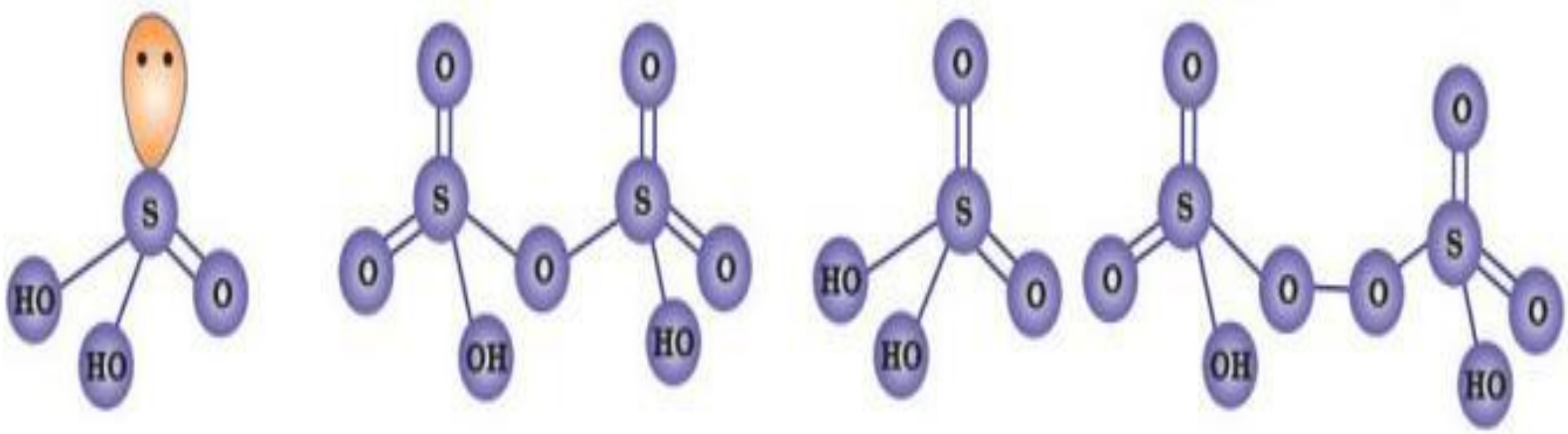
- When moist, sulphur dioxide behaves as a reducing agent. For example, it converts iron(III) ions to iron(II) ions and decolourises acidified potassium permanganate(VII) solution; the latter reaction is a convenient test for the gas.

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

$$5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + 2Mn^{2+}$$

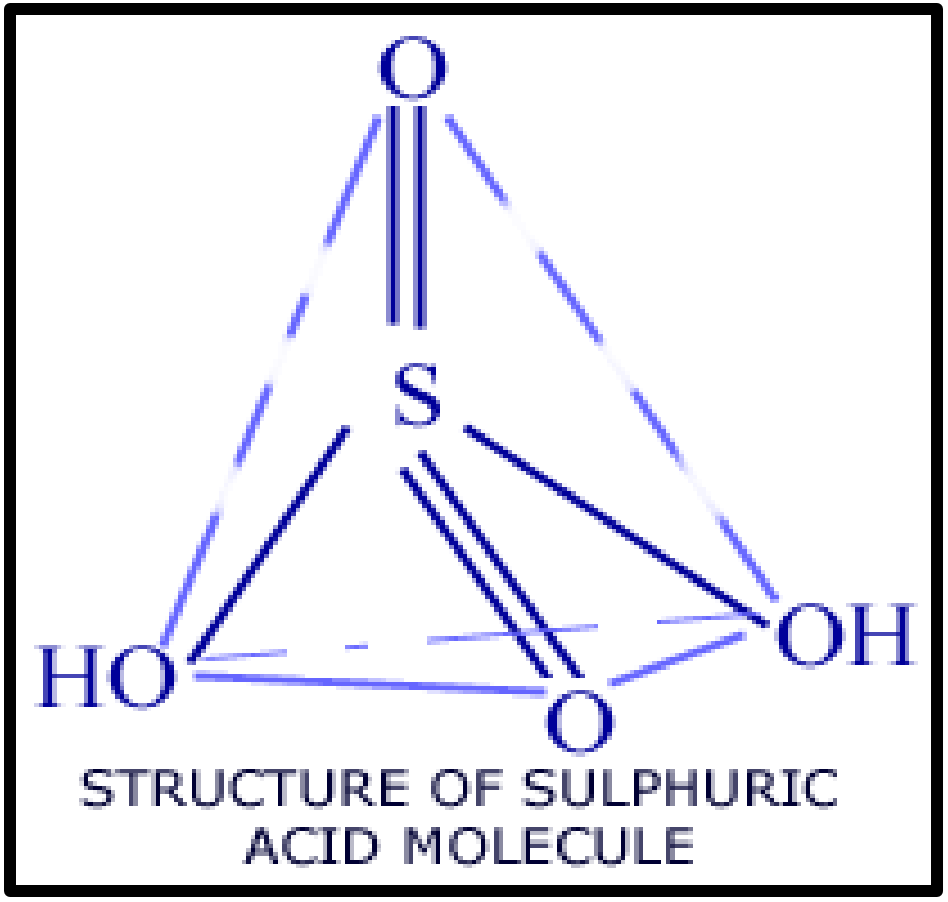
Uses of Sulphur dioxide

Oxoacids of Sulphur



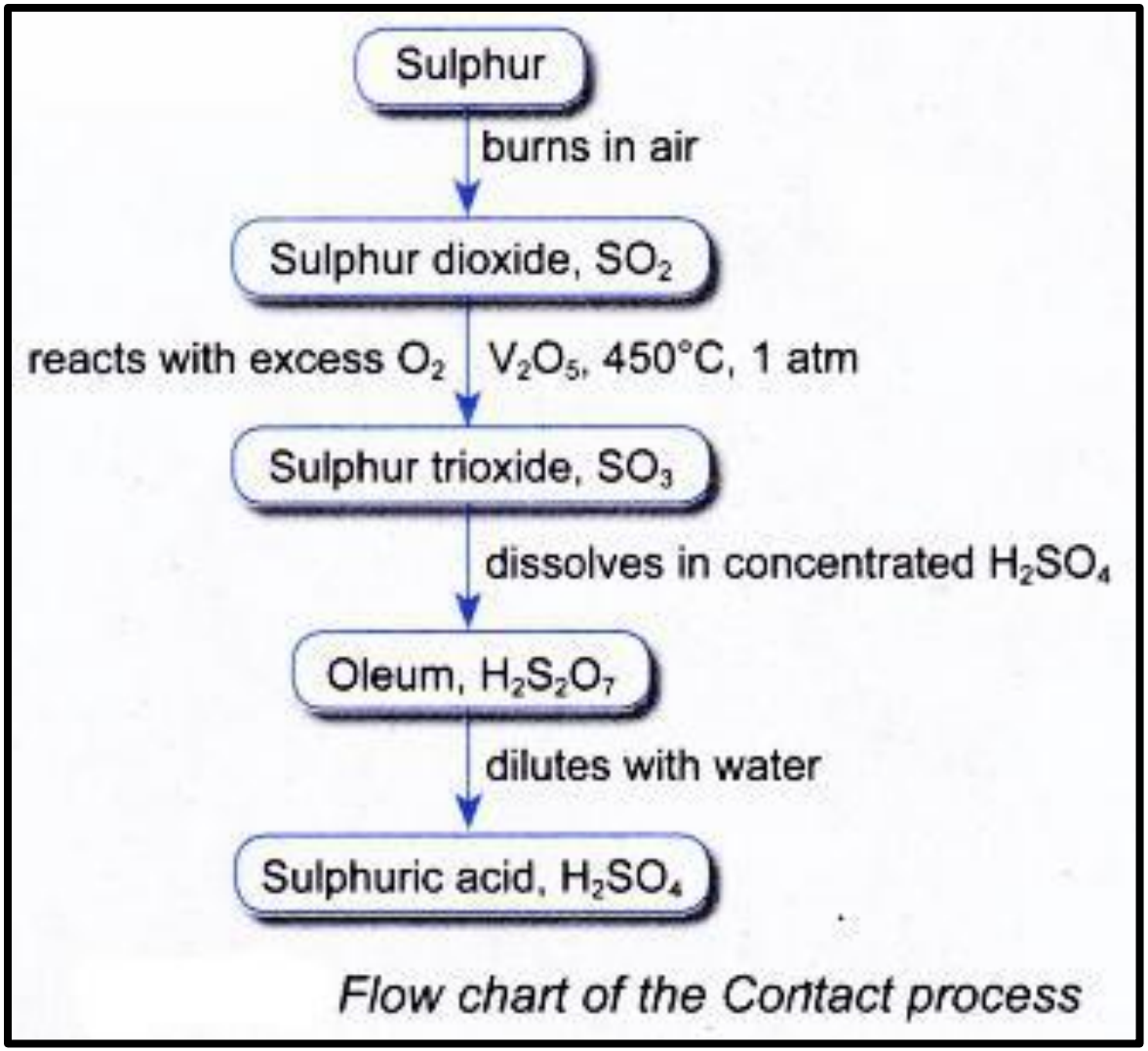
Structure of some important oxoacids of sulphur

SULPHURIC ACID



STRUCTURE OF SULPHURIC ACID MOLECULE

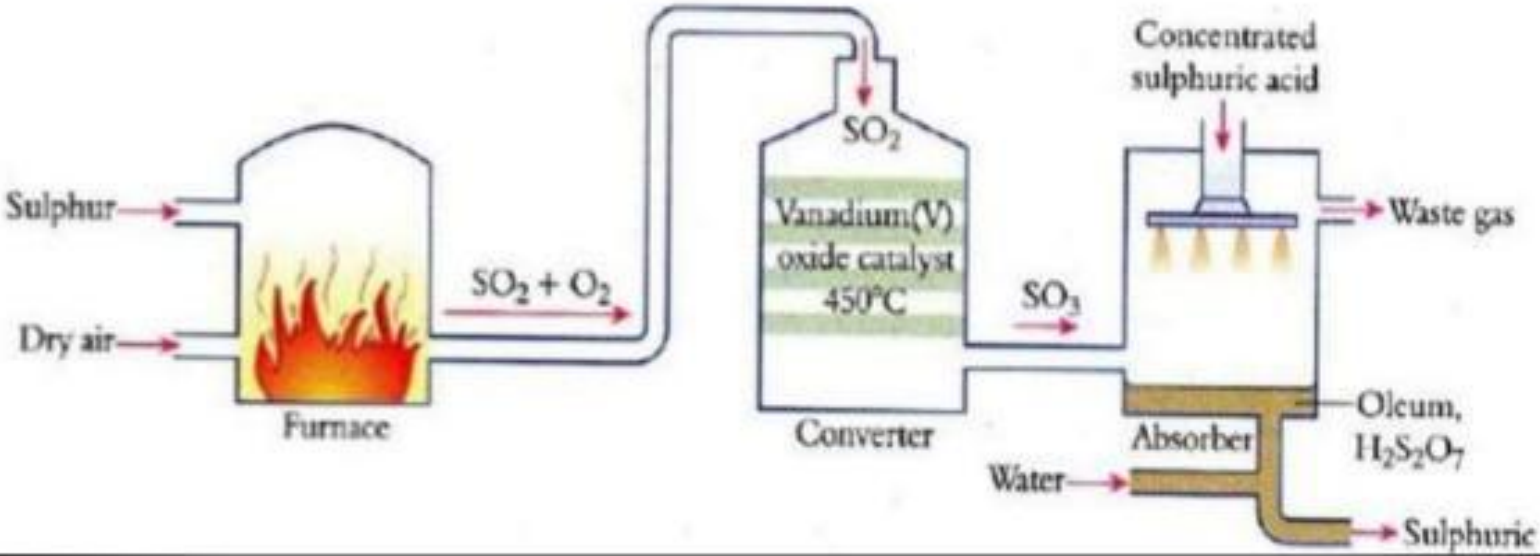
MANUFACTURE OF SULPHURIC ACID



Flow chart of the Contact process

CONTACT PROCESS

The Manufacture of H_2SO_4, through the Contact Process



CHEMICAL PROPERTIES OF SULPHUR

Properties of Sulfuric Acid (H_2SO_4)

- Sulfuric acid is a diprotic acid (can donate 2 protons to a base)
- Sulfuric acid ionises in water in two stages:

$$H_2SO_4(l) + H_2O(l) \text{ -----> } HSO_4^-(aq) + H_3O^+(aq)$$

$$HSO_4^-(aq) + H_2O(l)\ SO_4^{2-}(aq) + H_3O^+(aq)$$

- Sulfuric acid is a strong acid (complete dissociation in water, K_a approaches infinity)
- Sulfuric acid reactions:

sulfuric acid + metal -----> metal sulfate + hydrogen gas

sulfuric acid + carbonate -----> metal sulfate + carbon dioxide gas + water

sulfuric acid + base -----> salt + water

sulfuric acid + ammonia -----> ammonium sulfate

- Sulfuric acid can take part in redox reactions.

Concentrated sulfuric acid is a very powerful dehydrating agent.

Dehydrating agents remove water from a compound, in a vigorous exothermic reaction. An example is the reaction of sulfuric acid with glucose.

$$\text{glucose} \xrightarrow{\text{conc. } H_2SO_4} \text{carbon} + \text{water}$$

The sugar is rapidly broken down, producing an expanding mass of steaming carbon.