

## SULPHUR

Sulphur is a non-metallic element, which is very important in the chemical industry.

### Sources:

It is found as the element in sulphur beds 200m below the ground in volcanic areas and also in metal ores such as copper pyrites (iron sulphides) and zinc blende and also in volcanic areas.

### Properties:

- Brittle yellow solid
- Melting point of 119°C
- Non-conductor of heat and electricity
- Burns with blue flame when lit
- Insoluble in water

### Uses of Sulphur:

The main use of sulphur is to manufacture sulphuric acid, quite possibly the most important industrial chemical. Sulphur is also used for:

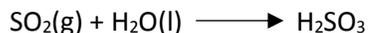
- vulcanising rubber (making it stronger) in tyres, etc.
- sulphur concrete (used in acid factories) which is resistant to acids
- smaller quantities in matches, fireworks and fungicides, as a sterilising agent and in medicines

### Sulphur Dioxide:

Sulphur dioxide is a colourless gas, extremely poisonous and has a choking smell. It is produced when sulphur or substances containing sulphur, such as crude oil or coal, are burned in oxygen gas.

Sulphur dioxide is considered a 'problem pollutant' in two main ways:

- It is an acidic oxide that dissolves in water to form sulphurous acid, which leads to the problem of acidic rain.



- It causes bronchospasm in asthmatics, therefore considered a respiratory irritant.

Despite this sulphur dioxide is also very useful for the following reasons:

- as a bleaching agent especially in the manufacture of wood pulp for paper
- as a food preservative (by killing bacteria) for meats, etc.
- manufacturing of sulphuric acid (as is elemental sulphur)

### Sources:

- combustion of fossil fuels with sulphur impurities
- volcanic eruptions

- rotting vegetation

#### Contact Process (Industrial Manufacturing of Sulphuric Acid):

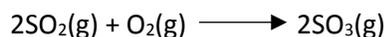
The process has the following stages:

Sulphur dioxide is first produced, primarily by the reaction (through combustion) of sulphur with oxygen.



Any dust and impurities are removed resulting in 'clean gases' consisting of unreacted oxygen and sulphur dioxide. These gases are heated to a temperature of approx. 450°C and fed into a reaction chamber of pressure 1-10 atmospheres.

In the chamber the clean gases undergo 'roasting' where they are passed over beds of catalyst, namely vanadium (V) oxide ( $\text{V}_2\text{O}_5$ ). This catalyzes the reaction between sulphur dioxide and oxygen to produce sulphur trioxide ( $\text{SO}_3$ )



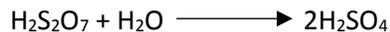
If the sulphur trioxide is added directly to water sulphuric acid is produced. The reaction however produces undesirable effects. It is very violent and very exothermic and produces a thick mist of sulphuric acid which is very dangerous.



The acid produced is very difficult to deal with and so a different route to sulphuric acid is employed. Instead, the sulphur trioxide is dissolved in concentrated sulphuric acid to give a substance called oleum ( $\text{H}_2\text{S}_2\text{O}_7$ )



The oleum formed is then added to the correct amount of water to produce sulphuric acid of the required concentration.



The reaction between sulphur dioxide and oxygen to form sulphur trioxide is reversible. So the ideas of Le Chatelier can be used to increase the proportion of sulphur trioxide in the equilibrium mixture. The forward reaction is exothermic and so would be favoured by low temperatures. The temperature of 450°C used is an optimum temperature which produces sufficient amounts of sulphur trioxide at an economical rate.

Since the back reaction is also accompanied by a decrease in the number of molecules of gas, a high pressure will favour it.

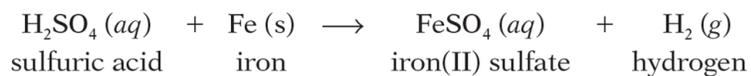
#### Properties of Sulphuric Acid:

Dilute sulphuric acid acts as a typical acid by:

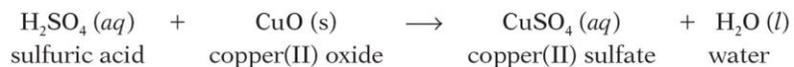
- reacting with reactive metals to form a salt and hydrogen gas
- reacting with carbonates to form a salt, carbon dioxide and water

- reacting with bases such as metal oxides to form a salt and water

For example dilute sulfuric acid reacts with iron like this:



And with copper(II) oxide like this:



#### Uses of Sulphuric Acid:

As said before sulphuric acid is arguably the most important industrial chemical.

It is mainly used for the raw material for the manufacturing of many substances:

- fertilizers
- chemicals
- steel manufacture
- soaps and detergents
- fibers
- paints, pigments and dyestuffs
- car batteries.