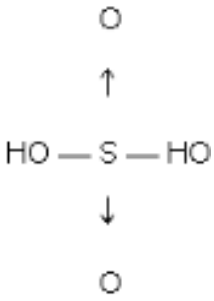
Study of Compounds – Sulphuric Acid

Sulphuric Acid

Molecular formula: H_2SO_4
Relative molecular mass: 98
Structure:



General Methods of Preparation

- By the action of heat on nitric acid and sulphur.
  $S + 6HNO_3 \rightarrow 6NO_2 + 2H_2O + H_2SO_4$
- By passing chlorine through an aqueous solution of sulphur trioxide.
  $Cl_2 + SO_2 + 2H_2O \rightarrow 2HCl + H_2SO_4$
- By dissolution of sulphur trioxide in water.
  $SO_3 + H_2O \rightarrow H_2SO_4$
- By hydrolysis of sulphuryl chloride.
  $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

Manufacture of Sulphuric Acid [Contact Process]

Steps involved in the contact process

(1) Production of sulphur dioxide
SO_2 is produced by roasting metallic sulphides in air.
$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

(2) Purification of gases
To enhance the efficiency of a catalyst, various impurities present in the mixture of sulphur dioxide and air are first removed.

(3) Catalytic oxidation of sulphur dioxide
Oxidation of SO_2 to SO_3 at 450°C in the presence of catalyst vanadium pentaoxide.

$$2SO_2 + O_2 \underset{450^0C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3$$

(4) Absorption of sulphur trioxide in sulphuric acid
Sulphur trioxide vapours are absorbed by a stream of conc. sulphuric acid.
$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ (oleum or pyrosulphuric acid)

(5) Dilution of oleum to obtain sulphuric acid
A calculated amount of water is added to obtain sulphuric acid of desired strength.
$H_2S_2O_7 + H2O \rightarrow 2H_2SO_4$

Properties of Sulphuric Acid

(A) Physical Properties

- Colourless, odourless with slight sour taste.
- It is highly corrosive in nature and chars the skin black.
- It is heavier than water and soluble in water.
- Boiling point is 338°C, and melting point is 10.4°C.

(B) Chemical Properties

Properties of Dilute Sulphuric Acid

- Dilute sulphuric acid reacts with metals to form metallic sulphate and hydrogen.
  $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
  $Fe + H_2SO_4 \rightarrow Fe_2SO_4 + H_2$
- It neutralises bases to form salts and water.
  $NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$
- It liberates carbon dioxide from metallic carbonates and bicarbonates.
  $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$
  $2KHCO_3 + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O + 2CO_2$
- It evolves hydrogen sulphide from metal sulphides.
  $Na_2S + H_2SO_4 \rightarrow Na_2SO_4 + H_2S$
  $ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S$
- It evolves sulphur dioxide from sulphites and hydrogen sulphites.
  $Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$
  $2NaHSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2SO_2$

Properties of Conc. Sulphuric Acid

- **Non-volatile nature**
  It has a high boiling point so it is used to prepare volatile acids such as HCl, HNO_3 and acetic acid from their salts.
  $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
  $NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$
- **As an oxidising agent**
  $C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$
  $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$
  $2HBr + H_2SO_4 \rightarrow Br_2 + 2H_2O + SO_2$

- **As a dehydrating agent**
  H_2SO_4 has a great affinity for water, and therefore, it acts as a dehydrating agent.
  $C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} C_2H_4 + H_2O$
  $C_6H_{12}O_6 \xrightarrow{\text{Conc. } H_2SO_4} 6C + 6H_2O$

Uses of Sulphuric Acid

- In the preparation of halogens, CO, CO_2 and SO_2.
- Extraction of metals: Leaching of metallic compounds produces sulphates which give the metal in pure form on electrolysis.
- Pickling of metals: Removes metallic impurities from the surface of metals before galvanising.
- Industrial uses:

i. In the manufacture of fertilisers such as ammonium sulphate $[(NH_4)_2SO_4]$ and superphosphate of lime $[Ca(H_2PO_4)_2 + CaSO_4]$.
ii. In the manufacture of explosives such as trinitrotoluene and picric acid.