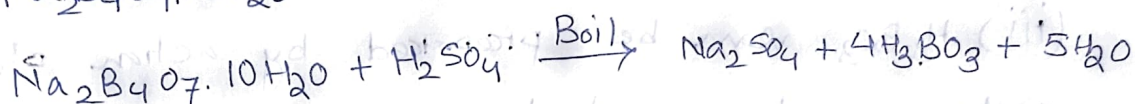


Boric acid, H_3BO_3 or $B(OH)_3$

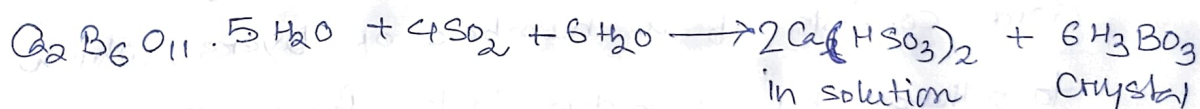
Preparation

(i) From borax, $Na_2B_4O_7 \cdot 10H_2O$ → Borax is finely powdered and then boiled with conc. HCl or conc. H_2SO_4 so that sparingly soluble H_3BO_3 separates out as crystals on cooling the solution.

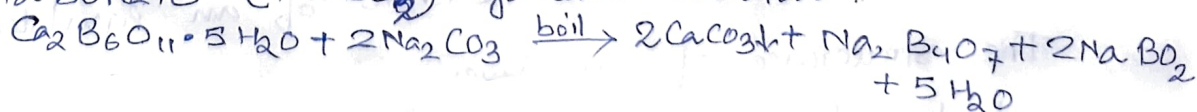


(ii) From colemanite ore, $Ca_2B_6O_{11} \cdot 5H_2O$. Boric acid can also be obtained from this ore by any of the following methods:

a. The finely powdered colemanite ore is dissolved in boiling water and then SO_2 gas is passed through this solution when highly soluble calcium bisulphite, $Ca(HSO_3)_2$ remains in solution while sparingly soluble H_3BO_3 separates out on cooling.



b. The finely powdered colemanite ore is boiled with Na_2CO_3 solution, so that $CaCO_3$ is obtained as precipitate, while borax ($Na_2B_4O_7$) and sodium metaborate ($NaBO_2$) go into solution.



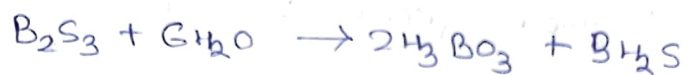
On filtration $CaCO_3$ is separated and on concentration, crystals of $Na_2B_4O_7$ separate out, but $NaBO_2$ still remain in the solution. Now a current of CO_2 is passed in the solution when $NaBO_2$ present

in the solution is converted into $\text{Na}_2\text{B}_4\text{O}_7$ which is separated by crystallisation.



The crystals of $\text{Na}_2\text{B}_4\text{O}_7$ obtained as above can be converted into H_3BO_3 by boiling it with conc. HCl or H_2SO_4 .

(iii) H_3BO_3 can be prepared by action of superheated water on boron nitride and boron sulphide.



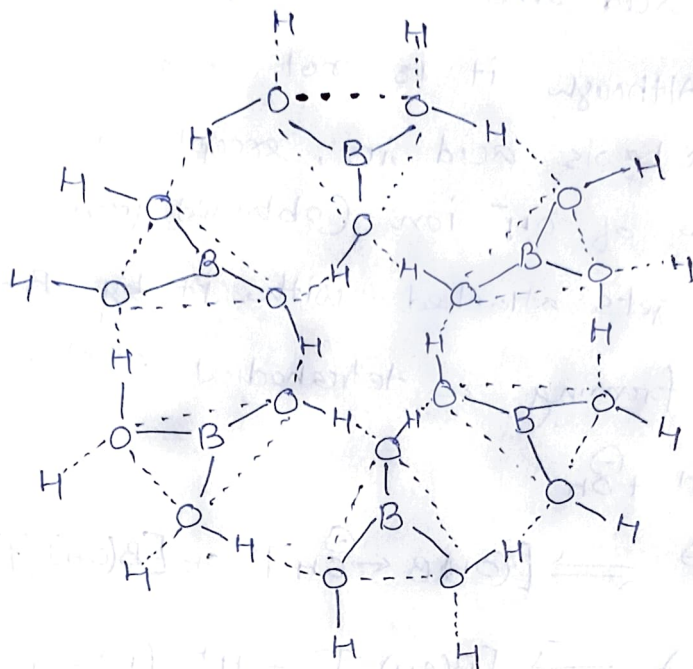
(iv) H_3BO_3 is also obtained by the hydrolysis of BCl_3 .



Structure of boric acid in the solid state

In solid state, boric acid has layer structure, i.e. boric acid consists of a number of layers, which are linked together by van der Waals forces and are at a distance of 318 pm from each other. Each layer is composed of various trigonal planar $\text{B}(\text{OH})_3$ units. B atom in each $\text{B}(\text{OH})_3$ unit is linked with three OH groups, which are arranged at the corners of an equilateral triangle. The structure of one layer is shown below from which it may be seen that H atom can act as a bridge between the two O atoms, belonging to two different $\text{B}(\text{OH})_3$ units. It is due to the layer structure of boric acid that this substance, in the

Solid state, consists of flakes, which are slippery to touch.



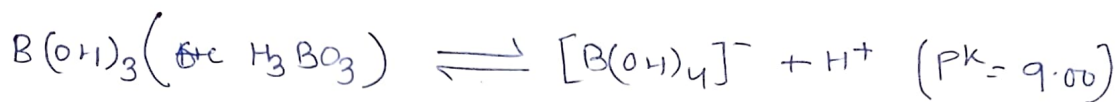
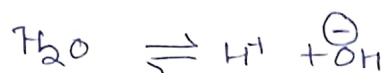
Uses of boric acid:

- (i) It is used for making enamels, borate glazes for pottery.
- (ii) It is used as an anti septic and as an eye wash in medicines.
- (iii) In the borax - phenolphthalein test for glycerol.
- (iv) In tanning industry and in candle industry to stiffen wick.

Properties

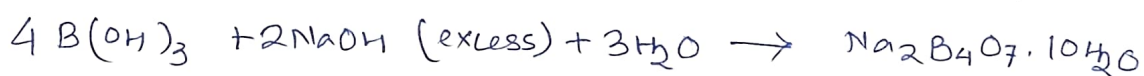
1. It forms soft pearly white, needle like crystals, which have greasy feel.
2. It is moderately soluble in H_2O . The dissolution is accompanied by the absorption of heat and hence its solubility increases with the increase in temperature.

3. Acidic nature \rightarrow H_3BO_3 is very weak acid and ionises as a monobasic acid and that too, to a very limited extent. Although it is not a proton donor, but behaves as a Lewis acid i.e., accepts an electron pair from O-atom of OH^- ion (obtained from ionisation of H_2O) and thus gets attached with it by B-OH⁻ coordinate bond, forming a tetrahedral metaborate ion.



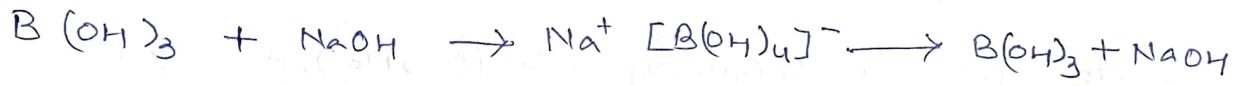
The above equilibrium lies to the left, showing that H_3BO_3 is a weak acid. It is also evident from this equilibrium that H_3BO_3 behaves as a monobasic acid.

4. Action of alkali \rightarrow H_3BO_3 reacts with aqueous solution of an alkali and gives various types of polymeric metaborates like, $NaBO_2 \cdot 2H_2O$, $Na_2B_3O_5 \cdot 2H_2O$, $Na_2B_4O_7 \cdot 10H_2O$, $KB_5O_8 \cdot 4H_2O$ etc.

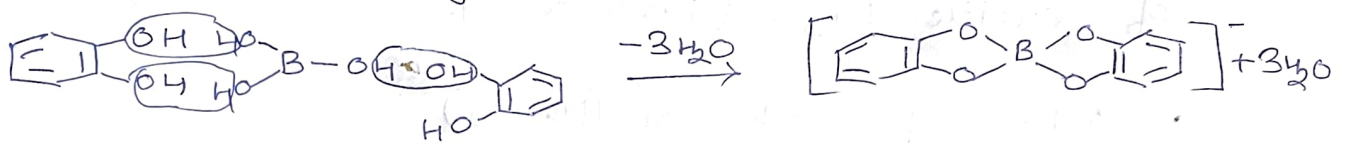


The titration between H_3BO_3 and a strong alkali solution (eg. NaOH) is not possible, because sodium

metaborate, $\text{Na}^+ [\text{B}(\text{OH})_4]^-$ formed by the reaction gets hydrolysed to regenerate $\text{B}(\text{OH})_3$ and NaOH

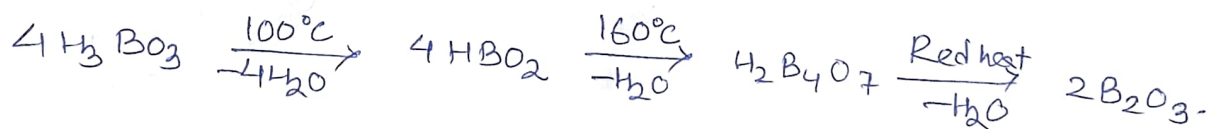


However, if some quantity of polyhydroxy compound, like catechol, glycerol, manitol, sugar etc. is added to the titration solution, the polyhydroxy compound combines with H_3BO_3 and forms chelated complex compound. The complex gives H^+ , which makes H_3BO_3 behave as a strong acid.



The titration between $\text{B}(\text{OH})_3$ and strong alkali solution, in presence of polyhydroxy compound (eg. phenolphthalein, is used as an indicator) makes the basis for the estimation of the acid and borax-phenolphthalein test for glycerol.

5. Action of heat \rightarrow when heated to 100°C , H_3BO_3 loses H_2O to give metaboric acid (HBO_2) which, on being heated to 160°C gives tetraboric acid ($\text{H}_2\text{B}_4\text{O}_7$). When $\text{H}_2\text{B}_4\text{O}_7$ is heated to redness, boron trioxide is obtained.

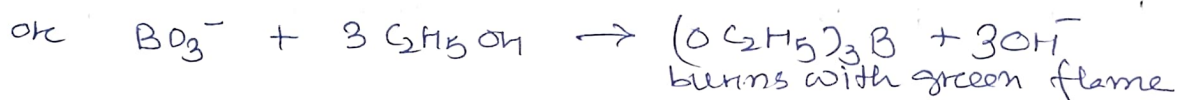


6. Action of sodium hydroperoxide, $\text{NaOOH} \rightarrow$ when H_3BO_3 is treated with NaOOH , dihydrated sodium peroxyborate, $\text{Na}_2\text{B}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ is formed.



7. Action of $\text{C}_2\text{H}_5\text{OH}$ in presence of conc. $\text{H}_2\text{SO}_4 \rightarrow$ when H_3BO_3 or any borate is heated with ethanol in presence of conc. H_2SO_4 , volatile

triethyl borate. $(C_2H_5)_3B$ (ester) is formed.

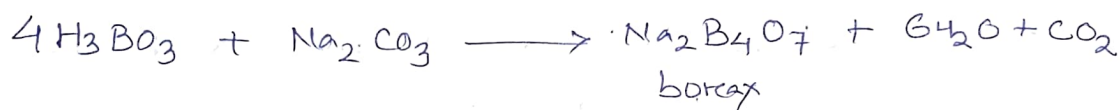


8. Action of CaF_2 and conc. H_2SO_4 .



If BF_3 produced above is brought near Bunsen flame, a green flame is produced due to burning of volatile BF_3 . (Presence of Ca^{2+} radical)

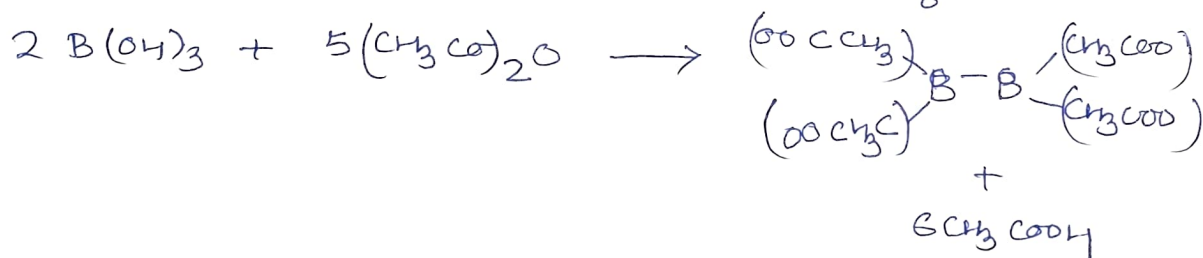
9. Action of soda-ash (Na_2CO_3)



10. Action of HF \rightarrow When H_3BO_3 is dissolved in HF, fluoroboric acid is obtained



11. Action of acetic anhydride



12. Action of alkali metal acid fluorides (MHF_2) \rightarrow
Alkali metal fluoroborate $M^+[BF_4]^-$ is obtained



Salts of boric acid : Borates

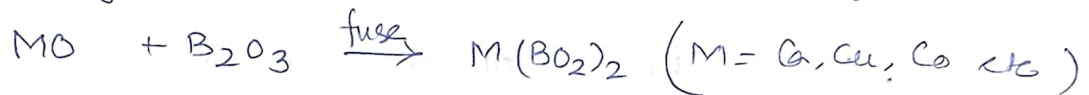
Metaborates (BO_2^-)

Preparation

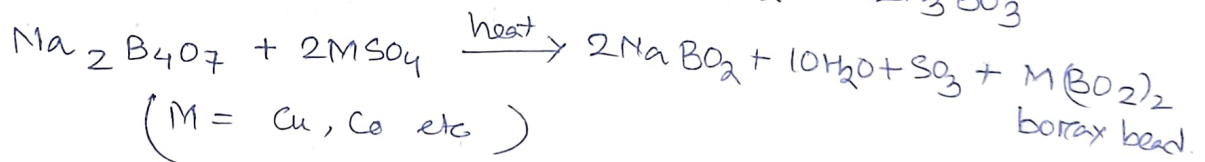
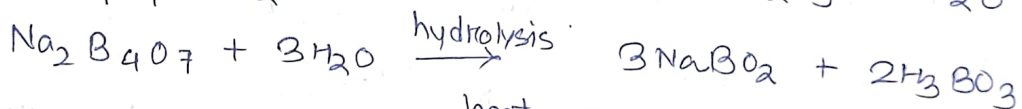
i) By adding the solution of borax ($\text{Na}_2\text{B}_4\text{O}_7$) to that of the appropriate salt of the metal, eg.



(ii) By fusing B_2O_3 with metallic oxide; eg \rightarrow



(iii) NaBO_2 can be obtained from H_3BO_3 or borax as is evident from the following equations.

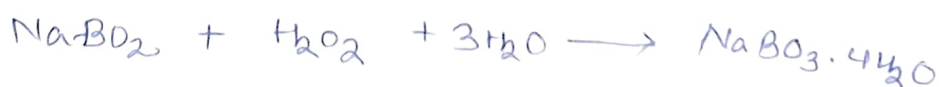


Properties

NaBO_2 forms colourless needles. When a current of CO_2 is passed through a solution of NaBO_2 , borax is obtained



The action of H_2O_2 on NaBO_2 gives sodium peroxyborate ($\text{NaBO}_3 \cdot 4\text{H}_2\text{O}$)



Sodium metaborate perhydrate, $\text{NaBO}_2 \cdot 3\text{H}_2\text{O} \cdot \text{H}_2\text{O}_2$

It is obtained by the electrolysis of a solution of borax and Na_2CO_3 at low temperature, using a platinum anode. It is colourless crystalline solid. It is finely soluble in water and its aqueous solution behaves as a mixture of borax and H_2O_2 . Its aqueous solution shows alkaline behaviour towards litmus. When this substance, in the solid state or in its aqueous solution, is heated, O_2 gas and sodium metaborate are obtained.



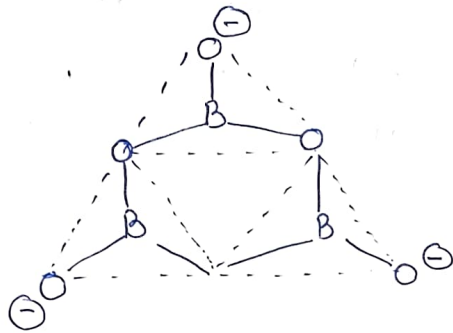
Due to evolution of O_2 , this substance has strong oxidising and bleaching properties. It is, therefore, used in a number of bleaching and oxidising processes. It has also antiseptic properties and hence used in mouth washes, toothpastes, soap powder, cosmetics etc.

Sodium pyroboreate, $\text{Na}_6\text{B}_4\text{O}_9$

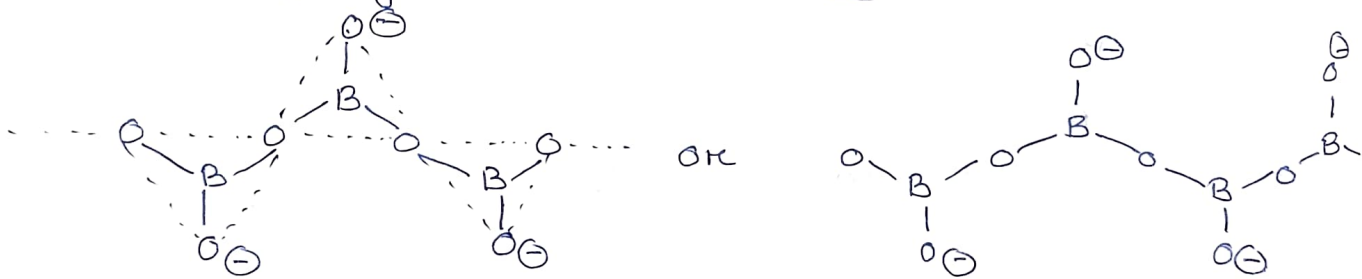
When borax ($\text{Na}_2\text{B}_4\text{O}_7$) is fused with Na_2CO_3 , $\text{Na}_6\text{B}_4\text{O}_9$ is formed



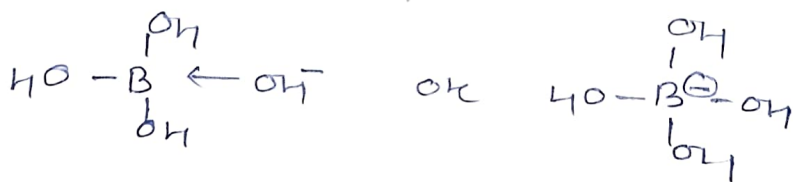
is made up of three trigonal BO_3 units which are linked together through O atoms, so that cyclic or ring structure is obtained



3. Calcium metaborate \rightarrow Calcium metaborate consists of Ca^{2+} and $[(\text{BO}_2)_n]^{n-}$ ions. $[(\text{BO}_2)_n]^{n-}$ ion is made up of triangular BO_3 units, which are joined together through O atoms, in such a way, the endless flat linear zig-zag chain is obtained.



4. Structure of $\text{NaBO}_2 \cdot 2\text{H}_2\text{O}$ \rightarrow The crystal structure of this metaborate shows that both H_2O molecules are part of the anion in this borate, i.e., metaborate is represented as $\text{Na}^+ [\text{BO}_2 \cdot 2\text{H}_2\text{O}]^-$. $[\text{BO}_2 \cdot 2\text{H}_2\text{O}]^-$ or $[\text{BO}_4\text{H}_4]^-$ ion has tetrahedral structure, in which B-atom is negatively charged and with which four OH groups are attached by four σ bonds.



5. Structure of $\text{Na B}_3\text{O}_5 \cdot 2\text{H}_2\text{O}$ \rightarrow The crystal structure of this metaborate has revealed that both H_2O molecules participate in the constitution of the anion present in this metaborate; i.e., this metaborate is represented as $\text{Na}^+ [\text{B}_3\text{O}_5 \cdot 2\text{H}_2\text{O}]^-$. The anion $[\text{B}_3\text{O}_5 \cdot 2\text{H}_2\text{O}]^-$ has two planar trigonal BO_3 units and one tetrahedral BO_4^- unit. B atom of BO_4^- unit is negatively charged and hence is sp^3 hybridised. Each B atom of both BO_3 units is linked with one OH group, while B-atom of BO_4^- unit is linked with two OH groups. And ^{thus} three bridging O-atoms and four OH groups form the $[\text{B}_3\text{O}_5 \cdot 2\text{H}_2\text{O}]^-$ ion and is represented as $[\text{B}_3\text{O}_3(\text{OH})_4]^-$.

