

7.2 ZINC

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🌟 Learning outcomes

After completion of the chapter, Students should be able to:

- ✓ Describe the occurrence of zinc
- ✓ Describe the extraction of zinc
- ✓ Describe properties (with air, acid, alkali, displacement reaction)
- ✓ State the uses of zinc.
- ✓ Explain the chemistry (preparation, properties, and uses) of white vitriol.

Occurrence

Doesn't exist in a free state, but exists as the following ores.

1. Zinc Blende - ZnS (most important ore)
2. Calamine - ZnCO_3
3. Zincite - ZnO
4. Franklinite - $\text{ZnO} \cdot \text{Fe}_2\text{O}_3$
5. Willimite - $2 \text{ZnO} \cdot \text{SiO}_2$

Extraction of Zinc from Zinc Blende

(By Carbon Reduction Process)

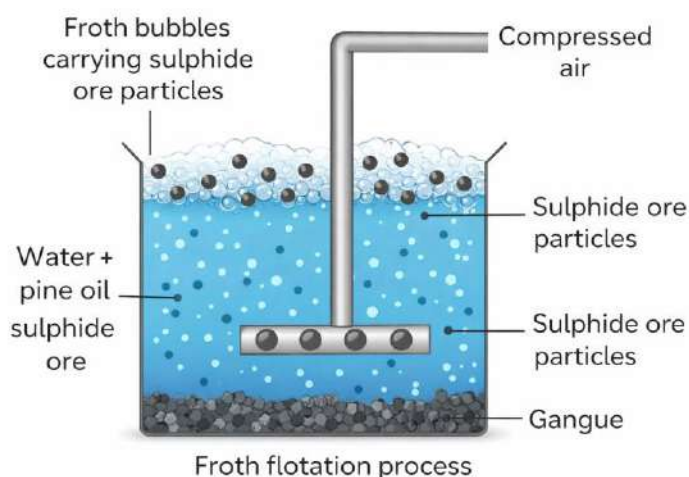
It involves the following processes.

A) Crushing and Pulverisation

The ore is crushed in big jaw crushers and finely ground in ball mills.

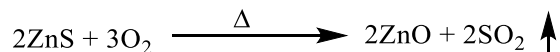
B) Concentration:- by the froth flotation method

- The powdered ore is mixed with water containing a little pine oil in a little tank.
- Air is blown through the mixture
- ZnS particles stick to the froth and float to the top.
- Impurities (gangue) settle at the bottom and are removed.



C) Roasting:

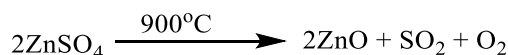
- The concentrated ore is heated to about 900°C in air.
- Main reaction: The sulphide ore gets converted into oxide.



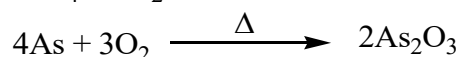
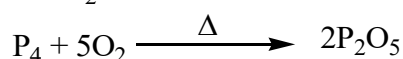
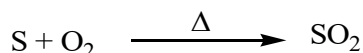
- During this process, some of the zinc sulphide is also converted into zinc sulphate.



- This later decomposes to give ZnO.



- Moisture is removed
- Impurities such as S, P, As, etc. are removed as their respective volatile oxides.



D) Reduction (Smelting)

- in a **vertical retort furnace**.
- Roasted ore (ZnO) + coke (2:1 ratio) is made into briquettes
- The briquettes are fed into the retort through the vertical furnace's charging door.
- The furnace is externally heated by producer gas (CO+N₂) at about 1400 °C.

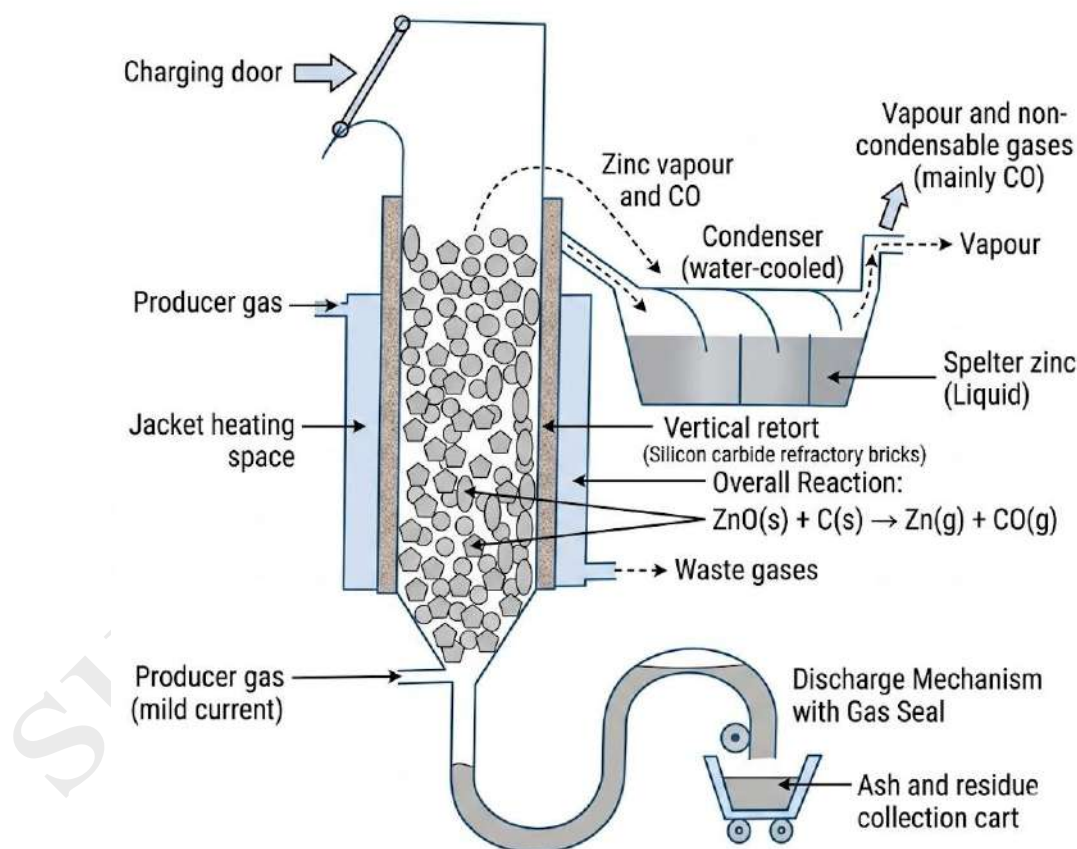


Figure: Vertical retort furnace for the extraction of zinc

- The oxide is reduced to metallic zinc.



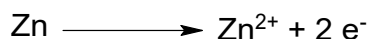
- Since zinc boils at about 907 °C and the furnace temperature is about 1400 °C, zinc is produced in a vapour state.
- A mild current of producer gas through the bottom of the furnace carries the vapour Zn + CO to the water-cooled condenser.

- The Condensed zinc is called **zinc spelter** (purity ~97-98%).

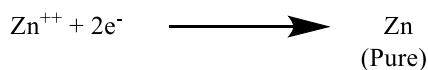
D) Refining- Electrolysis

- The thus obtained zinc contains Fe, Pb, Cd, As, Sb, etc. as impurities.
- Impure zinc is made an anode, and pure zinc a cathode, and they are placed in an acidified ZnSO_4 solution.
- When electricity is passed, the metal from the anode dissolves into the solution.

At anode:



- The pure metal is deposited at the cathode.



At cathode:

- The impurities remain at the bottom of the anode as **anode mud**.



- By this process, 99.5% pure zinc is obtained.

When **molten zinc** is poured into **cold water**, it cools rapidly and breaks into small, irregular granules. This process is called **granulation**, and the product formed is known as **granulated zinc**.

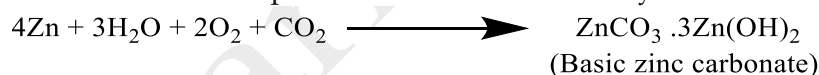
Granulated zinc is often preferred in chemical reactions because its larger surface area makes it react more easily than large solid pieces of zinc.

Properties

1. bluish-white shining metal.
2. brittle at room temperature (becomes malleable at 100-150 °C).
3. good conductor of heat and electricity.

4. Action of air:

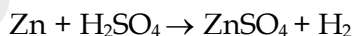
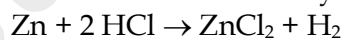
- Dry air → no reaction.
- Moist air → forms a protective basic carbonate layer:



On heating to 500 °C, zinc burns with a greenish-blue flame, forming Zinc oxide fumes. The white fluffy zinc oxide formed during burning is called Philosopher's wool.



4. **Action of acid:** With dilute hydrochloric acid and sulphuric acid, zinc gives hydrogen gas

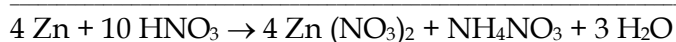
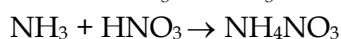
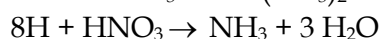
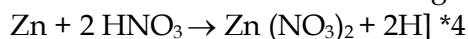


Conc. Sulphuric acid reacts with zinc to give sulphur dioxide

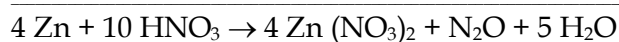
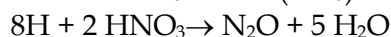
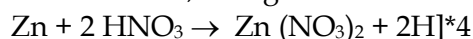


With nitric acid, zinc gives a variety of products depending upon the concentration of the acid.

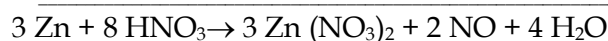
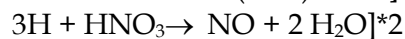
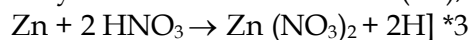
- (a) Very dilute nitric acid reacts with zinc to give ammonium nitrate.



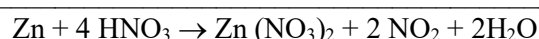
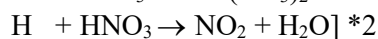
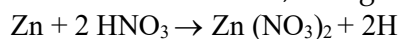
(b) With dilute nitric acid, zinc gives nitrous oxide, commonly called laughing gas.



(a) Moderately concentrated nitric acid (1:1), when reacted with zinc, gives nitric oxide

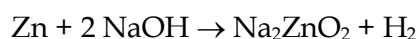


(b) With concentrated nitric acid, zinc gives nitrogen peroxide.



5. Action with alkali:

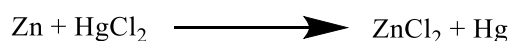
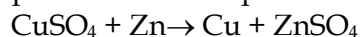
When zinc is boiled with concentrated caustic alkali like NaOH, hydrogen is liberated.



In aqueous solution, sodium zincate exists mainly as sodium tetrahydroxozincate(II), $\text{Na}_2[\text{Zn}(\text{OH})_4]$.

6. Displacement reaction

Zinc displaces less electropositive metals like Cu, Ag, Au, etc. from their aqueous solutions.



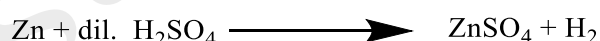
Uses of Zinc

- Galvanising iron (coating iron with zinc to prevent rusting)
 - Used in roofing sheets and construction materials
- Making alloys: brass, German silver, die-casting alloys, etc.
- As an electrode in electrochemical cells/batteries.
- Production of zinc compounds like ZnO , ZnSO_4 , etc.
- In dyes, drugs, and paints

White vitriol ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$)

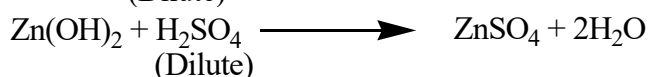
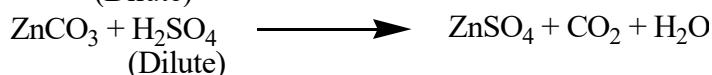
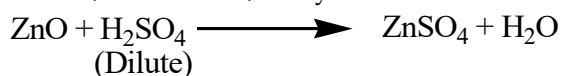
Preparation

From zinc metal: (with dil. H_2SO_4)



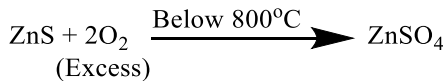
From Zinc compounds:

When oxides, carbonates, or hydroxides of zinc are treated with dil. H_2SO_4 , ZnSO_4 is formed.

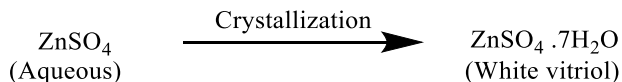


From zinc blende:

When zinc blende (ZnS) is roasted below 800°C with excess air, ZnSO_4 is formed.



The aqueous solution obtained by any of the above methods is evaporated till the crystallisation point to obtain white vitriol.



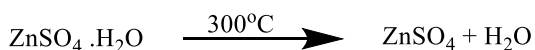
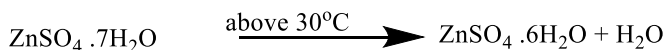
Properties

White crystalline solid, highly soluble in water.

Efflorescent and loses water when exposed to air.

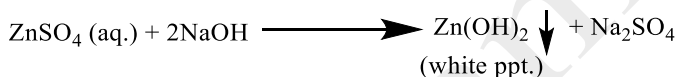
Action of heat:

When it is exposed to air above 30 °C, it loses one water molecule. It loses six molecules of water at 100°C and at 300°C anhydrous salt is formed. This anhydrous salt decomposes at 800°C to give SO₂ gas.

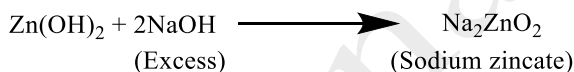


Action with alkali:

When aqueous ZnSO_4 is treated with NaOH solution, a white precipitate of $\text{Zn}(\text{OH})_2$ is formed.

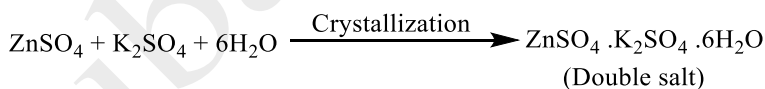


If excess NaOH is added, then the precipitate dissolves due to the formation of sodium zincate.



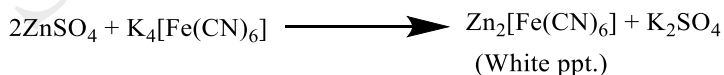
7. Formation of double salts:

When an equimolar solution of potassium sulphate and zinc sulphate is subjected to crystallisation, a double salt is formed. (also written as $\text{ZnK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$)



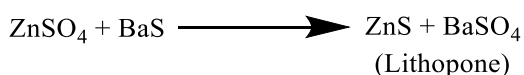
8. **Action with potassium ferrocyanide:**

When white vitriol is treated with potassium ferrocyanide, a white precipitate of zinc ferrocyanide is formed.



9. **Action with barium sulphide:**

Zinc sulphate reacts with barium sulphide to give lithopone (a white paint). It is not blackened by atmospheric hydrogen sulphide.



Uses of white vitriol

- In medicine (eye drops and lotion).
- In preparation of white pigment, lithopone.
- As an electrolyte in the electrorefining of zinc
- In the **preparation of double salts** and other zinc compounds.

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