7.3 MERCURY

Learning outcomes

The students should be able to:

- ✓ Describe the occurrence of copper
- ✓ Describe the extraction of copper
- ✓ State properties of mercury.
- ✓ Explain chemistry (preparation, properties and uses) of calomel and corrosive sublimate.

Occurrence

Generally, it occurs in a combined state.

The main ore is sulphide ore, **cinnabar** (HgS).

It has also been found as an amalgam of gold and silver.

Hg is mainly extracted in Russia, Spain, Mexico and Algeria.

In Nepal, Hg is reported from Tirche Pani/Taruka and Khimti river.

1. Quick silver is
   a. Ag b. Hg c. Sn d. Cu
2. Cinnabar is an ore of
   a. Hg b. Cu c. Pb d. Zn

Extraction of Hg from Cinnabar

A) Crushing and Pulverization

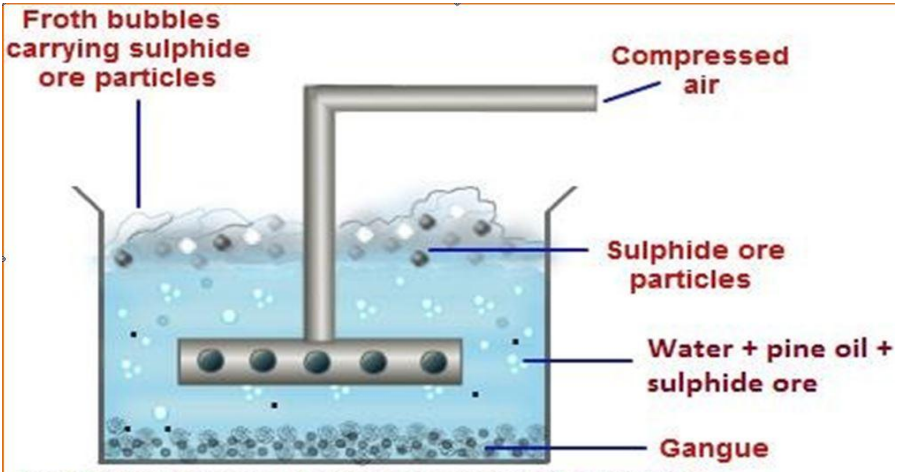
The ore is crushed in big jaw crushers, finely powdered in ball mills and sieved.

B) Concentration

- The process of removing gangue particles from ore.
- Gangue - unwanted material or impurities in the form of sand, rock etc. that surrounds the mineral in an ore deposit.
- The sulphide ores are concentrated by **Froth Floatation Process**.
  - The ore is powdered and a suspension is created in water and

pine or eucalyptus oil is added.

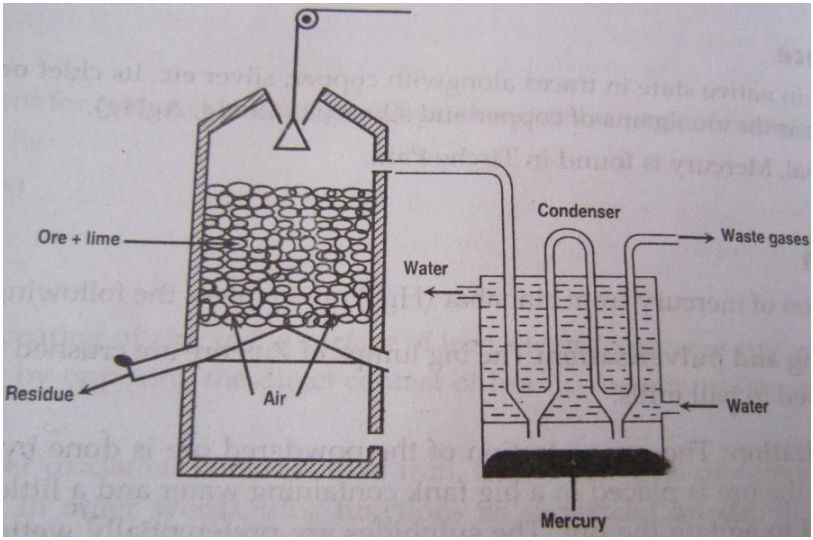
- The suspension is stirred by a blast of compressed air constantly.
- The oil (froth) wets the metal and the water wets the gangue.
- This frothy metal sulphide ore is skimmed off from the top.
- The gangue particles remain at the bottom and are removed.



Froth floatation process for the concentration of sulphide ores.

A) Roasting and Distillation

- In modern process, the concentrated ore is mixed with 2% coke and charged into a **shaft furnace**.
- A blast of air is introduced from bottom to burn the fuel for heating purpose.



- The sulphide ore gets converted into oxide which then decomposes to give metallic mercury in vapour state.

$$2HgS + O_2 \xrightarrow{\Delta} 2HgO + 2SO_2 \uparrow$$

$$2HgO \xrightarrow{\Delta} 2Hg + O_2 \uparrow$$

$$2HgO + C \xrightarrow{\Delta} Hg + CO \uparrow$$

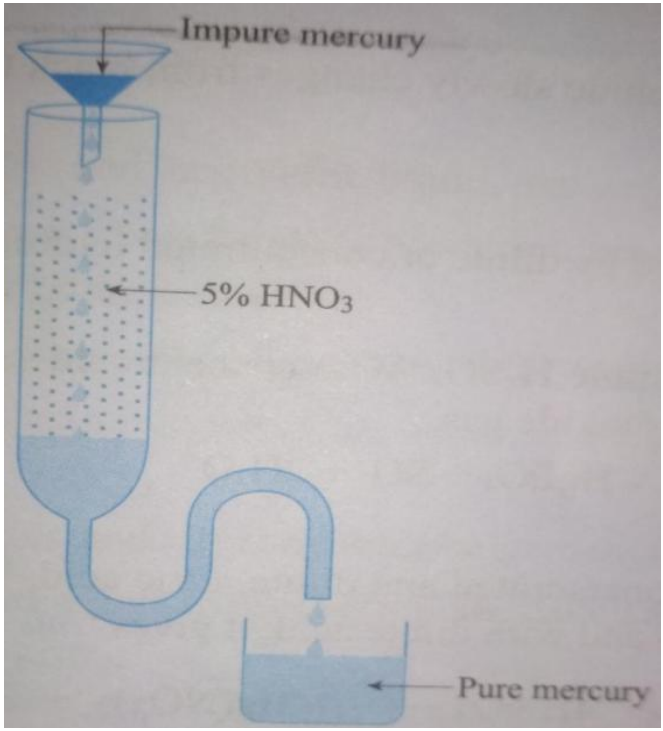
- The vapour of mercury along with gases comes out from the furnace is passed through Y-shaped water-cooled iron pipes, which acts as condenser where vapors of mercury condenses and waste gases escape from outlets.
- Mercury thus obtained is about 99.7% pure.

C. Purification

Mercury thus obtained is not pure and contains the impurities like Zn, Cd, Fe, Pb, Ag, Au etc. so, it is refined by following methods;

a) Certain reactive metals form their oxides due to their partial oxidation by air. These are removed by filtration through chamois leather or canvas.

b) The impurities like Zn, Fe, Cu etc. are removed by introducing the crude mercury into a tube, that contains 5% of HNO_3.



The metals form their soluble nitrates and get separated from mercury.

$$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

If any mercurous nitrate is formed, it is displaced by these metals,

$$Hg_2(NO_3)_2 + Zn \longrightarrow 2Hg + Zn(NO_3)_2$$

The mercury thus purified may contain Au, Ag, Pt etc. as impurities. These are removed by vacuum distillation, where more volatile mercury distilled off leaving impurities.

3. Mercurous ion is represented as
   a. Hg^{+} b. Mg^{2+} c. Hg_2^{+} d. Hg^{2+}
4. Cinnabar on roasting yields
   a. HgO b. Hg_2O c. Hg d. $HgSO_4$

1. Write down the molecular formula of Cinnabar. 0.5
2. Write short note on purification of mercury. 5
3. Explain the process of extraction of mercury from its ore. 5

Properties of mercury

- Mercury is silvery white liquid.
- It solidifies at -38.9°C and boils at 357°C.
- It is heaviest liquid known at ordinary temperature and its density is 13.6.
- **Action with air:**

At ordinary temperature mercury does not reacts with air, when heated up to 350°C it slowly oxidized to mercuric oxide,

$$2Hg + O_2 \xrightarrow{\Delta} 2HgO$$

On strong heating it decomposes to Hg and O_2.

$$2HgO \xrightarrow{\Delta} 2Hg + O_2$$

1. **Action with acids:**

a) With HCl:

It is not affected by dilute or concentrated HCl.

b) With H_2SO_4:

It does not react with dil. H_2SO_4, but reacts with conc. H_2SO_4 to give SO_2 gas.

$$Hg + 2H_2SO_4 \longrightarrow HgSO_4 + 2H_2O + SO_2$$

c) With HNO_3:

Mercury reacts with different concentration of HNO_3 to give different oxides of nitrogen.

$$Hg + \underset{\text{(Conc.)}}{4HNO_3} \longrightarrow \underset{\text{(Mercuric nitrate)}}{Hg(NO_3)_2} + 2H_2O + 2NO_2$$

$$6Hg + \underset{\text{(Dilute)}}{8HNO_3} \longrightarrow \underset{\text{(Mercurous nitrate)}}{3Hg_2(NO_3)_2} + 4H_2O + 2NO_2$$

d) With aqua regia:

Aqua regia is a mixture of concentrated nitric acid and concentrated hydrochloric acid in a molar ratio of 1:3. Mercury dissolves in aqua regia to form mercuric chloride.

$$HNO_3 + 3HCl \longrightarrow NOCl + H_2O + 2[Cl]$$

$$Hg + 2[Cl] \longrightarrow HgCl_2$$

$$Hg + HNO_3 + 3HCl \longrightarrow NOCl + 2H_2O + HgCl_2$$

2. Action with halogen:

When mercury heated with halogen it gives different product at different condition.

$$Hg + Cl_2 \xrightarrow[\text{(Excess)}]{\Delta} HgCl_2$$

$$Hg + Cl_2 \xrightarrow[\text{(Excess)}]{\Delta} Hg_2Cl_2$$

4. Write action of mercury with aqua regia. 1
5. What peculiar behavior does mercury have? 1

Mercury poisoning

Mercury vapours are poisonous, can cause giddiness, tremors, lung and brain damage if inhaled.

Many organic and inorganic mercuric compounds are also poisonous. They may cause deafness, brain damage and even death.

6. What is meant by mercury poisoning? 2

Uses of Hg

- In the thermometer, barometer etc.
- In the mercury vapour lamp.
- In the extraction of gold & silver by amalgamation process.
- To make amalgams, some amalgams are used in dentistry
- In the manufacture of ayurvedic medicine e.g. "*Paro Vasma*".

7. A metal (M) is extracted from its sulphide ore whose atomic number is 80. It also occurs as the amalgams of certain metals and is popularly known as quick silver.
   a. Name the metal (M) and write down the molecular formula of its common ore.
   b. Why the metal is called quicksilver?
   c. State the process by which the ore is concentrated during its extraction.
   d. Write down the chemical reaction involved during reduction in its extraction.
   e. Mention a use of the metal. 5

Calomel Hg_2Cl_2 [Mercurous chloride]

Preparation

1. From mercuric chloride:

When $HgCl_2$ and Hg is mixed in 4:3 ratio and heated in an iron vessel, Hg_2Cl_2 sublimes off.

$$HgCl_2 + Hg \xrightarrow{\Delta} Hg_2Cl_2$$

It may be prepared by reducing mercuric chloride by stannous chloride,

$$2HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2 + SnCl_4$$

2. From mercuric sulphate:

When mercuric sulphate is heated with sodium chloride in the presence of mercury, Hg_2Cl_2 is formed,

$$HgSO_4 + Hg + NaCl \xrightarrow{\Delta} Hg_2Cl_2 + Na_2SO_4$$

3. From mercuric nitrate:

When mercuric nitrate solution is treated with any soluble chloride, Hg_2Cl_2 is formed.

$$Hg(NO_3)_2 + 2HCl \longrightarrow Hg_2Cl_2 + 2HNO_3$$
$$Hg(NO_3)_2 + 2KCl \longrightarrow Hg_2Cl_2 + 2KNO_3$$

8. Write one method of preparation of $HgCl_2$. 1

Properties

1. White powder, insoluble in cold water, soluble in hot water.
2. It sublimes when heated.
3. **Action of heat:**

It dissociates into Hg and mercuric chloride when strongly heated.

$$Hg_2Cl_2 \xrightarrow{\Delta} HgCl_2 + Hg$$

4. **Action with ammonia:**

When Hg_2Cl_2 is treated with ammonia, a black precipitate of metallic mercury and basic mercuric aminochloride is formed.

$$Hg_2Cl_2 + 2NH_4OH \longrightarrow Hg + Hg(NH_2)Cl + NH_4Cl$$
(Black ppt.)

5. Action stannous chloride:

When Hg_2Cl_2 is treated with $SnCl_2$, it reduces Hg_2Cl_2 to Hg.

$$Hg_2Cl_2 + SnCl_2 \longrightarrow 2Hg + SnCl_4$$

(Black ppt.)

6. Action with aqua regia:

Mercurous chloride dissolves in aqua regia due to the formation of mercuric chloride.

$$HNO_3 + 3HCl \longrightarrow NOCl + H_2O + 2[Cl]$$

$$Hg_2Cl_2 + 2[Cl] \longrightarrow 2HgCl_2$$

$$Hg_2Cl_2 + HNO_3 + 3HCl \longrightarrow NOCl + 2H_2O + 2HgCl_2$$

Uses of Calomel

- In medicine as purgative (to clean intestine).
- In the manufacture of calomel electrode.

5. Calomel is
   a. $HgCl_2$ b. Hg_2Cl_2 c. Hg + $HgCl_2$ d. $HgCl_2$ and Hg

9. Write down the molecular formula of Calomel. 0.5
10. What happens when ammonia gas is passed through the aqueous solution of calomel? 1
11. Write down a balanced chemical equation for the preparation of calomel. 1
12. How is calomel prepared? Give its important properties and uses. 2
13. Write two uses of Calomel. 1
14. Write short note on chemistry of calomel. 5
15. Describe chemistry of calomel. 5

Corrosive Sublimate $HgCl_2$ [Mercuric chloride]

Preparation

1. From Mercury:

When mercury is heated with chlorine gas, $HgCl_2$ is formed.

$$Hg + Cl_2 \xrightarrow{\Delta} HgCl_2$$

It may be also prepared by treating mercury or Mercurous chloride with aqua regia.

$$3HCl + HNO_3 \longrightarrow NOCl + H_2O + 2[Cl]$$
$$Hg + 2[Cl] \longrightarrow HgCl_2$$

$$3HCl + HNO_3 \longrightarrow NOCl + H_2O + 2[Cl]$$
$$Hg_2Cl_2 + 2[Cl] \longrightarrow 2HgCl_2$$

2. From $HgSO_4$:

When mercuric sulphate is heated with sodium chloride in the presence of MnO_2, $HgCl_2$ is sublimes off.

$$HgSO_4 + NaCl \xrightarrow[\Delta]{MnO_2} HgCl_2 + Na_2SO_4$$

3. From HgO:

When mercuric oxide is treated with dil. HCl, $HgCl_2$ is formed.

$$HgO + 2HCl \longrightarrow HgCl_2 + H_2O$$

16. Write one method of preparation of $HgCl_2$. 1
17. Give balanced chemical equation for the preparation of corrosive sublimate. 1

Properties

1. White crystalline solid.
2. Slightly soluble in cold water but strongly soluble in hot water.
3. Poisonous and corrosive in nature.
4. **Action of heat:**

It is stable towards heat; but on strong heating it decomposes to free mercury and chlorine.

$$HgCl_2 \xrightarrow{\Delta} Hg + Cl_2$$

5. **Action with stannous chloride:**

When $HgCl_2$ is treated with $SnCl_2$ mercuric chloride is reduced to mercurous chloride and then to Hg.

$$2HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2 + SnCl_4$$
$$Hg_2Cl_2 + SnCl_2 \longrightarrow 2Hg + SnCl_4$$

18. What happens when corrosive sublimate is treated with excess $SnCl_2$

solution? 1

19. What happens when $HgCl_2$ reacts with $SnCl_2$? 1
20. What happens when an aqueous solution of $HgCl_2$ is treated with an aqueous solution of $SnCl_2$? 1

6. Action with sulphur dioxide:

When SO_2 gas is passed through a solution of mercuric chloride, a white precipitate of mercurous chloride is formed.

$$HgCl_2 + SO_2 + 2H_2O \longrightarrow Hg_2Cl_2 + H_2SO_4 + 2HCl$$

7. Action with potassium iodide:

When mercuric chloride solution is treated with KI solution, red scarlet precipitate of HgI_2 is formed. On further addition KI solution, the scarlet ppt. dissolves due to the formation of complex potassium mercuric iodide.

$$HgCl_2 + 2KI \longrightarrow HgI_2 + 2KCl$$
$$HgI_2 + 2KI \longrightarrow K_2[HgI_4]$$

(Potassium mercuric iodide)

The alkaline solution of potassium mercuric iodide is called **Nessler's reagent** and used to detect ammonia.

$$K_2[HgI_4] + KOH \Longrightarrow \textbf{Nessler's reagent}$$

21. Give the molecular formula of Nessler's reagent. 0.5
22. How is Nessler's reagent prepared from corrosive sublimate? Give a laboratory use of Nessler's reagent. 2
23. What is Nessler's reagent? How is it prepared? 1
24. Give one use of Nessler's reagent. 1
25. What is the action of corrosive sublimate on KI solution? 1
26. What happens when corrosive sublimate is treated with excess KI solution? 1
27. What happens when mercuric chloride is treated with excess KI solution? 1
28. What happens when an aqueous solution of $HgCl_2$ is treated with an aqueous solution of KI? 1

8. Action with ammonia:

When mercuric chloride is treated with ammonia, a white ppt. of ammonobasic mercuric chloride is formed.

$$HgCl_2 + 2NH_3 \longrightarrow \underset{\text{Ammonobasic mercuric chloride}}{Hg(NH_2)Cl} + NH_4Cl$$

i. In a filter paper soaked by Hg^{2+} ions exposed in a jar containing NH_3, the filter paper will turn

a. Black b. Red c. Brown d. Blue

19 What happens when ammonia gas is passed through the aqueous solution of corrosive sublimate? 1

Uses

- As antiseptic to sterilize surgical instruments.
- To prepare Nessler's reagent.
- In preserving skin, wood, fur etc.
- It is used as an antidote (medicine used against poison).

29. Write an important use of corrosive sublimate. 0.5

ii. Molecular formula of corrosive sublimate is

a. $HgCl_2$ b. Hg_2Cl_2 c. NaCl d. HgCl

iii. Which is used as purgative in medicine?

b. $ZnCl_2$ b. $HgCl_2$ c. Hg_2Cl_2 d. $ZnSO_4.7H_2O$

iv. Nessler's reagent is

a. $K_2[HgI_4]$

30. Write short note on chemistry of corrosive sublimate. 5

31. How is calomel obtained from corrosive sublimate and vice versa? 2

*****This is not a complete note. It is just to guide you. It is recommended to study prescribed textbooks along with this material. *****