

METALS AND METALLURGY

Characteristics of Metals, non metals and metalloids

- 90 elements occur in nature.
- More than 2 dozen elements prepared in laboratory.
- Out of 90, more than 70 are metals, rest are non-metals and metalloids.
- Elements lying in the border line of the step line have intermediate properties between metals and non-metals. These possess metallic lustre but form acidic oxides. Hence are called metalloids.
- Metals are usually solid, hard, good conductors of heat and electricity and possess metallic lustre, are malleable and ductile.
- On the other hand, non metals are gases or liquids and poor conductor of electricity. Besides possess no lustre, are not malleable and ductile.
- Although there is no clear demarcation between metals and non metals
- Metalloids are borderline elements of p-block which show both metallic and non-metallic characters. E.g B, Si, Ge, As and Te etc. These possess metallic lustre but form acidic oxides.

Distinction between metals and non metals

Metals	Non Metals
1. Usually Solids	1. All 3 states
2. Metallic lustre	2. Non lustrous
3. High density	3. Low density
4. Good conductors	4. Poor conductors
5. Malleable and ductile	5. Brittle
6. High M pt and B pt.	6. Low
7. Basic oxides	7. Acidic oxides
8. Electropositive (low IP)	8. Electronegative (high IP)

(study in details from book)

- 75) Define the term giving example : metalloids 1
70/69) Distinguish between metals and metalloids giving an example of each. 2
75) Define the term giving example: amalgam 1
76) Distinguish between alloys and amalgams giving an example of each.

Minerals and Ores

Metals being reactive, can not exist in free form (except a few like Gold copper etc). They generally exist in nature in the form of their compounds. Minerals can be defined as the compounds existing in nature in large amount that contain metals.

On the other hand, Ores are the minerals from which metals can be extracted economically.

Thus every ore is mineral but every mineral can not be ore. E.g, clay ($\text{Al}_2\text{O}_3 \cdot 2 \text{SiO}_2 \cdot 2\text{H}_2\text{O}$) is a mineral of aluminium but is not an ore. Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) is both mineral and ore of aluminium.

- 73) 'Every ore is a mineral but every mineral is not ore.' Give reason. 2
69) What are the differences between minerals and ores? Give an example of each.

52) Which metals can be obtained from following ores. Galena, Cinnabar, Argentite. 2

Solution: Galena is PbS (leadsulphide) Lead (Pb) can be obtained from it. Cinnabar is ZnS (Zinc sulphide) Zinc(Zn) can be obtained from it. Argentite is Ag_2S (Silversulphide) Silver (Ag) can be obtained from it.

Important mineral deposits in Nepal

Metal	Ore	Place of occurrence
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Iron	Magnetite/ Haematite	Phulchowki, Lalitpur, Ramechhap, Tanahuetc
Copper	Copper ore deposit	Solukhumbu, Makawanpur, Dhading, Udayapur
Lead/Zinc	Lead zinc deposit	Ganesh Himal, Rasuwa
Cobalt	Cobalt ore	Suwarbhuwar, Gulmi
Bismuth	Bismuth ore	Bhimphedi, Makawanpur
Gold	Native (traces)	Swayambhu-Halchowk area
Magnesium	Magnesite Talc	Kharidhunga, Dolkha Udayapur Kharidhunga, Dolkha Udayapur
Calcium	Limestone	Chobhar, Kathmandu Udayapur Jogimara, Dhading Okhare, Makawanpur

75/72) Name any four important ores found in different parts of Nepal. 1

Different processes involved in metallurgical process

Then one of the following type of metallurgy is used for main reduction of the ore into metal.

74) Define Gangue giving proper example. 1

Pyrometallurgy:

- Here after removal of main impurities from the ore it is converted into suitable form (generally oxides) and heated strongly with suitable reducing agent to get molten metal.
- Pyrometallurgy is the process of getting metal form its ore in high temperature.

Hydrometallurgy

- In this type of metallurgy, suitable reducing agent is added to the aqueous solution of the metal so as to precipitate the metal.
- Hydrometallurgy is suitable, if the percentage of metal in the ore is very low. For example : the extraction of gold and silver.

Electrometallurgy

- In this type of metallurgy, the fused compound of metal is subjected to electrolysis, where impure metal is made anode and pure copper is made cathode.
- The pure metal is obtained in the cathode, leaving behind impurities in anode.
- Alkali and alkaline earth metals can not be extracted by pyrometallurgy because of their low boiling points.
- That's why, electrometallurgy is used for the extraction of these metals.

General metals followed in metallurgy:

- Extraction of metals from form ores involves a number of steps.
- The branch of science that deals with the extraction of metals form the natural sources is called Metallurgy.

- In combined state metals do not exist as pure compounds, they are mixed with sand, clay limestone etc.
- These unwanted earthy impurities present in the minerals are called **gangue or matrix**.
- First these impurities should be removed to get metals from minerals.

52) *What is metallurgy? How is metal extracted form its ore?* 5

72) *How are metals generally extracted form ores and purified?* 5

75/73) *Write short note on hydrometallurgy.* 2.5

71) *What is meant by hydrometallurgy? Give an example of it.* 2

72) *Differentiate between pyrometallurgy and electrometallurgy.* 2

70) *Give a brief account of electrometallurgy.* 3

Concentration (dressing)

76) *What is meant by concentration in metallurgy? Name any two process involved in it.* 2

1. Hand picking

If the impurities of the ore are of large size and is visibly different, the impurities are removed by hand picking.

2. Gravity separation (levigation) method

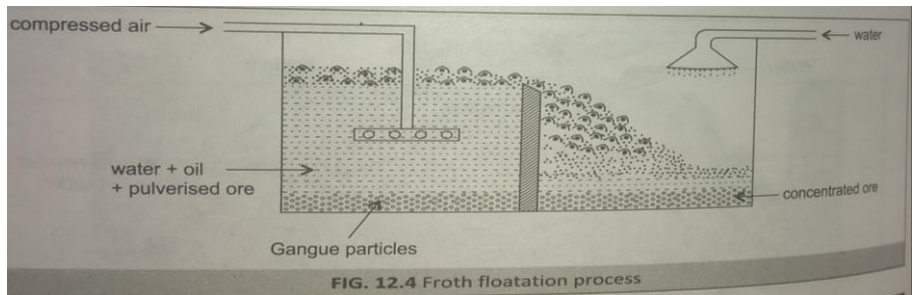
- The method of concentration is based upon the differential specific gravity of gangue and ore particles.

- In this method, powdered ore is agitated with a stream of running water.
- The ore particles being heavy settle down at the bottom and impurities, being lighter, are washed away.
- This method is used for the concentration of oxide ores like hematite, bauxite etc., carbonate ores and the ores of Au, Ag.

72) *What is the basic principle of gravity separation method for concentrating an ore. What types of ores are concentrated by this method?*

3. Froth floatation method

- This method is based upon the wettability of ore and gangue particles in oil (e.g.: pine oil).
- This method is suitable method for the concentration of sulphide ores.
- For example: zinc blende, copper pyrites, lead galena, cinnabar.
- The mixture is agitated by passing the compressed air.
- As the gangue particles are wetted by water, they sink to the bottom of the tank.
- Whereas the ore particles are wetted by oil, they float on the surface as a froth. The froth is then skimmed off.



75/74/73) Write short note on Froth floatation process. 2.5

72) Write the basic principle of froth floatation method for concentrating an ore. What types of ore are concentrated by this process? 2

51) Name the process for concentration of sulphide ore. 1

4. Magnetic separation method

- This method is suitable for those ores in which either ore or gangue is magnetic in nature.
 - In this method, the powdered ore is allowed to pass through a belt moving on two rollers, one of which is strongly magnetic.
 - The magnetic particles are attracted nearer to the magnetic roller and form a heap.
 - But non-magnetic particles are collected away from the roller.
- For example: metallurgy of tin

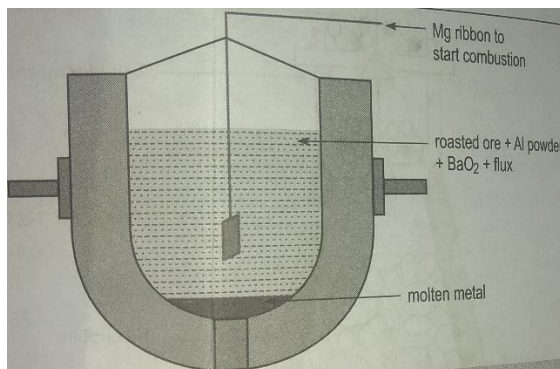
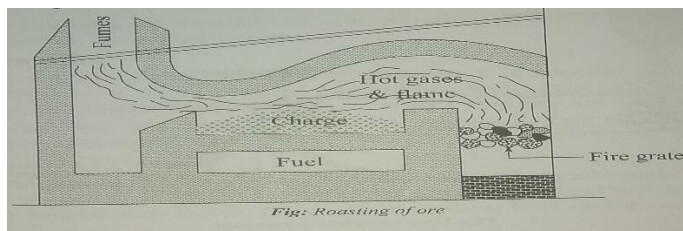
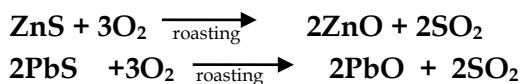


fig: magnetic separation

5. Leaching process:

- In this method, the ore is treated with the suitable chemical reagent, which selectively reacts with the required metallic compound of the ore, leaving behind the unreacted ore.
- The aqueous solution of the metallic compound is separated as filtrate from the impurities.

71) Give any two formula of ore which are applied for following metallurgical operations. a. Froth floatation b. leaching



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- 73) Differentiate between Calcination and Roasting. 2.5
- 71/66) What are the main differences between calcinations and roasting. 2
- 61/57/56) Distinguish between Calcination and Roasting. 2
- 63) Define the term: a) Calcination b) Roasting 2

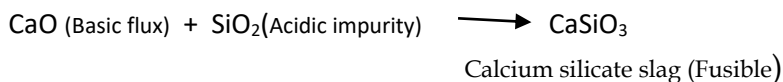
Heating of pyrites to remove sulphur is

- | | |
|-------------------|---|
| a. Bessmerization | c. Roasting |
| b. Calcination | d. None (IOM 2016) |

Reduction(Extraction)

1. Smelting

- This is the reduction method in pyrometallurgy. The process of heating calcined or roasted ore (Oxide form) strongly in presence of suitable reducing agent to get metal in molten state is called smelting.
- The roasted or calcined ore contains infusible impurities and they are converted into fusible mass. It floats on top of molten metal being lighter and removed.
- The substance used in smelting to convert infusible impurities into fusible is called **Flux** and the fusible mass is called **slag**.
- For acidic impurity basic flux is used and for basic impurity acidic flux is used.



Based on nature of ore following methods of smelting can be used.

69) Describe smelting process in the extraction of metal from their ores. 5

71) Define the terms flux. 1

74) What is meant by slag? Give an example of it. 2

74) Define slag giving proper example. 1

76) Distinguish between flux and slag giving an example of each. 2

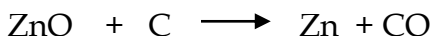
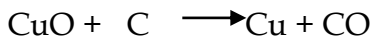
65) What is meant by slag? Why is it important in metallurgy? 2

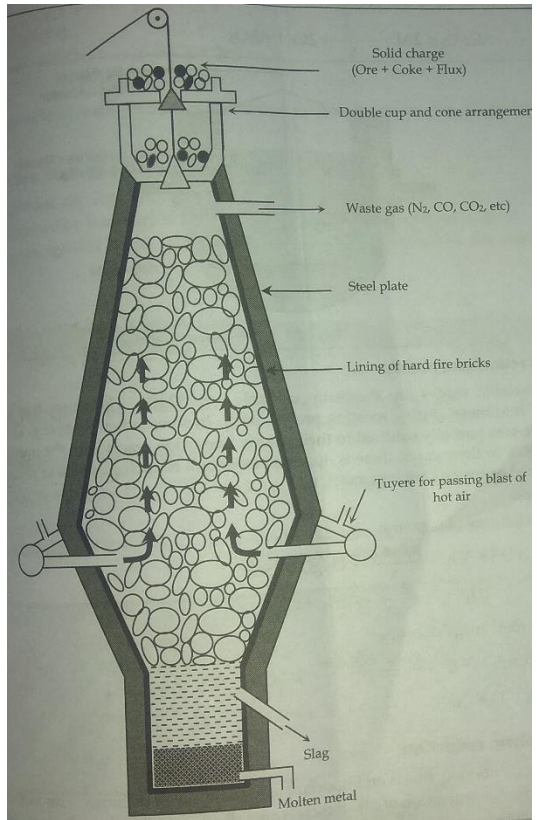
69) Give a brief account of smelting process. 2.5

69) Des

i. Carbon reduction process

- The roasted or calcined ore is mixed with coke (C) as a reducing agent and a suitable flux is fed in a blast furnace.
- Blast of hot air is supplied from bottom of furnace.
- On doing so oxide is reduced to metal and flux forms slag with impurities.
- Molten metal is obtained at the bottom of furnace and slag floats over molten metal.
- Molten metal and slag can be separately removed from two separate tapping holes.





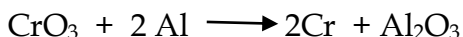
74) Write short note on Carbon reduction process. 2.5

70) Give a brief account of Carbon reductions. 3

70) Write the chemical reaction involved in Carbon reduction process. 1

ii. Thermite process (alumino thermite process)

- Some metallic oxides like CrO_3 and MnO_4 cannot be reduced by carbon because oxygen has more affinity with these metals than with carbon.
- Aluminium is used as reducing agent
- The mixture of roasted or calcined ore and aluminium is called thermite is mixed with barium peroxide and suitable flux in a crucible
- Burning Magnesium is introduced to crucible for ignition, large amount of energy is released.
- Metallic oxide is reduced to metal in molten form and collected in bottom.



73) Write short note on alumino thermite process. 2.5

69) Give a brief account of alumino thermite process. 2.5

62) What is meant by alumino thermite process? 2

73) Differentiate between carbon reduction and thermite process. 2.5

70) Write the chemical reaction involved in AluminoThermite process. 1

iv. Electrochemical reduction

- The metals which are very reactive are extracted by this method (alkali and alkaline earth metals).
- The fused ore is subjected for electrolysis
- Metal is deposited on cathode by reduction.

- Sometimes, other substances are to be added to ore to decrease melting point of ore.

70) Give a brief account of Electrometallurgy. 3

73) Differentiate between Carbon reduction and Electrolytic reduction process. 2.5

Purification (Refining of metals: Poling, Electro-refinement etc.)

1. Distillation
2. Liquation
3. Electrolytic refining
4. Zone refining
5. Poling

73) Write short note on Zone refining. 2.5

1. Distillation: metals having low melting point (Zn, Hg, Cd) are refined by this process.

- In this method, metal to be purified is heated around its boiling point; so metals gets vapourised leaving impurities back.
- The vapours of metals are condensed to get pure metal.

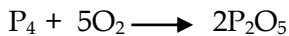
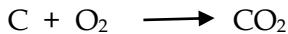
2. Liquation process

- Metals having low melting point (Pb, Sn etc) can be purified by this method.

- Impure metal is placed in inclined bed of furnace and heated
- Metal melts and flows away leaving non-fusible impurities (oxides) behind.

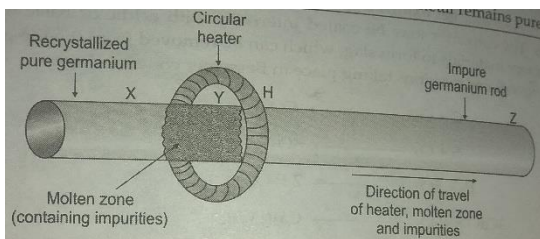
3. Oxidation of impurities

- This method is used for easily oxidizable impurities
- IN this process impure metal is heated in open furnace in excess of air.(Bassemerisation process).
- Non metallic impurities get oxidized and removed as waste gas.



4. Zone Refining (Fractional Crystallization)

- A circular heater is moved slowly around the circular metallic rod to be purified.
- Metal melts but the infusible impurities remain suspended.
- As heater moves ahead, pure metal gets crystallized while impurities keep moving with molten mass.
- All infusible impurities are taken at one end along with heater, the end is cut and removed.

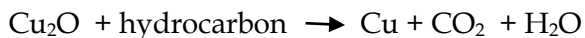


5. Electrolytic refining

- Impure metal is made anode and pure metal is made cathode
- Salt of same metal is made electrolyte.
- When electricity is passed metal dissolves from anode and get deposited over cathode.
- Soluble impurities pass into solution and Insoluble impurities left behind at anode.

6. Poling

- Molten metal is stirred with green wood poles
- Hydrocarbon present in green wood pole reduce metallic oxide (impurities) into free metal



7. Chemical treatments

- This method is used for very less reactive metals (GOLD, Mercury, platinum etc)

- Impure metal is passed allowed through HNO_3 , Most of the impurities dissolves while metal remains unreacted.