

Unit-1, Metallurgy

1. What is the difference between minerals and ores?

| Mineral | Ore |
|--|--|
| Naturally occurring substance obtained by mining which contains the metal in free state or combined state is called a Mineral. | Metal can be extracted conveniently and economically from its Mineral are called Ores. |
| All minerals are not ores. | All ores are minerals. |
| Bauxite and china clay are minerals of Al. | Bauxite is an ore of Al while china clay is not. |

2. What are the various steps involved in extraction of pure metals from their ores?

Steps of metallurgy:

- ❖ Concentration of the ore
- ❖ Extraction of crude metal
- ❖ Refining of crude metal

3. What is the role of Limestone in the extraction of Iron from its oxide Fe_2O_3 ?

Lime stone is decomposed to CaO (basic flux) which removes silica impurity (acidic) of the ore as slag (calcium silicate).



4. Which type of ores can be concentrated by froth floatation method? Give two examples for such ores.

Sulphide ores can be concentrated by froth floatation method because sulphide ore particles are preferentially wetted by pine oil and gangue wetted by water

Example: Galena (PbS), Zinc blende (ZnS)

5. out of Coke and CO, which is better reducing agent for the reduction of ZnO ? Why?

- ❖ Above 1273 K, C has more negative ΔG° value than ZnO, so it will be in lower part of Ellingham Diagram. Therefore, Coke can reduce ZnO.
- ❖ On the other hand, CO has lesser ΔG° value than ZnO, so it will be in upper part of Ellingham Diagram. Therefore, CO cannot reduce ZnO
- ❖ Hence Coke is better reducing agent than CO for reducing ZnO

Unit-1, Metallurgy

6. Describe a method for refining nickel.

Nickel is refined by Mond process. Impure nickel forms volatile complex with CO. which is further decomposed to give pure nickel metal at 460 K

**7. Explain zone refining process with an example.****Zone refining (fractional crystallisation)**

Principle: Impurities are more soluble in the melt than in the solid state metal.

Process:

- ❖ The impure metal is taken in the form of a rod.
- ❖ The impure metal is heated with the help of mobile induction heater at one end of the rod of impure metal.
- ❖ As the heater moves, the molten zone of the rod also moves with it.
- ❖ As a result, pure metal crystallises out of melt and the impurities pass on into the adjacent molten zone.
- ❖ The process is repeated several times by moving the heater in the same direction again and again to achieve the desired purity level.
- ❖ It is carried out in an inert gas atmosphere to prevent the oxidation of metals.

Example:

- ❖ Germanium, Silicon and Galium (which are used as semiconductor) are refined by this method

8. Using the Ellingham diagram given below.**(i) Aluminium might be expected to reduce magnesia.**

Above 1623K, Al has more negative ΔG° value than magnesia, so it will be in lower part of Ellingham Diagram. Hence Al will be used to reduce magnesia.

(ii) Magnesium could reduce alumina.

Below 1623K, Mg has more negative ΔG° value than alumina, so it will be in lower part of Ellingham Diagram. Hence Mg will be used to reduce Alumina.

(B) Carbon monoxide is more effective reducing agent than carbon below 983K but, above this temperature, the reverse is true –Explain.

- ❖ CO is more effective reducing agent below 983 K, because CO has more negative ΔG° value than C, so it will be in lower part of Ellingham Diagram.

Unit-1, Metallurgy

- ❖ Above 983 K Coke is more effective reducing agent, because C has more negative ΔG° value than CO, so it will be in lower part of Ellingham Diagram.
- ❖ e.g., CO reduces Fe_2O_3 below 1073 K but above it, Coke reduces Fe_2O_3 .

(c) It is possible to reduce Fe_2O_3 by coke at a temperature around 1200K

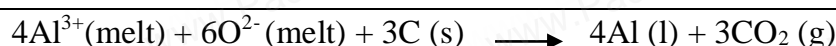
Around 1200K, C has more negative ΔG° value than Fe_2O_3 , so it will be in lower part of Ellingham Diagram Hence Coke will be used to reduce Fe_2O_3 .

9. Give the uses of zinc.

- ❖ Zn used in Galvanising iron, Die-castings in Automobile, Electrical and Hardware industries.
- ❖ Brass Alloy (Cu and Zn) is used in Water Valves and Communication Equipment.
- ❖ ZnO is used in Paints, Rubber, Cosmetics, Pharmaceuticals, Plastics, Inks, Batteries, Textiles and Electrical equipment.
- ❖ ZnS is used in luminous paints, Fluorescent lights and X-ray screens.

10. Explain the electrometallurgy of Aluminium.

- ❖ **Cathode:** Iron tank lined with Carbon
- ❖ **Anode:** Carbon blocks
- ❖ **Electrolyte:** 20% Alumina solution (obtained from bauxite ore)+ Molten cryolite +10% Calcium Chloride
- ❖ Here Calcium Chloride helps to lower the melting point of the mixture.
- ❖ The fused mixture is maintained at a temperature of above 1270 K.
- ❖ Ionisation of Alumina: $\text{Al}_2\text{O}_3 \longrightarrow 2\text{Al}^{3+} + 3\text{O}^{2-}$
- ❖ Cathode: $2\text{Al}^{3+} (\text{melt}) + 6\text{e}^- \longrightarrow 2\text{Al} (\text{l})$
- ❖ Anode: $\text{C} (\text{s}) + \text{O}^{2-} (\text{melt}) \longrightarrow \text{CO} + 2\text{e}^-$
- ❖ $\text{C} (\text{s}) + 2\text{O}^{2-} (\text{melt}) \longrightarrow \text{CO}_2 + 4\text{e}^-$
- ❖ Net electrolysis reaction

**11. Explain the following terms with suitable examples. (i) Gangue (ii) Slag****Gangue:**

The nonmetallic impurities, rocky materials and siliceous matter associated with an ore are

Unit-1, Metallurgy

called Gangue.

Slag: A flux combines with infusible gangue present in the ore to form a fusible compound known as Slag.



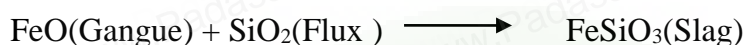
12. Give the basic requirement for vapour phase refining.

- ❖ The metal should form a volatile compound with an available reagent.
- ❖ The volatile compound should be easily decomposable so that the metal can be easily recovered.

13. Describe the role of the following in the process mentioned.

(i) Silica in the extraction of copper.

Silica acts as an acidic flux to remove ferrous oxide (basic Gangue) as ferrous silicate (slag).

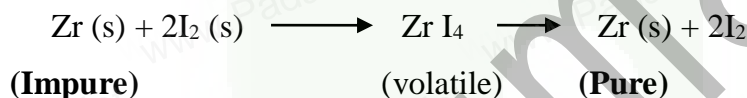


(ii) Cryolite in the extraction of aluminium.

Cryolite lowers the melting point of alumina and makes it a good conductor of electricity.

(iii) Iodine in the refining of Zirconium.

Zr is heated in iodine vapours at about 550 K to form volatile ZrI_4 which are heated over tungsten filament at 1800K to give pure Zr.



(iv) Sodium cyanide in froth floatation.

NaCN is used as a depressant. It selectively prevents ZnS from coming to froth but allows PbS to come with froth. Because NaCN reacts with ZnS to form $\text{Na}_2 [\text{Zn} (\text{CN})_4]$.

14. Explain the principle of electrolytic refining with an example.

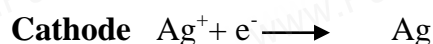
Electrolytic refining of silver

Cathode: Pure silver

Anode: Impure silver rods

Electrolyte: Acidified silver nitrate solution.

Electrolysis results in the transfer of Ag in pure form from the anode to cathode.



15. The selection of reducing agent depends on the thermodynamic factor: Explain with an example.

- ❖ A suitable reducing agent is selected based on the thermodynamic considerations.

Unit-1, Metallurgy

- ❖ We know that for a spontaneous reaction, the change in free energy (ΔG) should be negative.
- ❖ Therefore, thermodynamically, the reduction of metal oxide with a given reducing agent can occur if the free energy change for the coupled reaction is negative.
- ❖ Hence, the reducing agent is selected in such a way that it provides a large negative ΔG value for the coupled reaction.
- ❖ **Example:**
- ❖ Above 1623K, Al has more negative ΔG° value than magnesia Hence Al will be used to reduce magnesia.
- ❖ Below 1623K, Mg has more negative ΔG° value than alumina Hence Mg will be used to reduce Alumina.

16. Give the limitations of Ellingham diagram.

- ❖ Ellingham diagram is constructed based only on thermodynamic considerations.
- ❖ It gives information about the thermodynamic feasibility of a reaction.
- ❖ It does not tell anything about the rate of the reaction.
- ❖ It does not give any idea about the possibility of other reactions that might be taking place.
- ❖ The interpretation of ΔG is based on the assumption that the reactants are in equilibrium with the product which is not always true.

17. Write a short note on electrochemical principles of metallurgy.

- ❖ Gibbs free energy change for the electrolysis process is given by $\Delta G^\circ = -nFE^\circ$
- ❖ Where n = number of electrons
- ❖ F = Faraday
- ❖ E° = electrode potential
- ❖ If E° is positive then the ΔG is negative and the reduction is spontaneous and hence a redox reaction is planned in such a way that the e.m.f of the net redox reaction is positive.
- ❖ When a more reactive metal is added to the solution containing the relatively less reactive metal ions, the more reactive metal will go into the solution.
- ❖ e.g, $\text{Cu(s)} + 2\text{Ag}^+(\text{aq}) \longrightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{Ag(s)}$

R.SUKUMAR, PG ASST

GHSS, ARAVANKURICHI, DINDIGUL