METALLURGY
SOLVED EXAMPLE

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"An Innovative Practice Methodology by IITians."

1. (i) Arrange Ca, Pb, Fe, Na, Zn, Cu, and Al in the decreasing order of their reactivity.

(ii) Answer the following question related to above (i) sequence:

(a) Which of these is most likely to tarnish readily when exposed to the air?

(b) Which of these is most likely to be found in free state in nature?

(c) Which of these is most likely to react with cold water?

Ans. (i) The decreasing order of the given metals is as follows:

[Most reactive] Na, Ca, Al, Zn, Fe, Pb, and Cu [Least reactive]

(ii) (a) Sodium [Na]. (b) Copper [Cu]. (c) Sodium [Na] and calcium [Ca].

2. (i) From the metals copper, zinc, magnesium, sodium and iron, select the metal in each case which:

(a) Does not react with dil. hydrochloric acid.

(b) Has a hydroxide that reacts with both acids and alkalis.

(c) Does not react with cold water but reacts with steam when heated.

(d) Can form +2 and +3 ions.

(ii) Arrange the metals in decreasing order of reactivity.

Ans. (i) (a) Copper (b) Zinc (c) Magnesium (d) Iron

(ii) Sodium > Magnesium > Iron > Zinc > Copper.

3. (i) What is froth floatation process and for, what purpose it is used?

(ii) How is the metal sodium extracted? Write the equations for the reactions involved.

(iii) Name two other metals, which can be extracted by electrolytic reduction method.

Ans. (i) In this process, the heavy material containing metal is floated upward with froth to separate it from, waste material present in ore or mineral. Hence it is called froth floatation process.

(ii) Sodium metal is extracted by the electrolysis of fused sodium chloride. Sodium is collected at cathode, while chlorine gas is liberated at anode; as an important by product.

(iii) Calcium, and magnesium are other two metals, which can be extracted by electrolytic reduction method.

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

At Cathode : $Na^+ + e^- \longrightarrow Na$

At anode : $Cl^- - e^- \longrightarrow Cl$

$Cl + Cl \longrightarrow Cl_2$

4. (i) (a) Name two ores of iron.

(b) Name three raw materials used in the extraction of iron.

(c) Write equations that occur in the "Blast Furnace".

(ii) What are the main constituents of steel?

(iii) What is tempering of steel?

Ans. (i) (a) Two main ores of iron are : Haematite [Fe_2O_3] and Magnetite [Fe_2O_4].

(b) Iron ore, lime stone, and coke are used in the extraction of iron.

(c) Following are the reactions, which take place in the "Blast Furnace", during the extraction of iron.

$$C + O_2 \longrightarrow CO_2$$
$$CO_2 + C \longrightarrow 2CO$$
$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$
$$Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$$
$$CaCO_3 \longrightarrow CaO + CO_2$$
$$CaO + SiO_2 \longrightarrow CaSiO_3$$

Calcium Silicate [Slag]

(ii) Steel is an alloy of iron and carbon containing very small amounts of impurities that are present in the cast iron. The carbon content varies from 0-5 to 1-5%. The variety containing lower percentage of carbon is called "mild steel and the variety which contains higher percentage of carbon are known as "hard steel".

(iii) The hardened steel is brittle in nature and when it is heated upto a definite temperature and for certain time and then allowed to be cooled down slowly, then it loses its brittleness. This process is known as tempering of steel and is employed for bringing the steel into a suitable state of hardness and elasticity. The temperature required is generally judged from the colour of a thin film of oxide which is formed on the surface and varies from yellow to brown to blue as the temperature rises from 200°C to 300°C.

5. A to F below relate to the source and extraction of either Zinc or Aluminium.

A. Bauxite: B. Coke C. Cryolite D. Froth floatation E. Sodium hydroxide solution. F. Zinc blende.

(i) Write down the three letters each from the above list which is relevant to:

(1) Zinc (2) Aluminium.

(ii) (1) Metals are generally solid at room temperature. Name the metal which is liquid at room temperature [say 25°C].

(2) Which allotrope of the non-metal conducts electricity?

(iii) How many valence electrons are present in (a) Metals, (b) Non-metals?

Ans. (i) (1) B, D, F (2) A, C, E

(ii) (1) Mercury metal exists in liquid state at room temperature.

(2) Graphite, an allotrope of carbon is a good conductor of electric current.

(iii) Atom of metals contains 1, 2 and 3 valence electrons, while the atom of non-metals contains 4, 5, 6 and 7 valence electrons.

6. (i) Name an alloy used in aircraft construction and give a reason for its use.

(ii) What is rusting of iron?

(iii) (a) How are the following protected from rust ?

(1) A car bumper and (2) A food can.

(b) How can iron or steel be prevented from rusting, when used for?

(c) What is galvanized iron and for what purposes it is used?

(d) To protect iron from rusting it is coated with a thin layer of zinc. Name this process.

Ans. (i) Duralumin, an alloy of aluminium, is used in the construction of aircraft; because it is light, resistant to corrosion and has great tensile strength.

(ii) The rusting of iron is a process of atmospheric corrosion, i.e., slow destruction of iron by moisture and atmospheric oxygen. Rust is a reddish-brown powdery deposit and consists of a mixture of ferric hydroxide and hydrated ferric oxide.

(iii) (a) (1) Nickel Plating and (2) Galvanizing.

(b) By painting and by coating with nickel.

(c) Iron coated with zinc is called galvanized iron. Galvanization is a process of depositing a thin layer of zinc, over the surface of iron to protect iron from rusting. Zinc is more electropositive and would be attacked first and thus iron is protected from any corrosion. Galvanized iron is used in making different varieties of tools for industries, scientific apparatus and household fittings.

(d) Galvanization.

7. (i) The ore zinc blende is an important source of the metal zinc. What is the name of the zinc compound in zinc blende?

(ii) Which is the zinc compound obtained by roasting zinc blende?

(iii) What is the type of chemical reaction carried out after roasting in order to obtain zinc?

(iv) Are liquid zinc and liquid lead miscible or immiscible?

(v) What is the name of the alloy formed between zinc and copper?

Ans. (i) Zinc sulphide [ZnS].

(ii) Zinc blende is oxidized to zinc oxide by roasting in presence of excess air on reverberatory furnace.

(iii) Reduction of zinc oxide.

(iv) Immiscible.

(v) Brass.

8. State the main components of the following alloys :

(i) Brass. (ii) Duralumin. (iii) Bronze. (iv) Stainless steel.

Ans. (i) Copper and zinc. (ii) Aluminium and magnesium (iii) Copper and Tin. (iv) Iron

9. Give the composition and uses of the following alloys :

(i) Brass. (ii) Bronze. (iii) German silver (iv) Type metal. (v) Magnalium (vi) Duralumin

Ans. (i) It is an alloy of copper and zinc and is used for making utensils, condenser tubes, statues, and for making decoration pieces.

(ii) It is an alloy of copper, zinc and tin and is used for making statues, utensils and coins.

(iii) It is an alloy of copper, zinc and nickel and is used for making ornaments and utensils and also used for decoration.

(iv) It is a Hoy of lead, antimony and tin and is used for making printing type.

(v) It is an alloy of aluminum and magnesium and is used for making light instruments, parts of machines and balance beams.

(vi) It is an alloy of aluminium, copper, magnesium and manganese and is used for making aeroplanes, space crafts, sea ship and pressure cookers.

10. Why metals are called reducing agents?

Ans. Metals act as a reducing agent because they have tendency to donate electrons and get oxidized.

11. Why non-metals are called oxidizing agents?

Ans. Non- metals act as an oxidizing agent because non-metals have a tendency to gain electrons and get reduced.

12. Why iron is not found in free state in nature?

Ans. Iron is quite reactive metal; it easily combines with other metals. Iron thus occurs in nature in the form of its compounds and not as a free element.

13. Why carbon can reduce copper (II) oxide to copper but not calcium oxide to calcium?

Ans. Carbon is more reactive element than copper so it displaces copper from copper oxide but calcium is more reactive element than carbon so carbon does not displaces calcium from calcium oxide. So carbon can reduce copper oxide to copper but not calcium oxide to calcium.

14. Aluminium is highly electropositive metal; in spite of it aluminium does not oxidize rapidly in air. Why?

Ans. In moist air, a thin layer of aluminium oxide is formed on it quickly which protects aluminium to oxidize. This is the reason why aluminium does not oxidize rapidly in air.

15. Why extraction of aluminium is difficult?

Ans. Extraction of aluminium is difficult because:

(i) Pure aluminium oxide melts at 2050°C only. So, a large amount of energy is needed to maintain this high temperature.

(ii) A good amount of the aluminium vaporizes at this temperature.

(iii) Fused alumina does not conduct electricity well.

16. During the extraction of aluminium, cryolite and fluorspar are added to alumina. Why?

Ans. Cryolite and fluorspar are added to alumina:

(i) To lower the melting point of aluminium.

(ii) To make alumina a good conductor of electricity.

(iii) Cryolite acts as a solvent for alumina.

17. Aluminium transmission wires are preferred to copper transmission wires. Why?

Ans. (i) Aluminium is lighter than copper.

(ii) It is a good conductor of electricity.

(iii) Aluminium is cheaper than copper.

18. Why is sodium metal always stored under kerosene oil?

Ans. Sodium is a very reactive metal and on exposure to moist air, the surface of sodium metal is tarnished due to formation of sodium carbonate.

$$4Na + O_2 \longrightarrow 2Na_2O.$$
$$Na_2O + H_2O \longrightarrow 2NaOH$$
$$2NaOH + CO_2 \longrightarrow \underset{\text{Sodium Carbonate}}{Na_2CO_3} + H_2O$$

To avoid this sodium is always kept under kerosene oil.

19. Zinc displaces lead from lead nitrate solution, while gold is unable to do so. Why?

Ans. Zinc is above lead in the metal activity series. It is more reactive than lead while gold, a noble metal, lies far below lead in the activity series and it is less reactive or highly unreactive. Zinc reacts with lead nitrate solution to precipitate lead and zinc nitrate is formed. There is no reaction between gold and lead nitrate.

$$Pb(NO_3)_2 + Zn \longrightarrow Zn(NO_3)_2 + Pb \downarrow$$
$$Pb(NO_3)_2 + Au \longrightarrow \text{No reaction.}$$

20. Differentiate between:

Calcination and Roasting

Ans.

Calcination	Roasting
1. The ore is heated in the absence of air.	The ore is heated in the presence of air.
2. It is used for oxide or carbonate ores.	It is used for sulphide ores.