UNIT – 1 METALLURGY

I. CHOOSE THE CORRECT ANSWER

1. Bauxite has the composition
   a) Al_2O_3 b) $Al_2O_3 .n H_2O$ c) $Fe_2O_3 .2H_2O$ d)None of these
2. Roasting of sulphide ore gives the gas (A). (A) is a colourless gas. Aqueous solution of (A) is acidic. The gas (A) is
   a)CO_2 b)SO_3 c)SO_2 d) H_2S
3. Which one of the following reaction represents calcinations?
   a) $2Zn + O_2 \rightarrow 2ZnO$ b) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$
   c) $MgCO_3 \rightarrow MgO + CO_2$ d) Both (a) and (c)
4. The metal oxide which cannot be reduced to metal by carbon is
   a) PbO b) Al_2O_3 c) ZnO d) FeO
5. Which of the metal is extracted by Hall-Heroult process?
   a) Al b) Ni c) Cu d) Zn
6. Which of the following statements, about the advantage of roasting of sulphide ore before reduction is not true?
   a) ΔG_f^0 of sulphide is greater than those for CS_2 and H_2S.
   b) ΔG_r^0 is negative for roasting of sulphide ore to oxide
   c) Roasting of the sulphide to its oxide is thermodynamically feasible.
   d) Carbon and hydrogen are suitable reducing agents for metal sulphides.
7. Match items in column - I with the items of column – II and assign the correct code.

Column-I		Column-II	
A	Cyanide process	(i)	Ultrapure Ge
B	Froth floatation process	(ii)	Dressing of ZnS
C	Electrolytic reduction	(iii)	Extraction of Al
D	Zone refining	(iv)	Extraction of Au
		(v)	Purification of Ni

	A	B	C	D
(a)	(i)	(ii)	(iii)	(iv)
(b)	(iii)	(iv)	(v)	(i)
(c)	(iv)	(ii)	(iii)	(i)
(d)	(ii)	(iii)	(i)	(v)

8. Wolframite ore is separated from tinstone by the process of
   a) Smelting b) Calcination c) Roasting d) Electromagnetic separation
9. Which one of the following is not feasible
   a) $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$
   b) $Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow Zn_{(s)} + Cu^{2+}_{(aq)}$
   c) $Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Ag_{(s)} + Cu^{2+}_{(aq)}$
   d) $Fe_{(s)} + Cu^{2+}_{aq} \rightarrow Cu_{(s)} + Fe^{2+}_{(aq)}$
10. Electrochemical process is used to extract
    a) Iron b) Lead c) Sodium d) silver
11. Flux is a substance which is used to convert
    a) Mineral into silicate b) Infusible impurities to soluble impurities
    c) Soluble impurities to infusible impurities d) All of these
12. Which one of the following ores is best concentrated by froth – floatation method?
    a) Magnetite b) Hematite c) Galena d) Cassiterite
13. In the extraction of aluminium from alumina by electrolysis, cryolite is added to
    a) Lower the melting point of alumina b) Remove impurities from alumina
    c) Decrease the electrical conductivity d) Increase the rate of reduction

14. Zinc is obtained from ZnO by
    a) Carbon reduction b) Reduction using silver
    c) Electrochemical process d) Acid leaching
15. Extraction of gold and silver involves leaching with cyanide ion. silver is later recovered by (NEET-2017)
    a) Distillation b) Zone refining c) Displacement with zinc d) liquation
16. Considering Ellingham diagram, which of the following metals can be used to reduce alumina? (NEET-2018)
    a) Fe b) Cu c) Mg d) Zn
17. The following set of reactions are used in refining Zirconium

$Zr\ (impure) + 2I_2 \xrightarrow{523\ K} ZrI_4$

$ZrI_4 \xrightarrow{1800K} Zr\ (pure) + 2I_2$, This method is known as
    a) Liquation b) van Arkel process c) Zone refining d) Mond's process
18. Which of the following is used for concentrating ore in metallurgy?
    a) Leaching b) Roasting c) Froth floatation d) Both (a) and (c)
19. The incorrect statement among the following is
    a) Nickel is refined by Mond's process
    b) Titanium is refined by Van Arkel's process
    c) Zinc blende is concentrated by froth floatation
    d) In the metallurgy of gold, the metal is leached with dilute sodium chloride solution.
20. In the electrolytic refining of copper, which one of the following is used as anode?
    a) Pure copper b) Impure copper c) Carbon rod d) Platinum electrode
21. Which of the following plot gives Ellingham diagram
    a) ΔS Vs T b) ΔG^0 Vs T c) ΔG^0 Vs $1/T$ d) ΔG^0 Vs T^2
22. In the Ellingham diagram, for the formation of carbon monoxide
    a) $(\Delta S^0 / \Delta T)$ is negative b) $(\Delta G^0 / \Delta T)$ is positive
    c) $(\Delta G^0 / \Delta T)$ is negative d) initially $(\Delta T / \Delta G^0)$ is positive, after 7000C , $(\Delta G^0 / \Delta T)$ is negative
23. Which of the following reduction is not thermodynamically feasible?
    a) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$ b) $Al_2O_3 + 2Cr \rightarrow Cr_2O_3 + 2Al$
    c) $3TiO_2 + 4Al \rightarrow 2\ Al_2O_3 + 3Ti$ d) none of these
24. Which of the following is not true with respect to Ellingham diagram?
    a) Free energy changes follow a straight line. Deviation occurs when there is a phase change.
    b) The graph for the formation of CO2 is a straight line almost parallel to free energy axis.
    c) Negative slope of CO shows that it becomes more stable with increase in temperature.
    d) Positive slope of metal oxides shows that their stabilities decrease with increase in temperature.

ANSWER

1	2	3	4	5	6	7	8	9	10
b	***c***	***c***	***b***	***a***	***d***	***c***	***d***	***b***	***c***
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
b	***c***	***a***	***a***	***c***	***c***	***b***	***d***	***d***	***b***
21	**22**	**23**	**24**						
b	***c***	***b***	***b***						

S.JOSEPH SURESH , M.Sc.,M.Ed., PG ASST CHEMISTRY, DINDIGUL. 9994342531

II. ONE MARK FROM INSIDE THE LESSON

1. In froth floatation process collector is.....
   a) sodium ethyl Xanthate b) Pine oil c) Ore d) Sodium Chloride
2. Which is not refined by liquation?
   a) Tin b) Zinc c) Lead d) Bismuth
3. Which is used in making luminous paints, fluorescent lights and x - ray screens?
   a) Brass b) Zinc sulphide c) Cast iron d) Gold nano particles
4. In the metallurgy of iron, limestone is added to coke .which acts as a_____
   a)reducing agent b)oxidizing agent c)slag d)Flux
5. $Na[Ag(CN)_2]$ is _____.
   a)Sodium aurocyanide b)Sodium meta aluminate
   c)Aluminosilicate d)Sodium dicyano argentite
6. Malachite has _____ composition.
   a) $2CuCO_3.Cu(OH)_2$ b) $CuCO_3Cu(OH)_2$ c) Cu_2O d) Cu_2S
7. Identify the halide ore among the following
   a) Epsom salt b) Pyrolusite c) Anglesite d) Rock salt
8. Which of the following mineral contains calcium as well as magnesium?
   a) Zinc blende b) Aragonite c) Dolomite d) Carnalite
9. Name the process by which elements such as germanium ,silicon and galium are refined.
   a) Vapour phase method b) Electrolytic refining
   c) Zone refining d) Van–Arkel method.
10. Sodium, Magnesium and Aluminium can be obtained from their ore by .....
    a)Electro metallurgy b) Pyro metallurgy c)Hydro metallurgy d)Smelting
11. Cerrusite is .....
    a) Sulphide ore of Ag b) Carbonate ore of Pb c) Sulphide ore of Pb d) Sulphate ore of Pb
12. Low boiling volatile impure metals are refined by …… method.
    a) Zone refining b) Distillation c) Roasting d) Mond's
13. Sodium cyanide solution is used to extract_____ from its ores.
    a)Copper b)Silver c)Gold d)Both (b) and (c)
14. Which of the following ores undergoing Ammonia leaching process ?
    a) Fe , Cu, Co b) Ni, Cu, CO c) Hg, Zn, Al d) Zn, Cu, Al
15. Which one is used for cutting tools?
    a) Chrome vanadium steel b) Nichrome c) Chrome steel d) Nickel steel

ANSWER

1	2	3	4	5	6	7	8	9	10
a	*b*	*b*	*d*	*d*	*b*	*d*	*c*	*c*	*b*
11	**12**	**13**	**14**	**15**					
b	***b***	***d***	***b***	***c***					

S.JOSEPH SURESH , M.Sc.,M.Ed., PG ASST CHEMISTRY, DINDIGUL. 9994342531

III. TEXT BOOK QUESTIONS AND ANSWERS

1. What is the difference between minerals and ores?

SNo.	Minerals	Ores
1.	Naturally occurring substances obtained by mining which contain the metals in free state or in the form of compounds like oxides, sulphides, etc. are called minerals.	Minerals that contain high percentage of metal from which it can be extracted conveniently and economically are called ores.
2.	All the minerals are not ores	All the ores are minerals
3.	Mineral of Al is Bauxite ($Al_2O_3\,nH_2O$) and China clay ($Al_2O_3\,SiO_2\,.2H_2O$)	Ore of Al is Bauxite ($Al_2O_3\,nH_2O$)

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

i) Concentration of the ore ii) Extraction of the crude metal. iii) Refining of the crude metal.

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

Lime stone ($CaCO_3$) is used as a basic flux in the extraction of iron from its oxide Fe_2O_3.

Limestone decomposes to form CaO

$$CaCO_3 \longrightarrow CaO + CO_2$$

Impurity silica (SiO_2)react with CaO form fusible slag calcium silicate.

$$CaO_{(s)} + SiO_{2(s)} \longrightarrow CaSiO_{3(s)}$$

Flux Gaugue Slag

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

Sulphide ores can be concentrated by froth flotation method.

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

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

Out of coke and CO, coke is better reducing agent than CO for the reduction of ZnO.

$$ZnO_{(s)} + C \longrightarrow Zn_{(s)} + CO_{(g)}$$

In Ellingham diagram formation ZnO line lies above the formation $C \longrightarrow CO$ at low temperature (T_1), ZnO line also lies above the $CO \longrightarrow CO_2$ but at high temperature.

Hence carbon can be used as a better reducing agent than CO for the reduction of ZnO. Below the temperature T_1 both Coke and CO cannot reduce ZnO.

6. Describe a method for refining nickel. (or) Write a note about Mond's Process.

Impure nickel is heated in a stream of carbon monoxide at around 350K. Nickel reacts with CO to form a highly volatile nickel tetracarbonyl. The solid impurities are left behind.

$$Ni_{(s)} + 4CO_{(g)} \xrightarrow{350\ K} Ni[CO]_{4(g)}$$

On heating nickel tetra carbonyl around 460K, decomposes to give pure nickel.

$$Ni[CO]_{4(g)} \xrightarrow{460\ K} Ni_{(s)} + 4CO_{(g)}$$

7. Explain zone refining process with an example

Principle :

When an impure metal is melted and allowed to solidify, the impurities will prefer to remain in the molten region. 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. One end of the rod is heated using a mobile induction heater, melting the metal on that portion of the rod.

When the heater is slowly moved to the other end pure metal crystallises while impurities will move on to the adjacent molten zone formed due to the movement of the heater.

As the heater moves further away, the molten zone containing impurities also moves along with it.

This process is repeated several times by moving the heater in the same direction again and again to achieve the desired purity level.

This process is carried out in an inert gas atmosphere to prevent the oxidation of metals.

Germanium, Silicon and Gallium which are used as semiconductor are refined by this process.

8. Using the Ellingham diagram given below.

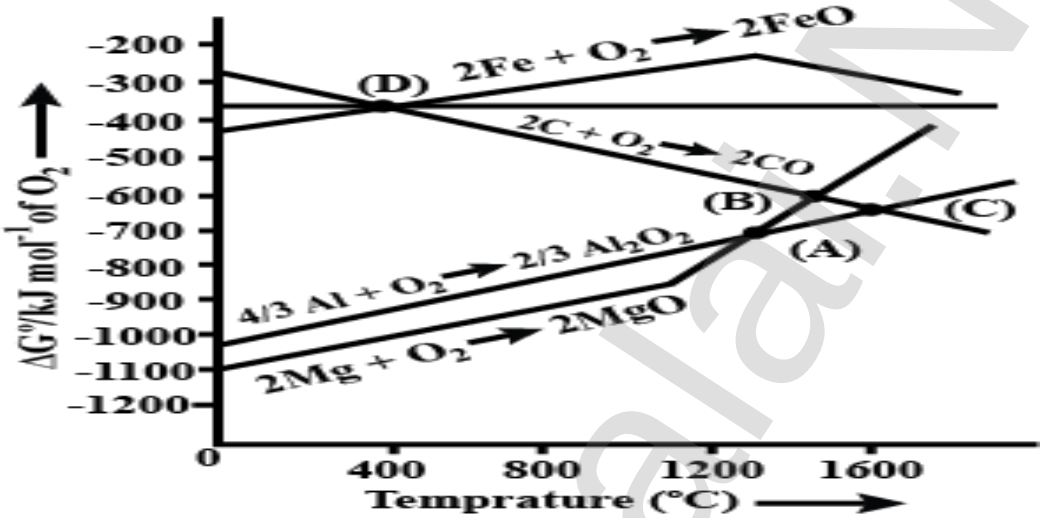
(A) Predict the conditions under which

i) Aluminium might be expected to reduce magnesia. ii) Magnesium could alumina.

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

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

A) i) Ellingham diagram for the formation of Al_2O_3 and MgO intersects around 1600K.
Above this temperature aluminium line lies below the magnesium line. Hence we can use aluminium to reduce magnesia above 1600K.



ii) In Ellingham diagram below 1600K magnesium line lies below aluminium line. Hence below 1600K magnesium can reduce alumina.

B)The two lines for CO→CO_2 and C →CO cross at about 983K. Below this temperature the reaction to form CO_2 is energetically more favourable hence CO is more effective reducing agent than carbon. But above 983K the formation of CO is preferred, hence carbon is more effective reducing agent than CO above this temperature.

C)In Ellingham diagram above 1000K carbon line lies below the iron line. Hence it is possible to reduce Fe_2O_3 by coke at a temperature around 1200K.

9. Give uses of Zinc.

1. Metallic zinc is used in galvanisation to protect iron and steel structures from rusting and corrosion.
2. Zinc is used to produce die - castings in the automobile, electrical and hardware industries.
3. Zinc oxide is used in the manufacture of paints, rubber, cosmetics, pharmaceuticals, plastics, inks, batteries, textiles and electrical equipment.
4. Zinc sulphide is used in making luminous paints, fluorescent lights and x - ray screens.
5. Brass an alloy of zinc is used in water valves and communication equipment as it is highly resistant to corrosion

10. Explain the electrometallurgy of Aluminium.

Hall – Herold Process:

Cathode : Iron tanked lined with carbon

Anode : Carbon blocks

Electrolyte : 20% solution of alumina obtained from bauxite + Molten Cryolite + 10% calcium chloride (lowers the melting point of the mixture)

Temperature: Above 1270K

Ionisation of Alumina $Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$

Reaction at cathode: $2Al^{3+}(melt) + 6e^- \longrightarrow 2Al_{(l)}$

Reaction at anode: $6O^{2-}(melt) \longrightarrow 3O_2 + 12e^-$

Since carbon acts as anode the following reaction also takes place on it.

$C_{(s)} + O^{2-}(melt) \longrightarrow CO + 2e^-$

$C_{(s)} + 2O^{2-}(melt) \longrightarrow CO_2 + 4e^-$

During electrolysis anodes are slowly consumed due to the above two reactions. Pure aluminium is formed at the cathode and settles at the bottom.

Net electrolysis reaction is

$4Al^{3+}(melt) + 6O^{2-}(melt) + 3C_{(s)} \longrightarrow 4Al_{(l)} + 3CO_{2(g)}$

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

i) Gangue:

The non metallic impurities, rocky materials and siliceous matter present in the ores are called gangue. (eg): SiO_2 is the gangue present in the iron ore Fe_2O_3.

ii) Slag:

Slag is a fusible chemical substance formed by the reaction of gangue with a flux.

$CaO_{(s)} + SiO_{2(s)} \longrightarrow CaSiO_{3(s)}$

Flux gangue slag

12. Give the basic requirement for vapour phase refining.

The metal is treated with a suitable reagent to form a volatile compound.

Then the volatile compound is decomposed to give the pure metal at high temperature.

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

i) Silica in the extraction of copper. ii) Cryolite in the extraction of aluminium.

iii) Iodine in the refining of Zirconium. iv) Sodium cyanide in froth floatation.

i) In the extraction of copper, silica acts as an acidic flux to remove FeO as slag $FeSiO_3$.

$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_{3(s)}$

Gangue Flux Slag

ii) As Al_2O_3 is a poor conductor, cryolite improves the electrical conductivity. In addition, cryolite serves as an added impurity and lowers the melting point of the electrolyte.

iii) First Iodine forms a Volatile tetraiodide with impure metal, which decomposes to give pure metal. Impure zirconium metal is heated in an evacuated vessel with iodine to form the volatile zirconium tetraiodide (ZrI_4). The impurities are left behind, as they do not react with iodine.

$Zr_{(s)} + 2I_{2(s)} \longrightarrow ZrI_{4(Vapour)}$

On passing volatile zirconium tetraiodide vapour over a tungsten filament, it is decomposed to give pure zirconium.

$ZrI_{4(Vapour)} \longrightarrow Zr_{(s)} + 2I_{2(s)}$

iv) Sodium cyanide acts as a depressing agent in froth floatation process. When a sulphide ore of a metal contains other metal sulphides, the depressing agent sodium cyanide selectively prevent other metal sulphides coming to the froth. eg: NaCN depresses the floatation property ZnS present in Galena (PbS) by forming a layer of Zinc complex $Na_2[Zn(CN)_4]$on the surface of Zinc sulphide.

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

Crude metal is refined by electrolysis carried out in an electrolytic cell.

Cathode : Thin strips of pure metal.
Anode : Impure metal to be refined.
Electrolyte : Aqueous solution of the salt of the metal with dilute acid.

As current is passed,metal ions from the electrolytic solution will be deposited at the cathode.
Less electro positive impurities in the anode settle down as anode mud.

Example : Electro refining of silver

Cathode : Pure silver
Anode : Impure silver rods.
Electrolyte: Acidified aqueous solution of silver nitrate.

When current passed, the following reactions will take place.

Reaction at anode: $Ag_{(s)} \rightarrow Ag^{+}_{(aq)} + e^{-}$
Reaction at cathode: $Ag^{+}_{(aq)} + e^{-} \rightarrow Ag(s)$

At anode silver atoms lose electrons and enter the solution. From the solution, silver ions (Ag^{+})migrate towards the cathode. At cathode silver ions get deposited on the 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.
For a spontaneous reaction ΔG should be negative.
Thermodynamically, the reduction of metal oxide with a given reducing agent can occur if ΔG for the coupled reaction is negative.
Ellingham diagram is used to predict thremodynamic feasibility of reduction of oxides of one metal by another metal.
Any metal can reduce the oxides of other metals that are located above it in the diagram.
Ellingham diagram for the formation of FeO and CO intersects around 1000K. Below this temperature the carbon line lies above the iron line.
Hence FeO is more stable than CO and the reduction is not thermodynamically feasible.
However above 1000K carbon line lies below the iron line. Hence at this condition FeO is less stable than CO and the reduction is thermodynamically feasible. So coke can be used as a reducing agent above this temperature.

Following free energy calculation also confirm that the reduction is thermodynamically favoured.From the Ellingham diagram at 1500K

$2Fe_{(s)} + O_{2(g)} \rightarrow 2FeO_{(g)}$ $\Delta G_1 = -350\ kJmol^{-1}$ ⟶ ①
$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$ $\Delta G_2 = -480\ kJmol^{-1}$ ⟶ ②

Reverse the reaction ①

$2FeO_{(s)} \rightarrow 2Fe_{(s)} + O_{2(g)}$ $\Delta G_1 = 350\ kJmol^{-1}$

Couple the reactions ② and ③

$2FeO_{(s)} + 2C_{(s)} \rightarrow 2Fe_{(s)} + 2CO_{(g)}$ $\Delta G_3 = -130\ kJmol^{-1}$

The standard free energy change for the reduction of one mole of FeO is $\Delta G = -65\ Jmol^{-1}$

16. Give the limitations of Ellingham diagram.

1. It gives information about the thermodynamic feasibility of a reaction.
2. It does not tell anything about the rate of the reaction.
3. More over it does not give any idea about the possibility of other reactions that might be taking place.
4. 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.

Reduction of oxides of active metals such as sodium, potassium etc by carbon is thermodynamically not feasible.

Such metals are extracted from their ores by using electrochemical methods.
In this method the metal salts are taken in fused form or in solution form.

The metal ion present can be reduced by treating the solution with suitable reducing agent or by electrolysis.

Gibbs free energy change for the electrolysis is

$G^o = - nFE^o$

n = number of electrons involved in the reduction

F = Faraday = 96500 coulombs

E^o = electrode potential of the redox couple.

If E^o is positive, ΔG^o is negative and the reduction is spontaneous.

Hence a redox reaction is planned in such a way that the e.m.f of the net redox reaction is positive.

A more reactive metal displaces a less reactive metal from its salt solution.

eg: $Cu^{2+}_{(aq)} + Zn_{(s)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$

Zinc is more reactive than copper and displaces copper from its salt solution.

IV. EVALUATE YOURSELF

1. Write the equation for the extraction of silver by leaching with sodium cyanide and show that the leaching process is a redox reaction.

In the metallurgy of silver metal is leached with a dilute solution of NaCN in the presence of air (O_2).

$$4Ag + 8CN^- + 2H_2O + O_2 \longrightarrow 4[Ag(CN)_2] + 4OH^-$$

In this reaction, $Ag \rightarrow Ag^+$ oxidation number of Ag increases from 0 to +1, hence oxidation

$O_2 \rightarrow OH^-$ (oxidation number of oxygen decreases from 0 to -2, hence reduction)

Hence Leaching of silver is a **redox reaction**.

2. Magnesite (Magnesium carbonate) is calcined to obtain magnesia, which is used to make refractory bricks. Write the decomposition reaction

Magnesite (Magnesium carbonate) is heated in the **absence of oxygen** decomposes to form Magnesium oxide (Magnesia)

$$MgCO_3 \longrightarrow MgO + CO_2$$

3. Using Ellingham diagram indicate the lowest temperature at which ZnO can be reduced to Zinc metal by carbon. Write the overall reduction reaction at this temperature

Ellingham diagram for the formation of ZnO and CO intersects around 1233K Below this temperature, **Carbon line lies above Zinc line**. Hence ZnO is more stable than CO so the reduction is thermodynamically not feasible at this temperature range.

However above 1233K carbon line lies below the zinc line, hence carbon can be used as a reducing agent above 1233K.

$2Zn + O_2 \longrightarrow 2ZnO$ .....①

$2C + O_2 \longrightarrow 2CO$ .....②

Reversing ① and adding with equation ②

$2ZnO \longrightarrow 2Zn + O_2$

$2C + O_2 \longrightarrow 2CO$

$2ZnO + 2C \longrightarrow 2Zn + 2CO$

4. Metallic Sodium is extracted by the electrolysis of brine (aq.NaCl). After electrolysisthe electrolytic solution becomes basic in nature. Write the possible electrode reactions.

Sodium metal is prepared by Down's process. This involves the electrolysis of fused NaCl and $CaCl_2$ at 873K. During electrolysis sodium is discharged at the cathode and Cl_2 is obtained at the anode.

$$NaCl_{(l)} \longrightarrow Na^{+}_{(melt)} + Cl^{-}_{(melt)}$$

Cathode: $Na^{+}_{(melt} + e^{-} \longrightarrow Na_{(s)}$

Anode : $2Cl^{-}_{(aq)} \longrightarrow Cl_{2(g)} + 2e^{-}$

If an aqueous solution of NaCl is electrolysed, H_2 is evolved at cathode and Cl_2 is evolved at anode. NaOH is obtained in the solution.

$NaCl_{(aq)}$ Electrolysis $\longrightarrow$ $Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

Cathode: $2H_2O_{(l)} + 2e^{-} \longrightarrow H_{2(g)} + 2OH^{-}_{(aq)}$

Anode : $Cl^{-}_{(aq)} \longrightarrow 12Cl_{2(g)} + 2e^{-}$

Na^{+} and OH^{-} ions to form NaOH .

Hence solution is basic in nature.

V. ADDITIONAL QUESTIONS AND ANSWERS

1. What is concentration of ores?

The removal of non-metallic impurities, rocky materials and siliceous matter (gangue) from the ores.

2. What is leaching?

In this method crushed ore is allowed to dissolve in a suitable solvent to form a soluble metal salt or complex leaving the gangue undissolved is called leaching.

3. What is ammonia leaching?

Crushed ore containing nickel, copper and cobalt is treated with aqueous ammonia under suitable pressure.

Ammonia selectively leaches these metals by forming their soluble complexes namely $[Ni(NH_3)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$ and $[Co(NH_3)_5H_2O]^{3+}$ from the ore.

The gangue left behind are iron (III) oxides / hydroxides and alumino silicate.

4. What is acid leaching?

Sulphide ores ZnS, PbS can be leached with hot aqueous sulphuric acid.

In this process the insoluble sulphide is converted into soluble sulphate and elemental sulphur.

$$2ZnS_{(s)} + 2H_2SO_{4(aq)} + O_{2(g)} \longrightarrow 2ZnSO_{4(aq)} + 2S_{(s)} + 2H_2O$$

5. What are the steps involved in the extraction of crude metal?

1.Conversion of the ore into metal oxide either by roasting or calcination.

2.Reduction of the metal oxide into metal.

6. In the extraction of metal, ore is first converted into metal oxide before reduction into metal. Why?

In the concentrated ore the metal exists in positive oxidation state and hence it is to be reduced to elemental state.

From the principles of thermodynamics, the reduction of oxide is easier compared to the reduction of other compounds of metal.

Hence before reduction the ore is first converted into metal oxide.

7. Write about the extraction of metal by the process of reduction by hydrogen.

This method can be applied to the oxides of the metals (Fe, Pb, Cu) which are less electropositive than H.

$$Ag_2O_{(s)} + H_{2(g)} \longrightarrow Ag_{(s)} + H_2O_{(l)}\uparrow$$

Nickel oxide is reduced to nickel by a mixture of hydrogen and carbon monoxide(water gas)

$2NiO_{(s)} + CO_{(g)} + H_{2(g)} \longrightarrow 2Ni_{(s)} + CO_{2(g)} + H_2O_{(l)}\uparrow$

8. What is auto reduction of metallic ores?

Simple roasting of some of the metallic ores give the crude metal.

Use of reducing agent is not necessary because of low thermal stability

(eg) Cinnabar is roasted to give mercury.

$HgS_{(s)} + O_{2(g)} \rightarrow Hg_{(l)} + SO_{2(g)}\uparrow$

9. Write the applications of copper.

1. Copper is the first metal used by humans and extended use of its alloy bronze resulted in a new era, 'Bronze age'.

2.Used for making coins and ornaments along with gold and other metals.

3.Copper and its alloys are used for making wires, water pipes and other electrical parts.

10. Write the applications of gold.

1. Gold is one of the expensive and precious metals.
2. Used for coinage and has been used as standard for monetary systems in some countries.
3. Extensively used in jewellery in its alloy form with copper.
4. Used in electroplating to cover other metals with a thin layer of gold, which are used in watches, artificial limb joints, cheap jewellery, dental fillings and electrical connectors.
5. Gold nanoparticles are used for increasing the efficiency of solar cells.
6. Used as a catalyst.

11. Write about alumino thermite process.

In this method a metal oxide such as Cr_2O_3 is reduced to metal by aluminium.

Metal oxide (Cr_2O_3) is mixed with aluminium powder in a fire clay crucible. The reduction process is initiated by ignition mixture of Magnesium power and barium peroxide.

$BaO_2 + Mg \rightarrow BaO + MgO$

It is an exothermic process where heat is liberated.

Temperature = 2400^{o}C Heat liberated = 852kJmol^{-1}.This heat initiate the reduction of Cr_2O_3 by Al.

$Cr_2O_3 + 2Al \longrightarrow 2Cr + Al_2O_3$

12. What is refining process of a metal?

Metals extracted from its ore contains impurities such as unreacted oxide ore, other metals, non metals etc,. Removal of such impurities from crude metal is known as refining process of a metal.

13. Write about distillation process of refining a metal?

This method is used for low boiling volatile metals like zinc and mercury. In this method impure metal is heated to evaporate and the vapours are condensed to get pure metal.

14. Write about liquation process of refining a metal?

This method is used to remove the impurities with high melting points from metals having relatively low melting points.(eg) Tin, lead, mercury, bismuth.

The impure metal is placed on sloping hearth of a reverberatory furnace and it is heated just above the melting point of the metal in the absence of air, the molten metal flows down and impurities are left behind .The molten metal is collected and solidified.

15. Give example for the following

1. Frothing agent 2. Collector 3.Depressing agent

Frothing agent :Pine oil , eucalyptus oil

Collector :Sodium ethyl xanthate

Depressing agent :Sodium cyanide , sodium carbonate

16. What is cementation ?

Gold can be recovered by reacting the deoxygenated leached solution with Zinc. In this process Gold is reduced to its elemental state (zero oxidation state) and the process is called cementation

$Zn_{(S)} + 2[Au(CN)_2]^-_{(aq)} \rightarrow [Zn(CN)_4]^{2-}_{(aq)} + 2Au_{(S)}$

17. Why Fe, Pb , Cu are reduced by hydrogen ?

The oxides of metal Fe ,Pb , Cu having less electropositive character than hydrogen , these metal oxide can be reduced by hydrogen.

$Ag_2O_{(S)} + H_{2(g)} \longrightarrow Ag_{(S)} + H_2O_{(l)}$

$Fe_2O_{3(S)} + 4H_{2(g)} \longrightarrow 4Fe_{(S)} + 4H_2O_{(l)}$

18. Write about separation or hydraulic wash?

Ore with high specific gravity is separated from gaugue with low specific gravity by simply washing with running water.

Finely powdered ore is treated with rapidly flowing current of water.

Lighter gaugue particles are washed away by the running water.

This method is used for concentrating native ore such as gold and oxide ores such as haematite (Fe_2O_3), tin stone(SnO_2).

19. Write about magnetic separation.

This method is applicable to ferromagnetic ores.

It is based on the difference in the magnetic properties of the ore and the impurities.

Non-magnetic tin stone can be separated from the magnetic impurities wolframite.

Similarly magnetic ores chromite, pyrolusite can be removed from non magnetic siliceous impurities.

The crushed ore is poured to an electromagnetic separator with a belt moving over two rollers of which one is magnetic.

Magnetic part of the ore is attached towards the magnet and falls as a heap close to the magnetic region.

Non- magnetic part falls away from it.

20. Write about calcination.

Calcination is the process in which the concentrated ore is strongly heated in the absence of air.

During this process water of crystallisation present in the hydrated oxide escapes as moisture.

This method can also be carried out with a limited supply of air.

During calcination of carbonate ore is decomposed to metal oxide and carbon dioxide is liberated.

$PbCO_3 \longrightarrow PbO + CO_2\uparrow$

$CaCO_3 \longrightarrow CaO + CO_2\uparrow$

$Al_2O_3.2H_2O \longrightarrow Al_2O_{3(s)} + 2H_2O_{(g)}\uparrow$

21. Write about Van – Arkel method for refining zirconium/titanium?

This method is based on the thermal decomposition of gaseous metal compounds to metals.(eg) Titanium and Zirconium.

Impure titanium is heated in an evacuated vessel with iodine at 550K to form volatile titanium tetra iodide.

The impurities do not react with iodine.

$Ti(s) + 2I_2(s) \xrightarrow{550\ K} TiI_4(vapour)$

Volatile titanium tetraiodide is passed over a tungsten filament at 1800K.

Titanium tetraiodide is decomposed to pure titanium which is deposited over the filament.Iodine is reused.

$TiI_{4(vapour)} \xrightarrow{1800\ K} Ti_{(s)} + 2I_{2(s)}$

22. What is Vapour phase method ?

The impure metal is treated with a suitable reagent which can form a volatile compound with the metal. Then the volatile compound is decomposed to give the pure metal.

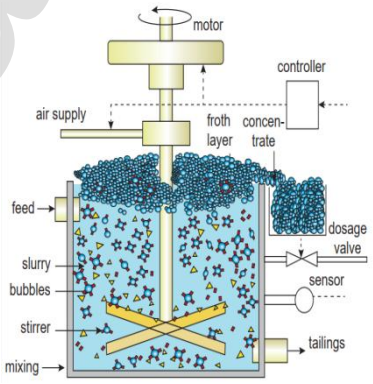
23. Write the applications of aluminium.

1. Used for making heat exchangers/sinks.
2. Used for making our day to day cooking vessels.
3. Used for making aluminium foils for packing, food items.
4. Alloys of aluminium with copper, manganese, magnesium, silicon are light weight and strong hence used in design of aeroplanes and other forms of transport.
5. Due to its high resistance to corrosion, it is used in the design of chemical reactors, medical equipment's, refrigeration units and gas pipelines.
6. It is a good electrical conductor and cheap.

24. Write the applications of iron.

1. Iron and its alloys are used as bridges, electricity pylons, bicycle chains, cutting tools and rifle barrels.
2. Cast iron is used to make pipes, valves and pump stoves etc.
3. Magnets can be made from iron , its alloys and compounds.
4. Important alloy of iron is stainless steel which is very resistant to corrosion.
5. It is used in architecture, bearings, cutlery, surgical instruments and jewellery.
6. Nickel steel is used for making cables, automobiles, and aeroplane parts.
7. Chrome steels are used for manufacturing cutting tools and crushing machines.

25. Explain froth floatation method.



This is used to concentrate sulphide ores such as galena (PbS) Zinc blende (ZnS) etc.
Metallic ore particles preferentially wetted by oil can be separated from gangue.
Crushed ore is mixed with water and a frothing agent like pine oil or eucalyptus oil.
A small amount of sodium ethyl xanthate is added as a collector.
A froth is formed by blowing air through the mixture.
The collector molecules attach to the ore particles and make them water repellent.
As a result ore particles wetted by the oil rise to the surface along with the froth.
The froth is skimmed off and dried to recover the concentrated ore.
Gangue particles preferentially wetted by water settle at the bottom.
When sulphide ore contains other metal sulphides as impurities, depressing agents such as sodium cyanide, sodium carbonate etc. are used to selectively prevent other from coming to the froth.

For example ,

When impurities such as ZnS is present in Galena (PbS) , Sodium cyanide NaCN is added to depresses the flotation property of ZnS) by forming a layer of zinc complex $Na_2[Zn(CN)_4]$ on the surface of ZnS.

S.JOSEPH SURESH , M.Sc.,M.Ed., PG ASST CHEMISTRY, DINDIGUL. 9994342531