
VJ
+2
CHEMISTRY
A COMPLETE GUIDE
BOOK BACK
ONE MARKS
SHORT ANSWERS
LONG ANSWER
ADDITIONAL QUESTIONS
TOPIC WISE Q/A
PTA QUESTIONS
PUBLIC EXAM Q/A
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+2

CHEMISTRY

A COMPLETE GUIDE

- *BOOK BACK*
- *PTA QUESTIONS*
- *PUBLIC QUESTIONS*
- *CREATIVE QUSTIONS*

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Dear students!

- ***VJ*** *11th std chemistry 1 ,2 , 3 & 5 marks questions has been thoroughly revised and updated as per the new syllabus.*
- *This book provides complete tutorial to students in such a way that they can confidently all questions in their examination.*
- *This booklet series is prepared effectively keeping in mind the scoring aspects of the students.*
- *We wish the student to score high marks using this 1 , 2 ,3 & 5 marks question of booklet.*

CONTENT

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PG ASSISTANT IN CHEMISTRY

+2 CHEMISTRY PUBLIC EXAM QUESTION BANK

	MARCH 2020					JULY 2020					SEPTEMBER 2020					AUGUEST 2021					May -2022				
Ln	1 M	2 M	3 M	5M	T	1 M	2 M	3 M	5M	T	1 M	2 M	3 M	5M	T	1 M	2 M	3 M	5M	T	1 M	2 M	3 M	5M	T
1	1			1(5)	6	1	1	1		6	2	1		1(2)	6	1			1(5)	6	1	1		1(2) 1(3)	8
2	1		1 C	1(2)	6	1	1 C		1(3)	6	1		1	1(2)	6	1	1	1		6	1			1 (3)	4
3	1	1		1(3) 1(3)	9	1		1	1(3) 1(2)	9	1	1		1(3) 1(3)	9	1		1	1(3) 1(2)	9	1		1	1(2) 1(3)	9
4	1	1	1		6	-			1(5)	5	1	1	1		6		1		1(3) 1(2)	7	1	1	1		6
5	-	1	1	1(2) 1(3)	10	2	1	1	1(2)	9	1		1	1(5)	9	1		1	1(2) 1(3)	9	1	1	1 C	1(5)	10
6	1	1		12)	5	1		1	1(2)	6	1	1		1(3)	6	1	1	1 1 C		9	1	1		1(5)	8
7	1			1(5)	6	-		1 C	1(3) P RO	6	1	1		1(2)	5	1			1(2) 1(3)	6	1	1	1		6
8	1	1	1	1(2)	8	1	2	1	1(2)	10	1	1	1	1(3)	9	1	1		1(5) P RO	8	1	1		1(2) 1(3)	8
9	2		1	1(3) P RO	8	1			1(5)	6			1 C P	1(5)	8	1	2	1		8	1		1	1(5)	9
10	-	1	1	1(3)	8	-	1		1(5)	7	1		1	1(2) 1(2)	8	2	1		1(5)	9	2	1	1	1(5)	12
11	2	1 C		1(2) 1(3)	9	2		1	1(5)	10	1	1		1(3) 1(2)	8	1		1	1(2) 1(3)	9	1	1	1		6
12	1	1	1	1(2)	8	1	1	1	1(3) 1(2)	11	1		1	1(5) Me	9	2		1	1(5)	10	1		1	1(5)	9
13	1	1		1(2) 1(3)	8	1	1	1		6	1	1		1(3) 1(2)	8	1	1 C		1(5) P RO	8	1	1 C		1(2) 1(3)	8
14	1		1	1(3)	7	2	1		1(3)	7	1	1	1		6	1	1	1		6	1		1		4
15	1		1	1(2)	6	1			1(3) 1(2)	6	1		1	1(3)	7	-	-	-	-	-	-	-	-	-	-
	15	9	9	50	110	15	9	9	50	110	15	9	9	50	110	15	9	9	50	110	15	9	9	50	110

	Inorganic unit – 1, 2 ,3 , 4 ,5		Physical unit – 6 , 7 , 8 , 9 , 10		Organic unit – 11 , 12 , 13 , 14,15	
Part (I) 1 M	5 x 1	5	5 x 1	5	5 x 1	5
Part (II) 2 M	3 x 2	6	3 x 2	6	3 x 2	6
Part (III) 3 M	3 x 3	9	3 x 3	9	3 x 3	9
Part (IV) 5 M	3 x 5	15	3 x 5	15	4 x 5	20
Total marks	35		35		40	

UNIT – 1 METALLURGY

CHOOSE THE CORRECT ANSWER: [BOOK BACK]

1. Bauxite has the composition **(May-2022)**

   a) Al_2O_3 **b) $Al_2O_3.nH_2O$** 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-Herold 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^o of sulphide is greater than those for CS_2 and H_2S .

   b) ΔG_r^o 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 - 2	
A	Cyanide process	I	Ultrapure Ge
B	Froth flotation process	ii	Dressing of ZnS
C	Electrolytic refining	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 **(PTA-2 , Mar -2020)**

   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 **(July-2022)**

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 **(J-2020)**

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?

a) Fe b) Cu **c) Mg** d) Zn

17. The following set of reactions are used in refining Zirconium

$Zr(Impure) + 2I_2 \xrightarrow{523\ K} ZrI_4$: $ZrI_4 \xrightarrow{1800\ K} Zr(\ Pure) + 2I_2$

This method is known as **(PTA-5 , Aug -2021)**

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 **(J-2020)**

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^o Vs T** c) ΔG^o Vs 1 / T is negative d) ΔG^o Vs T^2 is negative

22. In the Ellingham diagram, for the formation of carbon monoxide

a) $\Delta S^o/\Delta T$ is negative b) $\Delta G^o/\Delta T$ is positive

c) $\Delta G^o/\Delta T$ is negative d) Initially $\Delta T/\ \Delta G^o$ is positive, after 700°C, $\Delta G^o\ /\Delta T$ is negative

23. Which of the following reduction is not thermodynamically feasible? **(PTA-3)**

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 CO_2 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.

PTA & YEAR WISE QUESTIONS

1. Elements like Silicon and Germanium to be used as a semiconductor is purified by **(PTA-1)**
   a) Heating under vaccum b) Van-Arkel method **c) Zone refining** d) Electrolysis
2. The process of converting hydrated alumina into anhydrous alumina is called **(PTA-6)**
   a) Roasting b) Smelting c) Auto-reduction **d) Calcination**
3. Sulphide ores of metals are usually concentrated by froth flotation process. Which one of the following sulphide ores offer an exception and is concentrated by chemical leaching? **(PTA-4)**
   a) Galena b) Copper pyrites c) sphalerite **d) Argentite**
4. The metal which is used in packing material for food items **(July-2020)**
   a) Zn b) Zr **c) Al** d) Au

Text Book Exercise Questions and Answers

1. What is the difference between minerals and ores? (Q-19, June 20 , May 22)

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 and China clay	Ore of Al is Bauxite

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? (Sep-2020)

- Lime stone (CaO) is used as a basic flux in the extraction of iron from its oxide Fe_2O_3.
- Flux is a chemical substance that forms an easily fusible slag with gangue
- In this extraction, a basic flux, limestone (CaO) is used. Since the silica gangue present in the ore is acidic in nature, the limestone combines with it to form calcium silicate (slag).

$$\underset{\text{Flux}}{CaO_{(s)}} + \underset{\text{Gangue}}{SiO_{2(s)}} \longrightarrow \underset{\text{Slag}}{CaSiO_{3(s)}}$$

4. **Which type of ores can be concentrated by froth flotation method? Give two examples for such ores. (Sep-2020)**
   - ❖ Sulphide ores can be concentrated by froth flotation method.
   - ❖ Examples : 1) Galena (PbS) 2) Zinc blende (ZnS)
5. **Describe a method for refining nickel. (PTA – 3, May – 22)**
   - ❖ 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, the complex decomposes to give pure nickel.

     $Ni[CO]_{4\ (g)} \xrightarrow{460\ K} Ni_{(s)} + 4CO_{(g)}$
6. **Explain zone refining process with an example ,(PTA -6 , march -2020)**

Principle of Zone refining: Fractional crystallization.

- ❖ When an impure metal is melted and allowed to solidify, the impurities will prefer to remain in the molten region. ie; impurities are more soluble in the melt than in the solid state metal.

Explanation:

- ❖ In this 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 crystallizes 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.
- ❖ **Examples:** Germanium, Silicon and gallium which are used as semiconductor are refined by this process.

7. **Using the Ellingham diagram given below. (A) Predict the conditions under which**

   i) Aluminium might be expected to reduce magnesia.
   - ❖ In the Ellingham diagram, above 1623 K, the ΔG^0 value for Al_2O_3 is more negative than that of MgO. Thus ΔG^0 of the reaction is negative.
   - ❖ Therefore above 1623 K , A*l* can reduce MgO to Mg

   $3\ MgO + 2Al \xrightarrow{1623\ K} Al_2O_3 + 3Mg$

   ii) Magnesium could alumina.
   - ❖ In Ellingham diagram, below 1623K the ΔG^0 value of Al_2O_3 is less negative than that of MgO. Thus ΔG^0 of the reaction is negative.
   - ❖ Therefore below 1623 K , Mg can reduce Al_2O_3 to A*l*

   $Al_2O_3 + 3\ Mg \xrightarrow{below\ 1623\ K} 3\ MgO + 2\ Al$

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

- Yes, it is possible to reduce Fe_2O_3 by coke at a temperature around 1200 K. Ellingham diagram for the formation of Fe_2O_3 and CO intersects around 1000 K.
- Below this temperature, the carbon line lies above the iron line which indicates that Fe_2O_3 is more stable than CO and hence at this temperature range the reduction is not thermodynamically feasible.
- However above 1000 K carbon line lies below the iron line and hence we can use coke as a reducing agent around 1200 K. Around 1200 K, coke is better reducing agent because above 1000 K, Gibb's free energy for the formation of Fe_2O_3 is more than the formation of CO_2 from C.

(or)

- 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.

8. Give uses of zinc.

- It is used in galvanization to protect iron and steel structures from rusting and corrosion.
- It is used to produce die - castings in the automobile, electrical and hardware industries.
- Zinc oxide is used in the manufacture of paints, rubber, cosmetics, pharmaceuticals, plastics, inks, batteries, textiles and electrical equipment.
- Zinc sulphide is used in making luminous paints, fluorescent lights and x - ray screens.

9. 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
Ionization of Alumina	$Al_2O_3 \rightarrow 2Al^{3+} + 3O^{2-}$
Reaction at cathode	$2Al^{3+}(melt) + 6e^- \rightarrow 2Al(l)$
Reaction at anode	$6O^{2-}(melt) \rightarrow 3O_2 + 12e^-$

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

$$C(s) + O^{2-}(melt) \rightarrow CO + 2e^-$$

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

- 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

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

10. Explain the following terms with suitable examples. i) Gangue ii) Slag (PTA-2 , June 2020)

i) Gangue:

- The non metallic impurities, rocky materials and siliceous matter present in the ores are called gangue.
- **Example :** 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.
- **Examples :** $CaO_{(s)}$ (Flux) + $SiO_{2(s)}$ (gangue) $\rightarrow$ $CaSiO_{3(s)}$ (slag)

11. Give the basic requirement for vapour phase refining.

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

ii. Then the volatile compound is decomposed to give the pure metal.

12. Describe the role of the following in the process mentioned. (Q-19)

i) Silica in the extraction of copper.

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

$$FeO_{(s)} + SiO_{2(s)} \rightarrow FeSiO_{3(s)}$$
(Flux) (Slag)

ii) Cryolite in the extraction of aluminium.

- The melting point of alumina is very high. Hence it is mixed with cryolite (Na_3AlF_6) , which lowers its melting point.
- Cryolite increases the electrical conductivity of alumina.
- The function of cryolite is to lower the fusion temperature.

iii) Iodine in the refining of Zirconium.

- 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.

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

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

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

iv) Sodium cyanide in froth floatation.

- Sodium cyanide acts as a depressing agent in froth floatation process.
- 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.

$$4\,NaCN + ZnS \rightarrow Na_2[\,Zn(CN)_4\,] + Na_2S$$

13. Explain the principle of electrolytic refining with an example. (J – 22)

- Less electro positive impurities in the anode settle down as anode mud.

  eg : 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 migrate towards the cathode. At cathode silver ions get discharged by gaining electrons and deposited on the cathode.

14. 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.
- Hence the reducing agent is selected in such a way that it provides a large negative ΔG value for the coupled reaction.
- Ellingham diagram is used to predict thermodynamic feasibility of reduction of oxides of one metal by another metal.
- **For example :** 1) Above 1623 K , Al has more negative ΔG^{o} value than Mg

  2) Hence Al is used to reduce magnesia 3) Below 1623 K , Mg more negative ΔG^{o} value than Al

  4) Hence Mg is used to reduce Al

15. 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. Moreover 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.

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

- 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 $\Delta G^{o} = - nFE^{o}$

  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: $Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$
- Zinc is more reactive than copper and displaces copper from its salt solution.

III. 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)

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

     $Ag \rightarrow Ag^+$ 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)

     $MgCO_3 \rightarrow MgO + CO_2\uparrow$
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 1200K 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 1200K carbon line lies below the zinc line, hence carbon can be used as a reducing agent above 1200K.

     $2Zn + O_2 \rightarrow 2ZnO$ 1

     $2C + O_2 \rightarrow 2CO$ 2
   - Reversing 1 and adding with equation 2

     $2ZnO \rightarrow 2Zn + O_2$

     $2C + O_2 \rightarrow 2CO$

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

4. Metallic Sodium is extracted by the electrolysis of brine (aq.NaCl). After electrolysis the 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.

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

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

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

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

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

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

Anode: $Cl^{-}(aq) \rightarrow \frac{1}{2} Cl_{2(g)} + 2e^{-}$

- Na^{+} and OH^{-} ions to form NaOH .Hence solution is basic in nature.

ADDITIONAL QUESTIONS: ONE MARKS

1. The element which occur in native state is
   a) Iron b) Nickel **c) Gold** d) Manganese
2. The element which always in combined state is
   a) Gold b) Silver c) Platinum **d) sodium**
3. The element which presents small amount in naturally occurring substance is
   a) Ores **b) Mineral** c) Flux d) Slag
4. Which of the following is not a mineral of aluminium?
   a) Bauxite b) Cryolite c) China clay **d) Malachite**
5. Which of the following mineral contains calcium as well as magnesium?
   a) Zinc blende b) Aragonite c) **Dolomite** d) Carnalite
6. Malachite has _____ composition.
   a) $2CuCO_3.Cu(OH)_2$ **b) $CuCO_3Cu(OH)_2$** c) Cu_2O d) Cu_2S
7. Magnesite is _____
   a) magnesium oxide **b) magnesium carbonate** c) magnesium sulphate d) magnesium chloride
8. Find the odd one out a) Sphalerite b) Galena **c) Azurite** d) Iron pyrite
9. Which of the follwing is not an oxide ore?
   a) Cuprite **b) Siderite** c) Cassiterite d) Zincite
10. Which of the following is an oxide ore?
    a) Sphaelerite b) Calamine **c) Cassiterite** d) Stefinite
11. Which of the following is not a sulphide ore?
    a) Stefinite b) Argentite **c) Cerrusite** d) Sphaelerite

12. Which of the following is a sulphide ore?

a) Pyrargyrite b) Malachite c) Limonite d) Kaolinite

13. Which of the following is not a carbonate ore?

a) Siderite b) Calamine **c) Cerrusite** d) Cassiterite

14. Which of the following is a carbonate ore?

a) Limonite **b) Siderite** c) Magnetite d) Haematite

15. Which of the following is the ore of iron?

a) Limonite b) Azurite c) Stefinite d) Cerrusite

16. Which of the following is not an ore of iron?

a) Haematite b) Magnetite c) Siderite **d) Anglesite**

17. Which of the following is an ore of silver?

a) Azurite **b) Prousitite** c) Cerrusite d) Limonite

18. Which of the following is a sulphate ore?

a) Galena b) Zinc blende c) Cerrusite **d) Anglesite**

19. Match the following

	Ore		Composition
A	Galena	1	$Al_2Si_2O_5(OH)_4$
B	Kaolinite	2	PbS
C	Magnetite	3	Ag_2S
D	Argentite	4	Fe_3O_4

	A	B	C	D
a)	1	3	4	2
b)	**2**	**1**	**4**	**3**
c)	2	4	1	3
d)	4	1	3	2

20. Match the following

	Ore		Composition
A	Limonite	1	Pb
B	Cerrusite	2	Fe
C	Cassiterite	3	Cu
D	Malachite	4	Sn

	A	B	C	D
a)	1	3	4	2
b)	**2**	**1**	**4**	**3**
c)	2	4	1	3
d)	4	1	3	2

21. Identify the halide ore among the following .

a) Epsom salt b) Pyrolusite c) Anglesite **d) Rock salt**

22. Which of the following is a mineral of iron?

a) pyrolusite b) Cassiterite c) Malachite **d) Magnetite**

23. Sulphide ores are common for the metals

a) Ag , Cu and Pb b) Ag , Cu and Sn c) Ag , Mg and Pb d) Al , Cu and Pb

24. Oxide ores are concentrated by

a) hand picking **b) hydraulic washing**

c) froth floatation d) magnetic separation process

25. The process of removal of gangue material from ore is known as

a) **Concentration** b) roasting c) calcination d) smelting

26. The native ore is concentrated by

a) **Gravity separation** b)) froth floatation c) magnetic separation d) leaching process

27. The correct statement among the following is

a) Metals having more chemical reactivity occur as native elements.

b) Removal of gangue from ores is called refining.

c) Tin stone ore is concentrated by gravity separation.

d) Silver glance is a carbonate ore.

28. In the froth-floatation process the collectors such as pine oil and xanthates, etc enhances.

a)Non –wettability of the mineral particles in froth

b)Non –wettability of the mineral particles in water

c)Non –wettability of the gangue particles in froth

d)Non –wettability of the gangue particles in water.

29. Concentration of copper glance is done by

a) leaching b) magnetic separation **c) froth flotation** d) hydraulic washing

30. $Na[Ag(CN)_2]$ is _____.

a)Sodium aurocyanide b)Sodium meta aluminate

c)Aluminosilicate d)**Sodium dicyano argentate**

31. Froth flotation process is suitable for concentrating _____ore.

a)Oxide b)Carbonate c)**Sulphide** d)Halide

32. In froth floatation sodium ethyl Xanthate is used as a

a) Collector b) depressing agent c) frothing agent d) Flux

33. The complex formed when NaCN is added to galena in which ZnS is the impurity

a) $2Na[Zn(CN)_4]$ **b) $Na_2[Zn(CN)_4]$** c) $2Zn[Na(CN)_2]$ d) $Na_4[Zn(CN)_4]$

34. In the froth floatation process for the purification of ores the particles that because

a) they are light **b) their surface is not easily wetted by water**

c) they bear electrostatic charge d) they are insoluble

35. Froth flotation process is applicable for

a) oxide ores b) carbonate ores c) chloride ores **d) sulphide ores**

36. Depressing agents used to separate ZnS from PbS is

a) NaCN b) NaCl c) $NaNO_3$ d) $NaNO_2$

37. The correct statement among the following is

a) In froth floatation sodium ethyl xanthate acts as a collector.

b) In leaching the ore is converted into insoluble salt or complex and the gangue remains in the solution.

c) Ammonia leaching is suitable for gold and silver.

d) Bauxite ore is subjected to acid leaching .

38. The method of concentration based on the solubility of the ore in a suitable solvent is

a) Gravity separation b)) froth floatation c) magnetic separation d) **leaching**

39. In acid leaching process, the insoluble sulphide is converted into soluble sulphate and elemental—---

a) Carbon b) Lead **c)Sulphur** d)Zinc

40. Sodium cyanide solution is used to extract_____ from its ores.

a)Copper b)Silver c)Gold d)**Both (b) and (c)**

41. The process of Gold is reduced to its elemental state (Zero oxidation state) is called

a) oxidation **b) cementation** c) galvanization d) smelting

42. Which of the following ores undergoing Ammonia leaching process ?

a) Ni, Cu, CO b) Fe , Cu, Co c) Zn, Cu, Al d) Hg, Zn, Al

43. Leaching process is a a) reduction b) dehydration **c) redox reaction** d) dehydrogenation

44. Which type of leaching process convert insoluble sulphide ore into soluble sulphates?

a) cyanide leaching b) alkali leaching **c) acid leaching** d) hand picking

45. Sulphide ores of metals are usually concentrated by froth floatation process. Which one of the following sulphide ores offer an exception and is concentrated by chemical leaching?

a) Galena b) Copper pyrite c) Sphalerite **d) Argentite**

46. Magnetic separation it is based on the difference in the _____of the ore and the impurities.

a) Magnetic properties b) Chemical properties c) Physical properties d) Melting point

47. Tin stone , Chromite and Pyrolusite are concentrated by ---------- process.

a) Gravity separation b) Hydraulic wash c) Froth flotation **d) Magnetic separation**

48. Wolframite ore consists of a) Zn **b) W** c) Au d) Hg

49. The process of heating of copper pyrites to remove sulphur is called

a)froth flotation **b)roasting** c)calcination d)smelting

50. Among the following, one does not belong to calcination. Pick the odd one out.

a) $PbCO_3 \xrightarrow{\Delta} PbO+CO_2$ b) $CaCO_3 \xrightarrow{\Delta} CaO+CO_2$

c) $PbSO_3 \xrightarrow{\Delta} PbO+2SO_2$ d) $ZnCO_3 \xrightarrow{\Delta} ZnO+CO_2$

51. Sulphide ore is converted to oxide form by using the process _____

a) Calcination **b) Roasting** c) Smelting d) Leaching

52. The process of ore into metal oxide with absence of air is called ---------

a) Oxidation b) Cementation c) Galvanization **d) Calcination**

53. Process followed before reduction of carbonate ore is

a) calcination b) roasting c) liquation d) polling

54. Calcination is the process in which :

a) ore is heated above its melting point to expel H_2O or CO_2 or SO_2

b) ore is heated below its melting point to expel volatile impurities

c) ore is heated above its melting point to remove S, As and Sb as SO_2 ,As_2O_3 and Sb_2O_3 respectively

d) ore is heated below its melting point to expel H_2O or CO_2

55. Roasting is generally done in case of the

a) oxide ores b) silicate ores **c) sulphide ores** d) carbonate ores

56. Heating of pyrites in air for oxidation of sulphur is called

a) roasting b) calcination c) smelting d) slagging

57. The role of calcination in metallurgical operations is

a) to remove moisture b) to decompose carbonates

c) to drive off organic matter d) to decompose carbonates and drive off moisture and organic matter

58. Heating of carbonates ores to remove carbon is called

a) roasting b) calcination c) smelting d) fluxing

59. Which oxides will decompose on heating even in the absence of a reducing agent.

a) Ag_2O, HgO b) FeO, CaO c) SiO_2, FeO d) MgO, HgO

60. Which is the correct order of reactivity of metals

a) Zn > Cu < Ag b) Zn < Cu < Ag c) Cu > Zn < Ag **d) Zn > Cu > Ag**

61. In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduction of cuprous oxide with

a) Iron sulphide(FeS) b)Carbon monoxide(CO)

c) Copper (I)sulphide (Cu_2S) d)Sulphur dioxide (SO_2)

62. In the metallurgy of iron, limestone is added to coke .which acts as a_____

a) reducing agent b)oxidizing agent c)slag d)**Flux.**

63. Metal oxide is converted into metal by the _____process

a)Calcination b)Roasting c)**Smelting** d)Bessemerisation .

64. In a metallurgical process , an acid flux is used for removing

a) slag b) basic flux c) acidic gangue **d) basic gangue**

65. Zinc is extracted from zinc blende by_____

a) Carbon reduction process b) Nitrogen reduction process

c) Oxygen reduction process d) All of these.

66. Metals which do not form carbides with carbon at reduction temperature can be extracted from their oxides by

a) Reduction by metal b) Reduction by hydrogen

c) Reduction by carbon d) Auto reduction

67. Aluminothermic process is used for the extraction of metals, whose oxides are

a) fusible **b) not easily reduced by carbon**

c) not easily reduced by hydrogen d) strongly basic

68. Ignition mixture used in aluminothermic process is

a) $Cr+Al_2O_3$ **b)$Mg+BaO_2$** c)$Al+Cr_2O_3$ d) Ba+MgO

69. Cr_2O_3 can be reduced by

a) Aluminothermic process b) Mond's process

c) Cyande process d) hydrogen reduction

70. Aluminium is extracted from alumina (Al_2O_3) by electrolysis of a molten mixture of

a) $Al_2O_3 + KF + Na_3AlF_6$ b) $Al_2O_3 + HF + NaAlF_4$

c) $Al_2O_3 + CaF_2 + NaAlF_4$ **d) $Al_2O_3 + Na_3AlF_6 + CaF_2$**

71. Which of the following will give respective metal by self- reduction?

a) galena(Pbs) b)HgS c)ZnS **d)both (a)and(b)**

72. Which of the following is used as acidic flux?

a) FeO b) CaO **c) SiO_2** d) $FeSiO_3$

73. Which of the following is used as basic flux?

a) FeO **b) CaO** c) SiO_2 d) $FeSiO_3$

74. The correct statement among the following is

a) Calcination is the process in which concentrated ore is strongly heated in the presence of air.

b) Flux is a chemical substance that forms an easily fusible slag with gangue.

c) In aluminothermite process the ignition mixture used is magnesium peroxide and barium.

d) Any metal can reduce the oxides of other metals that are located below it in Ellingham diagram.

75. Thermodynamically the reduction of metal oxide with a given reducing agent can occur if the free energy change for the coupled reaction is

a) Positive **b) Negative** c) One d) Zero

76. Elingham diagram helps to select

a) suitable reducing agent b) appropriate temperature **c) both (a) and (b)** d) oxidizing agent

77. For the reduction of metal oxide into metal a reducing agent is selected in such a way that for the coupled reaction it provides a

a) Large positive ΔG value b) Small positive Δ G value

c) Large negative Δ G value d) Small negative ΔG value

78. In Ellingham diagram, for most of the metal oxide formation the slope is

a) Positive b) Negative c) Zero d) One

79. In Ellingham diagram as temperature increases, generally ΔG value for the formation of the metal oxide become

a) Less positive b) More positive **c) Less negative** d) More negative

80. Gibb's free energy is given by _____

a) $\Delta G^0 = -nFE^0$ b) $\Delta G^0 = nF$ c) $\Delta G^0 = nFE^0$ d) $\Delta E^0 = -nFG^0$

81. In Hall-Herold process, _____act as an anode.

a)Carbon blocks **b)** Hydrogen c)Copper rods d)Zinc rods

82. If the e.m.f of the net redox reaction is positive, its ΔG is

a) Positive **b) Negative** c) Zero d) One

83. In Hall – Herold process calcium chloride helps to

a) increase the melting point **b) decrease the melting point**

c) maintain the temperature d) increase the boiling point

84. Which is not refined by liquation? a) Tin **b) Zinc** c) Lead d) Bismuth

85. Metals having low melting points such as tin, lead, mercury and bismuth are refined by

a) Distillation **b) Liquation** c) Electrolytic d) Zone refining

86. Zone refining is based on

a) fractional distillation b) simple distillation c) sublimation **d) fractional crystallization**

87. Semi conductors are purified by method _____

a) Zone refining b) Electrolytic refining c) Mond's process d) Bessemerisation

88. Ge, Si, Ga are the semi conductor metals are refined by ---------- process

a) Zone refining b) Hydraulic wash c) Aluminothermic d) Magnetic separation

89. 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.

90. Which of the following pairs of metals is purified by van Arkel method?

a) Ga and In **b) Zr and Ti** c) Ag and Au d) Ni and Fe

91. The method of zone refining of metals is based on the principle of

a) greater mobility of the pure metal than that of the impurity

b) higher melting point of the impurity than that of the pure metal

c) greater noble character of the solid metal than that of the impurity

d) greater solubility of the impurity in the molten state than in the solid.

92. The correct statement among the following is

a) In electro refining pure metal is taken as anode and impure metal is taken as cathode.

b) Distillation is employed for high boiling non volatile metals.

c) Zone refining is based on the principle of fractional crystallisation.

d) Mond's process is used for refining titanium.

93. 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

94. Which is used for increasing the efficiency of solar cells?

a) Brass b) Zinc sulphide c) Cast iron **d) Gold nanoparticles**

95. Which one is used in the manufacture of many products such as paints, rubber, cosmetics.

a) Zinc carbonate **b) Zinc oxide** c) Zinc metal d) Zinc sulphide

96. Which one is used for cutting tools and crushing machines.

a) Nickel steel **b) Chrome steel** c) Chrome vanadium steel d) Nichrome

97. Which one is used for making aeroplane parts

a) Cu **b) Au** c) Fe d) Zn

ADDITIONAL QUESTIONS: 2 and 3 MARKS

1. **What is concentration of ores?**
   - ❖ The preliminary step in metallurgical process is removal of gangue (nonmetallic impurities, rocky materials and siliceous matter) . This removal process is known as concentration of ore.
2. **Write about gravity separation or hydraulic wash? (May – 22)**
   - ❖ 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 gold and haematite (Fe_2O_3), tin stone(SnO_2).
3. **Describe the underlying principle of froth floation process. (PTA- 3)**
   - ❖ This method is commonly used to concentrate sulphide ores such as galena (PbS), zinc blende (ZnS) etc...
   - ❖ In this method, the metallic ore particles which are preferentially wetted by oil can be separated from gangue.
4. **What is the role of depressing agent in froth flotation process? (or) What is the role of sodium cyanide in froth flotation process? (PTA-1)**
   - ❖ When a sulphide ore of a metal of interest contains other metal sulphides as impurities, depressing agents such as sodium cyanide, sodium carbonate etc are used to selectively prevent other metal sulphides from coming to the froth.
   - ❖ 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.
5. **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 (NaCN) , sodium carbonate (Na_2CO_3)

6. **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 un-dissolved is called leaching.

7. What is cyanide leaching? (or) The extraction of Au by leaching with NaCN involves both oxidation and reduction.Justify giving equation. (July – 22)

- The crushed ore of gold is leached with aerated dilute solution of sodium cyanide. Gold is converted into a soluble cyanide complex. The gangue, aluminosilicate remains insoluble.

$$4Au_{(s)} + 8CN^-_{(aq)} + O_{2\,(g)} + 2H_2O_{(l)} \longrightarrow 4[Au(CN)_2]^-_{(aq)} + 4OH^-_{(aq)}$$

8. 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

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

9. What is ammonia leaching? (or) What is the reaction of ammonia with copper salt?

- 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 gaugue left behind are iron(III) oxides/hydroxides and alumino silicate.

10. What is Alkali leaching? (or) How will you get pure alumina from impure alumina using leaching? [OR] What is the significance of leaching in the extraction of aluminium?

- In this method, the ore is treated with aqueous alkali to form a soluble complex.

$$Al_2O_{3\,(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \xrightarrow{470-520\,K,\,35\,atm} 2Na[Al(OH)_4]_{(aq)} + \text{iron oxide} + \text{Titanium oxide}$$

Bauxite — Sodium meta aliminate

- The hot solution is decanted, cooled, and diluted. This solution is neutralised by passing CO_2 gas, to the form hydrated Al_2O_3 precipitate.

$$2Na[Al(OH)_4]_{(aq)} + CO_{2\,(g)} \rightarrow \underset{\text{precipitate}}{Al_2O_3.xH_2O_{(s)}} + 2NaHCO_{3\,(aq)}$$

- The precipitate is filtered off and heated around 1670 K to get pure alumina Al_2O_3.

11. What is acid leaching?

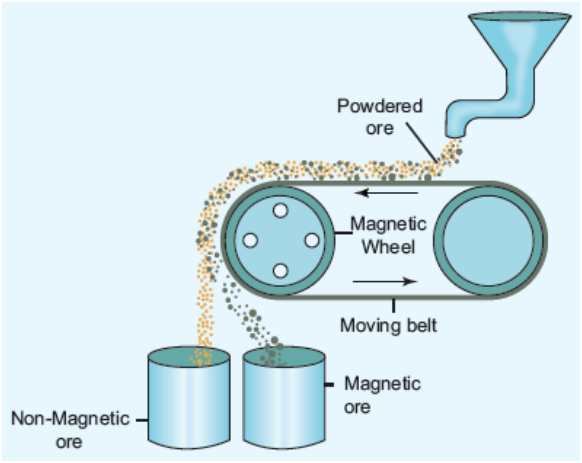
- Sulphide ores ZnS, PbS can be leached with hot aqueous sulphuric acid.
- In this process the insoluble sulphide is converted into soluble sulphate and elemental sulphur.

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

12. Write about magnetic separation. (or) Explain concentration of ore by electro magnet separation. (or) How are ores concentrated by magnetic separation method?

- 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 on, 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.



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

1. Conversion of the ore into metal oxide.
2. Reduction of the metal oxide into metal.

14. How sulphur dioxide pollution is controlled in factories?

- The sulphur dioxide produced during roasting process is harmful to the environment.
- In modern metallurgical factories, this by product is trapped and converted into sulphuric acid to avoid air pollution.

$$2SO_2 + O_2 + 2H_2O \longrightarrow 2H_2SO_4$$

15. Write about Roasting (PTA-4)

- Roasting is the method, usually applied for the conversion of sulphide ores into their oxides.

$$2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2$$

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

16. Write about calcination. (PTA-4)

- Calcination is the process in which the concentrated ore is strongly heated in the absence of air.
- During this process water of crystallization present in the hydrated oxide escapes as moisture.
- Any organic matter present also gets expelled leaving the ore porous.

$$PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$$

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$$

17. Write the differences between roasting and calcination

S.No	Roasting	Calcination
1	In this concentrated ore is oxidised by heating it with excess of oxygen in a suitable furnace below the melting point of the metal.	It is the process in which the concentrated ore is strongly heated in the absence of air or limited supply of air below the melting point of the metal
2	It is used for concentrating sulphide ores	It is used for concentrating carbonate ores
3	During this process SO_2 is released	During this process CO_2 is released

18. How Cr_2O_3 is reduced to Cr by Al powder? (or) Write about alumino thermite process.(PTA-6)

- 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.

$$BaO_2 + Mg \xrightarrow{(ignition)\ \Delta} BaO + MgO$$

- It is an exothermic process where heat is liberated.

$$Cr_2O_3 + 2Al \xrightarrow{2400^0C} 2Cr + Al_2O_3 + 852\ kJmol^{-1}$$

19. Write about smelting (or) Explain the role of flux in smelting process with suitable example.

- Smelting is a process in which the concentrated ore is mixed with a mixture of a flux and reducing agent in a smelting furnace.
- Flux is forms an easily fusible slag with gangue.
- Carbon, carbon monoxide and aluminium - reducing agents.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g) \uparrow$$

20. What is blister copper? How it is obtained?

- It is an impure copper.
- In Bessemerization process , the metallic copper is solidified and it has blistered appearance due to evolution of SO_2 gas formed in this process. This copper is called blistered copper**.**

21. Why is sulphur ore of copper heated in a furnace after mixing with silica?

- In the extraction of copper from copper pyrites, the concentrated ore is heated in a reverberatory furnace after mixing with silica, an acidic flux.
- The ferrous oxide formed due to melting is basic in nature and it combines with silica to form ferrous silicate (slag) and removed.

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

Flux Gangue Slag

22. 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.

23. Write about the extraction of metal by the process of reduction by carbon.

- In this method oxide ore of the metal is mixed with coal (coke) and heated strongly in a blast furnace.

$$ZnO(S) + C \rightarrow Zn(S) + CO(g) \uparrow$$

24. 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 hydrogen.

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

25. Write about the extraction of metal by the process of reduction by water gas.

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

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

26. 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.

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

27. Write about the extraction of metal by the process of reduction by metal

- In this process a metal oxide is reduced to metal by some active metals such as sodium, potassium , calcium and aluminum

$$B_2O_3 + 6Na \rightarrow 2B + 3Na_2O$$

$$Cr_2O_3 + 2Al \xrightarrow{\Delta} 2Cr + Al_2O_3$$

28. What is auto reduction of metallic ores? (or) What is auto reduction?

- 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.

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

29. Oxides like Ag_2O and HgO undergo self reduction why? (Q-19)

- Oxides like Ag_2O and HgO undergoes reduction because it is highly unstable oxides. Stability of metallic oxides decrease with increase in temperature.
- Highly unstable oxides like Ag_2O and HgO easily undergo thermal decomposition.

30. 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.

31. What are Ellingham diagrams?

- Ellingham diagrams are graphical representation of variation of ΔG vs T for the formation of oxides of elements

32. Sulphide and carbonate ores are converted to oxide before reduction. Why?

- The reduction of oxide ores involves a decrease in Gibb's free energy making ΔG value more negative, it is easier to reduce oxides therefore suphide and carbonate ores are converted to oxides before reduction.

33. What is the role of graphite rods in the electro metallurgy of aluminium?

- Electrolysis is carried out in an iron tank lined with carbon which acts as a cathode. The carbon blocks immersed in the electrolyte act as a anode

34. 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.

35. List out the common refining methods

1. Distillation
2. Liquation
3. Electrolytic refining
4. Zone refining
5. Vapour phase method

36. Which method is used to refine volatile metals? (or) How is metal purified by distillation method? Give example.

- Distillation method is employed for low boiling volatile metals like zinc (boiling point 1180 K) and mercury (630 K).
- In this method, the impure metal is heated to evaporate and the vapours are condensed to get pure metal.

37. What is anode mud?

- During electrolysis, the less electropositive impurities in the anode, settle down at the bottom and are removed as anode mud.
- Example : during electrolytic refining of copper , the metals such as gold , silver , platinum are deposited as anode mud.

38. Give two examples of metal refined by a) Distillation b) Liquation c) Electrolytic refining

a) Distillation – Zinc and Mercury

b) Liquation – Tin and Antimony

c) Electrolytic refining – Copper and Zinc

39. 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.

40. Write about Van – Arkel method for refining zirconium/titanium? (or) Write down the chemical reactions involved in Van- Arkel method.

- This method is based on the thermal decomposition of metal compounds to metals.

(eg) Titanium and Zirconium.

$$Ti_{(s)} + 2I_{2(s)} \xrightarrow{550K} TiI_4 \text{ (vapour)}$$

$$TiI_4\text{(vapour)} \xrightarrow{1800K} Ti_{(s)} + 2I_{2(s)}$$

41. Write the applications of copper. (or) Give uses of copper

- Copper is the first metal used by humans and extended use of its alloy bronze resulted in a new era, 'Bronze age'.
- Used for making coins and ornaments along with gold and other metals.
- Copper and its alloys are used for making wires, water pipes and other electrical parts.

42. Write the applications of gold (or) Give uses of gold

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

43. Write the applications of aluminium. (or) Give uses of aluminium

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

44. Write the applications of iron. (or) Give uses of iron

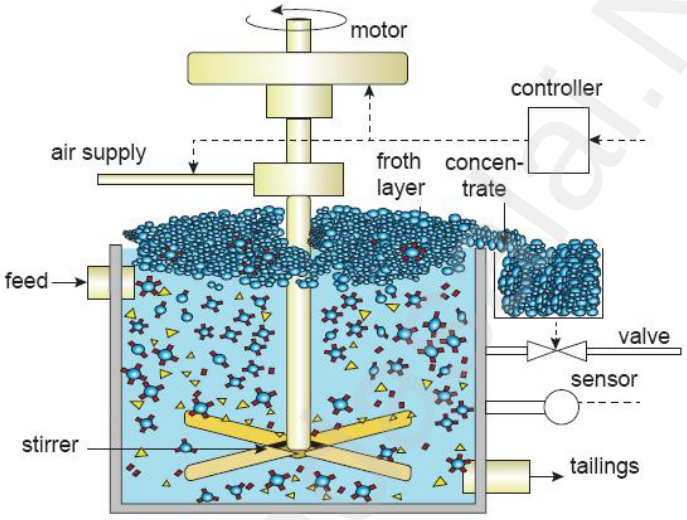
- Iron is one the most useful metals and its alloys are used everywhere including bridges, electricity
- Pylons, bicycle chains, cutting tools and rifle barrels.
- Cast iron is used to make pipes, valves and pump stoves etc.
- Magnets can be made from iron , its alloys and compounds.
- Important alloy of iron is stainless steel which is very resistant to corrosion.
- It is used in architecture, bearings, cutlery, surgical instruments and jewellery.
- Nickel steel is used for making cables, automobiles, and aeroplane parts.
- Chrome steels are used for manufacturing cutting tools and crushing machines.

ADDITIONAL QUESTIONS: 5 MARKS

1. Explain froth floatation method. (Aug 2021)

- 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.
- If the sulphide ore contains other metal sulphides as impurities, they are selectively prevented from coming to the froth by using depressing agents like sodium cyanide, sodium carbonate etc.
- Sodium cyanide depresses the floatation property of the impurity ZnS present in galena (PbS) by forming a layer of zinc complex $Na_2[Zn(CN)_4]$ on the surface of ZnS.



(OR)

- 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.

Frothing agent	Pine oil , eucalyptus oil
Collector	Sodium ethyl xanthate
Depressing agent	Sodium cyanide (NaCN) , sodium carbonate (Na_2CO_3)

- 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.
- Sodium cyanide depresses the floatation property of the impurity ZnS present in galena (PbS) by forming a layer of zinc complex $Na_2[Zn(CN)_4]$ on the surface of ZnS.

2. How is copper extracted from copper pyrite? (PTA-5)

- Principle ore : Copper pyrites.
- Concentration : Froth floatation
- Concentrated ore is heated in a reverberatory furnace with an acidic flux silica.
- The basic ferrous oxide formed reacts with silica to form the slag ferrous silicate.
- Mutually soluble metal sulphides Cu_2S and FeS known as copper matte are formed.

$$2CuFeS_2(s) + O_2(g) \rightarrow 2FeS(l) + Cu_2S(l) + 2SO_2(g)$$

$$2FeS(l) + 3O_2(g) \rightarrow 2FeO(l) + 2SO_2(g)$$

$$FeO(s) + SiO_2(s) \rightarrow FeSiO_3(s)$$

Gangue Flux Slag

- Matte is removed from the slag and fed to the converting furnace. FeS present in the matte is first converted to FeO. FeO is removed as slag with silica.
- Remaining copper sulphide is oxidised to cuprous oxide. Cuprous oxide and copper sulphide react to form metallic copper.

$$2Cu_2S(l,s) + 3O_2(g) \rightarrow 2Cu_2O(l,s) + 2SO_2(g)$$

$$2Cu_2O(l) + Cu_2S(l) \rightarrow 6Cu(l) + SO_2(g)$$

- SO_2 is liberated through molten copper and on solidification it has blistered appearance. This is copper is called blister copper.

3. Write a note on thermodynamic principle of metallurgy.

- As we discussed, the extraction of metals from their oxides can be carried out by using different reducing agents. For example, consider the reduction of a metal oxide M_xO_y.

$$2/y\ M_xO_{y\ (s)} \longrightarrow 2x/y\ M_{(s)} + O_{2(g)} \text{ -------- (1)}$$

- The above reduction may be carried out with carbon. In this case, the reducing agent carbon may be oxidised to either CO or CO_2.

$$C + C \longrightarrow O_{2\ (g)} \text{ ------ (2)}$$

$$2C + O_2 \longrightarrow 2CO_{\ (g)} \text{ ------ (3)}$$

- If carbon monoxide is used as a reducing agent, it is oxidised to CO_2 as follows,

$$2CO + O_2 \longrightarrow 2CO_{2\ (g)} \text{ ------ (4)}$$

- A suitable reducing agent is selected based on the thermodynamic considerations. We know that for a spontaneous reaction, the change in free energy (ΔG) should be negative.
- Therefore, thermodynamically, the reduction of metal oxide [equation (1)] with a given reducing agent [Equation (2), (3) or (4)] can occur if the free energy change for the coupled reaction.
- [Equations (1) & (2), (1) & (3) or (1) & (4)] is negative. Hence, the reducing agent is selected in such a way that it provides a large negative ΔG value for the coupled reaction.

4. What are the main observations of Ellingham diagram? (Q-19)

- For most of the metal oxide formation, the slope is positive. It can be explained as follows. Oxygen gas is consumed during the formation of metal oxides which results in the decrease in randomness. Hence, ΔS become negative and it makes the term, $T\Delta S$ positive in the straight line equation.
- The graph for the formation of carbon monoxide is a straight line with negative slope. In this case ΔS is positive as 2 moles of CO gas is formed by the consumption of one mole of oxygen gas. It indicates that CO is more stable at higher temperature.
- As the temperature increases, generally ΔG value for the formation of the metal oxide become less negative and becomes zero at a particular temperature. Below this temperature, ΔG is negative and the oxide is stable and above this temperature ΔG is positive. This general trend suggests that metal oxides become less stable at higher temperature and their decomposition becomes easier.
- There is a sudden change in the slope at a particular temperature for some metal oxides like MgO, HgO. This is due to the phase transition (melting or evaporation).

5. Write the application of Ellingham diagram

- It is used to evaluate the ease of reduction of metal oxides and sulfides.
- In metallurgy it is used to predict the equilibrium temperature between metal, oxide and oxygen. It also predicts the reaction of metals with nitrogen, sulfur and nonmetals.
- By Ellingham diagram we can predict the condition under which an ore can be reduced to its metal.
- It is used for finding the best suitable reducing agent for reduction of metal oxides.
- It is used to find out the feasibility of thermal reduction of an ore. As we know, the Ellingham curve for aluminum lies below most metals such as Fe, Cr etc. which indicates that Al can be used as the reducing agent for oxides of all these metals.
- Ellingham diagram for the formation of Ag_2O and HgO is at the upper part and their decomposition temperatures are 600 and 700K respectively. This shows that these oxides are unstable at moderate temperatures and will decompose on heating even in the absence of a reducing agent.

6. Explain electrochemical principle of metallurgy

- Electrochemical principles also find applications in metallurgical process. The 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 technique, the metal salts are taken in a fused form or in solution form. The metal ion present can be reduced by treating it with some suitable reducing agent or by electrolysis.
- Gibbs free energy change for the electrolysis process is given by the following expression

$$\Delta G^\circ = -nFE^\circ$$

- Where n is number of electrons involved in the reduction process, F is the Faraday and E^0 is the electrode potential of the redox couple.
- If E^0 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. For example,

$$Cu\ (s) + 2Ag^{+}\ (aq) \longrightarrow Cu^{2+}\ (aq) + 2Ag\ (s)$$

$$Cu^{2+}\ (aq) + Zn\ (s) \longrightarrow Cu(s) + Zn^{2+}\ (aq)$$