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Q1. **What are the collectors used in froth floatation process? Name a substance that can be used as such.**

Q2. **Describe the underlying principle of froth floatation process of concentration of ores.**

Q3. **What role is played by CO_2 in getting pure alumina (Al_2O_3) in the extraction of aluminium?**

Q4. **Name the depressant which is used to separate ZnS and PbS ores in froth floatation process.**

Q5. **What is the function of collectors in the forth floatation process for the concentration of ores.**

Q6. **Describe the role of the following: NaCN in froth floatation process.**

Q7. **Write the principle of the following method. Froth floatation method.**

Q8. **In the extraction of Al, impure Al_2O_3 is dissolved in conc. NaOH to form sodium aluminate and leaving impurities behind. What is the name of this process?**

Q9. **Name the principal ore of aluminium.**

Q10. **Differentiate between a mineral and an ore.**

Q11. **Name the chief ores of aluminium and zinc.**

Q12. **Describe the underlying principle of recovery of silver from the solution obtained by leaching silver ore with a solution of NaCN.**

Q13. **State the principle on which the following process operates: Recovery of silver after the silver ore has been leached with NaCN.**

Q14. **What is the role of depressants in the froth floatation process of dressing of ores?**

Q15. **What is the role of collectors in froth floatation process?**

Q16. **Explain the role of the following: NaCN in the extraction of silver from silver ore.**

Q17. **Name the method used for removing gangue from sulphide ores.**

Q18. **Which of the following ores can be concentrated by froth floatation method and why?**

Fe_2O_3, ZnS, Al_2O_3.

Q19. **Which solution is used for the leaching of silver metal in the presence of air in the metallurgy of silver?**

Q20. **What is the role of CO_2 in the extractive metallurgy of aluminium from its ore?**

Q21. **Describe the principle controlling the following process: Froth floatation method of concentration of a sulphide ore.**

Q22. Why is it that only sulphide ores are concentrated by froth floatation process?

Q23. What type of ores can be concentrated by magnetic separation method?

Q24. Describe the principle controlling the following process: Preparation of pure alumina (Al_2O_3) from bauxite ore.

Q25. What is the role of coke in the extraction of iron from its oxides?

Q26. What is meant by the term ‘pyrometallurgy’?

Q27. Answer the folowing: Differentiate between roasting and calcination.

Q28. Describe the role of the following: Depressant in froth floatation process.

Q29. State briefly the principle which serves as basis for the following operation in metallurgy: Froth floatation process.

Q30. Why is the froth floatation method selected for the concentration of sulphide ores.

Q31. Describe the leaching of aluminium ore.

Q32. Describe the principle involved in the following process of metallurgy: Froth floatation method.

Q33. Write the reactions involved in the following proccess: Leaching of bauxite ore to prepare pure alumina.

Q34. What is the composition of ‘copper matte’?

Q35. Out of C and CO, which is a better reducing agent at the lower temperature range in the blast furnace to extract iron from the oxide ore?

Q36. Describe the role of the following: SiO_2 in the extraction of copper from copper matte.

Q37. What is ‘copper matte’?

Q38. Which form of the iron is the purest form of commercial iron?

Q39. What is the role of silica in the extraction of copper?

Q40. What is the role of limestone in the extraction of iron from its oxides?

Q41. What is the function of SIO_2 in the metallurgy of copper?

Q42. Give reason for the following: Zinc oxide can be reduced to metal by heating with carbon but Cr_2O_3 cannot be reduced by heating with carbon.

Q43. Although thermodynamically feasible, in practice, magnesium metal is not used for reduction of alumina in the metallurgy of aluminium. Why?

Q44. Describe the principle controlling the following process: Preparation of cast iron from pig iron.

Q45. Copper matte is charged into a silica lined converter in extraction of copper. What is the role of silica lining here?

Q46. Describe the role of the following: Silica in the extraction of copper from copper pyrites ore.

Q47. The reaction $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$; $\Delta G^\circ = -421$ kJ is thermodynamically feasible as is apparant from the Gibbs energy value. Why does it not take place at room temperature?

Q48. What is the role of cryolite in the extraction of aluminium?

Q49. Which reducing agent is employed to get copper from the leached low grade copper ore?

Q50. What is the role of zinc metal in the extraction of silver?

Q51. What is the role of dilute NaCN in the extraction of gold?

Q52. Which of the two scraps, zinc or iron would be preferred for the recovery of copper from the leached copper ore and why?

Q53. Give reason for the following: Alumina is dissolved in cryolite for electrolysis instead of being electrolysed directly.

Q54. Describe the role of cryolite in the extraction of amuminium from pure alumina.

Q55. Which method is employed for extracting copper from low grade ores and scraps?

Q56. How is copper extracted from a low grade ore of it?

Q57. Write the role of graphite rod in the electrometallurgy of aluminium.

Q58. What is the principle behind the method used for the refining of zinc.

Q59. Indicate the principle behind the method used for the refining of zinc.

Q60. Name the method of refining of nickel.

Q61. Name the method of refining of metals such as germanium.

Q62. Why is electrolytic reduction preferred over chemical reduction for the isolation of certain metals?

Q63. Write the reaction involved in the following process: Recovery of gold after gold ore has been leached with NaCN solution.

Q64. Describe the role of NaCN in the extraction of gold from gold ore.

Q65. Name the methods used for refining of following metals. (a) Nickel, (b) Titanium.

Q66. Describe the following: The role of carbon monoxide in the refining of crude nickel.

Q67. Write the chemical reaction which takes place in Mond's process for refining of nickel.

Q68. Explain the role of the folowing: Iodine in the refining of titanium.

Q69. Name the methods used for the vapour phase refining of impure titanium and nickel metals.

Q70. Describe the underlying principle of the following process: Electrolytic refining of a crude metal.

Q71. Describe the underlying principle of the following process: Vapour phase refining of metals.

Q72. Write the role of the following: Iodine in the refining of zirconium.

Q73. Write the role of the following: CO in the purification of nickel.

Q74. **Name the method used for refining of copper metal.**

Q75. **What is meant by the term 'chromatography'?**

Q76. **Indicate the principle behind the method used for the refining of nickel.**

Q77. **What types of metals are usually purified by the method of zone refining? Give and example.**

Q78. **Describe the role of iodine in the refining of zirconium. Write chemical equations for the involved reactions.**

Q79. **Write the reactions involved in the following process: Refining of zirconium by van Arkel method.**

Q80. **Describe the principle controlling the following process: Vapour phase refining of titanium metal.**

Q81. **Describe how the following change is brought about: Impure titanium into pure titanium.**

Q82. **How can you obtain pure alumina (Al_2O_3) from a bauxite ore? Give necessary reaction involved.**

Q83. **Write the chemical reactions involved in the extraction of silver from silver ore.**

Q84. **Giving examples differentiate between calcination and roasting.**

Q85. **Answer the following terms: (a) Roasting (b) Calcination.**

Q86. **Give reasons for the following:**

(a) Zinc oxide can be reduced to the metal by heating with carbon but not Cr_2O_3.

(b) Extraction of copper directly from sulphide ores is less favourable than that from its oxide ore through reduction.

Q87. **Describe how the following changes are brought about:**

(a) Pig iron into steel (b) Zinc oxide into metallic zinc.

Q88. **Why is copper matte put in silica lined converter?**

Q89. **How is wrought iron different from steel?**

Q90. **(a) What is the role of silica in the extraction of copper?**

(b) How is 'cast iron' different from 'pig iron'?

Q91. **Give an example of zone refining of metals.**

Q92. **Describe the principle involved in each of the following processes.**

(a) Zone refining of a metal. (b) Vapour phase refining of metals.

Q93. **Write the principle of the following method: Vapour phase refining.**

Q94. **How is chemical reduction different from electrolytic reduction? Name a metal each which is obtained by (a) electrolytic reduction, (b) chemical reduction.**

Q95. **The extraction of gold by leaching with NaCN involves both oxidation and reduction. Justify giving chemical equations.**

Q96. Write all the reactions involved in the extraction of aluminium from bauxite ore.

Q97. Describe the principle controlling each of the following process:

(a) Zone refining of metals (b) Electrolytic refining of metals.

Q98. State briefly the principles which serve as basis for the following operatios in metallurgy:

(a) Zone refining (b) Refining by liquation.

Q99. Describe the underlying principle of each of the following metal refining methods:

(a) Electrolytic refining of metals (b) Vapour phase refining of metals.

Q100 Describe the principle involved in each of the following processes.

(a) Mond process for refining of nickel.

(b) Column chromatography for purification of rare elements.

Q101 Write the principle behind the forth floatation process. What is the role of collectors in this process?

Q102 What are the chief ores of zinc? Write chemical reactions taking place in the extraction of zinc from zinc blende.

Q103 What chemical principle is involved in choosing a reducing agent for getting the metal from its oxide ore? Consider the metal oxides, Al_2O_3 and Fe_2O_3, and justify the choice of reducing agent in each case.

Q104 Write down the reactions which occur in upper, middle and lower zones in the blast furnace during the extraction of iron from iron ore.

Q105 Write the reactions taking place in different zones of the blast furnace to obtain iron.

Q106 Write down the reactions taking place in different zones in the blast furnace during the extraction of iron. How is pig iron different from cast iron?

Q107 Outline the principles of refining of metals by the following methods: (a) Distillation, (b) Zone refining, (c) Electrolysis.

Q108 Outline the principles behind the refining of metals by the following methods: (a) Zone refining method (b) Chromatograpic method.

Q109 Which methods are usually employed for purifying the following metals? (a) Nickel (b) Germanium. Mention the principle behind each one of them.

Q110 Explain the principle of the method of electrolytic refining of metals. Give one example.

Q111 State the principle on which each of the following process operates: (a) Electrolytic refining of a metal, (b) Vapour phase refining of a metal.

Q112 What is meant by the term, 'Chromatography'? What criterion is followed for the selection of the stationary phase in chromatography?

Q113 State the principle involved in refining of metals by each of the following methods: (a) Zone refining, (b) Vapour phase refining, (c) Electrolytic refining.

Q114 State the principles of the following methods of refining crude metals: (a) Zone refining, (b) Liquation method, (c) Chromatographic method.

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S1. Collectors enhance non-wettability of the mineral particles. Pine oil can be used as collectors.

S2. The principle behind this method is that the sulphide ore is preferentially wetted by oils while gangue is preferentially wetted by water.

Then on agitation forth is formed that carries mineral particles and can be skimmed off.

S3. The aluminate in the solution is neutralised by passing CO_2 gas and hydrated Al_2O_3 is precipitated.

$$2Na[Al(OH)_4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

S4. NaCN is used to separate ZnS and PbS ores in froth floatation process.

S5. Collectors enhance non-wettability of the mineral particles. Pine oil can be used as collectors.

S6. NaCN is used as a depressant in froth floatation process which selectively prevents ZnS from coming to the froth but allows PbS to come with the froth.

S7. The principle behind this method is that the sulphide ore is preferentially wetted by oils while gangue is preferentially wetted by water.

Then on agitation forth is formed that carries mineral particles and can be skimmed off.

S8. Leaching.

S9. The chief ore of aluminium is bauxite.

S10. The naturally occurring chemical substances present in the earth's crust which can be obtained by mining are called minerals. Those minerals from which metals can be extracted economically are called ores.

S11. The chief ore of aluminium is bauxite and that of zinc is zinc blende or sphalerite.

S12. During leaching Ag is oxidised to Ag^+ which then combines with CN^- ions (from NaCN) to form soluble complex $[Ag(CN)_2]^-$. Silver is then recovered from this complex by displacement method using more electropositive zinc metal.

$$2[Ag(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Ag(s) + [Zn(CN)_4]^{2-}(aq)$$

S13. During leaching Ag is oxidised to Ag^+ which then combines whth CN^- ions (from NaCN) to form soluble complex $[Ag(CN)_2]^-$. Silver is then recovered from this complex by displacement method using more electropositive zinc metal.

$$2[Ag(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Ag(s) + [Zn(CN)_4]^{2-}(aq)$$

S14. NaCN is used as a depressant in forth floatation process which selectively prevents ZnS from coming to the forth but allows PbS to come with the forth.

S15. Collectors enhance non-wettability of the mineral particles. Pine oil can be used as collectors.

S16. During leaching Ag is oxidised to Ag^+ which then combines whth CN^- ions (from NaCN) to form soluble complex $[Ag(CN)_2]^-$. Silver is then recovered from this complex by displacement method using more electropositive zinc metal.

$$2[Ag(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Ag(s) + [Zn(CN)_4]^{2-}(aq)$$

S17. Forth floatation method.

S18. ZnS (Forth floatation method is used to remove gangue from sulphide ores).

S19. Dilute solution of NaCN or KCN in the presence of air (for O_2).

S20. The aluminate the solution is neutralised by passing CO_2 gas and hydrated Al_2O_3 is precipitated.

$$2Na[Al(OH)_4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

S21. The principle behind this method is that the sulphide ore is preferentially wetted by oils while gangue is preferentially wetted by water.

Then on agitation forth is formed that carries mineral particles and can be skimmed off.

S22. This is because the sulphide ore particles becomes lighter when preferentially wetted by oil and rise to surface along with the forth, whereas gangue particles are preferentially wetted by water become heavier and settle down.

S23. If either the ore or the gangue particles and capable of being attracted by magnetic field, then such ore is concentrated by magnetic separation method.

S24. Al_2O_3 present in bauxite is soluble in concentrated NaOH solution whereas impurities are not, Al_2O_3 is reprecipitated from the solution.

S25. Coke reduces iron oxide to iron.

$$FeO(s) + C(s) \longrightarrow Fe(s/l) + CO(g)$$

S26. The process of extraction of metal from its ore by heating the ore with a suitable reducing agent is known as pyrometallurgy.

S27.

Roasting	Calcination
1. It is the process of heating the ore below its melting point with excess of air.	1. It is the process of heating the ore below its melting point in the absence or limited supply of air.
2. Sulphide ore is converted into oxide form. $2ZnS + 3O_2 \xrightarrow{\text{Heat}} 2ZnO + 2SO_2\uparrow$ and volatile impurities are removed as oxides SO_2, As_2O_3 etc.	2. Carbonate ores are converted into oxide. $ZnCO_3 \xrightarrow{\text{Heat}} ZnO + CO_2\uparrow$ and water and organic impurities are removed.

S28. NaCN is used as a depressant in forth floatation process which selectively prevents ZnS from coming to the forth but allows PbS to come with the forth.

S29. The principle behind this method is that the sulphide ore is preferentially wetted by oils while gangue is preferentially wetted by water.

Then on agitation forth is formed that carries mineral particles and can be skimmed off.

S30. This is because the sulphide ore particles becomes lighter when preferentially wetted by oil and rise to surface along with the forth, whereas gangue particles are preferentially wetted by water become heavier and settle down.

S31. Leaching of bauxite ore to prepare pure alumina:

$$Al_2O_3 + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2Na[Al(OH)_4](aq)$$

$$2Na[AlOH)_4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

$$Al_2O_3 \cdot xH_2O(s) \xrightarrow{1470\,K} Al_2O_3(s) + xH_2O(s)$$

S32. The principle behind this method is that the sulphide ore is preferentially wetted by oils while gangue is preferentially wetted by water.

Then on agitation forth is formed that carries mineral particles and can be skimmed off.

S33. Leaching of bauxite ore to prepare pure alumina:

$$Al_2O_3 + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2Na[Al(OH)_4](aq)$$

$$2Na[AlOH)_4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

$$Al_2O_3 \cdot xH_2O(s) \xrightarrow{1470\,K} Al_2O_3(s) + xH_2O(s)$$

S34. Cu_2S and FeS.

S35. Ellingham diagram for oxides of metals and carbon shows

$$C(s) + O_2(g) \longrightarrow CO_2(g) \qquad \ldots \text{(i)}$$

$$2C(s) + O_2(g) \longrightarrow 2CO(g) \qquad \ldots \text{(ii)}$$

$$2CO(g) + O_2(g) \longrightarrow 2CO_2(g) \qquad \ldots \text{(iii)}$$

that at 673 K, $\Delta_f G°(CO)_2 < \Delta_f G°(CO)$ hence formation of CO_2 gas is more favourable than CO gas. Hence, out of C and CO, CO is a better reducing agent.

S36. During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides Cu_2O and SO_2.

$$\underset{\text{(Copper pyrites)}}{4CuFeS_2(s)} + 11O_2(g) \longrightarrow 4FeO(s) + 2Cu_2O(s) + 8SO_2(g)$$

To remove FeO, SiO_2 is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO(s)} + \underset{\text{(Acidic oxide)}}{SiO_2(s)} \longrightarrow \underset{\text{Slag}}{FeSiO_3(l)}$$

S37. Copper matte is mixture of Cu_2S and FeS.

S38. Wrought iron is the purest form of commercial iron.

S39. During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides Cu_2O and SO_2.

$$\underset{\text{(Copper pyrites)}}{4CuFeS_2(s)} + 11O_2(g) \longrightarrow 4FeO(s) + 2Cu_2O(s) + 8SO_2(g)$$

To remove FeO, SiO_2 is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO(s)} + \underset{\text{(Acidic oxide)}}{SiO_2(s)} \longrightarrow \underset{\text{Slag}}{FeSiO_3(l)}$$

S40. Litmestone decomposes to form CaO and CO_2. CaO thus formed acts as a flux and combines with silica (present as impurity) to form fusible calcium silicate slag.

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$\underset{\text{(Silica)}}{CaO + SiO_2} \longrightarrow \underset{\text{(Slag)}}{CaSiO_3}$$

S41. During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides Cu_2O and SO_2.

$$\underset{\text{(Copper pyrites)}}{4CuFeS_2(s)} + 11O_2(g) \longrightarrow 4FeO(s) + 2Cu_2O(s) + 8SO_2(g)$$

To remove FeO, SiO_2 is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO(s)} + \underset{\text{(Acidic oxide)}}{SiO_2(s)} \longrightarrow \underset{\text{Slag}}{FeSiO_3(l)}$$

S42. Carbon is suitable reducing agent for reduction of zinc oxide. Reduction of Cr_2O_3 by carbon is not thermodynamically favourable.

S43. Below the temperature (1623 K) corresponding to the point of intersection of Al_2O_3 and MgO curves in ellingham diagram magnesium can reduce alumina. But magnesium is a much costlier metal than aluminium and hence the process will be uneconomical.

S44. Pig iron is melted with scrap iron and coke using hot air blast. Due to this, impurities such as C, S and P present in the pig iron are removed as CO_2, SO_2 and P_2O_5 and carbon content is reduced to about 3%.

S45. The copper matte containing Cu_2S and FeS is put in silica lined converter. Some silica is also added and hot air blast is blown to convert remaining FeS to FeO, which is removed as slag with silica.

S46. During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides Cu_2O and SO_2.

$$\underset{\text{(Copper pyrites)}}{4CuFeS_2(s)} + 11O_2(g) \longrightarrow 4FeO(s) + 2Cu_2O(s) + 8SO_2(g)$$

To remove FeO, SiO_2 is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO(s)} + \underset{\text{(Acidic oxide)}}{SiO_2(s)} \longrightarrow \underset{\text{Slag}}{FeSiO_3(l)}$$

S47. In solid state chance of contact between reactants is negligible. Some thermodynamically feasible reactions also require some activation energy for initiation.

Hence, the reaction does not take place at room temperature.

S48. Purified alumina (Al_2O_3) is mixed with cryolite (Na_3AlF_6) which lowers the melting temperature of electrolyte and also increase its conductivity.

S49. Scrap iron or H_2.

S50. **Zinc in the extraction of silver:** Role of zinc is to recover silver from the complex by displacement reaction. Silver ore is leached with dilute solution of NaCN in the presence of air or oxygen to form a soluble complex.

$$4Ag(s) + 8CN^{-}(aq) + 2H_2O(l) + O_2(g) \longrightarrow \underset{\text{Soluble complex}}{4[Ag(CN)_2]^{-}} + 4OH^{-}(aq)$$

$$2[Ag(CN)_2]^{-} + Zn \longrightarrow [Zn(CN)_4]^{2-} + 2Ag$$

S51. NaCN is used for leaching of gold ore in the presence of air to form soluble gold complex from which metal is displaced by adding more reactive metal.

$$4Au(s) + 8CN^{-}(aq) + 2H_2O(l) + O_2(g) \longrightarrow 4[Au(CN)_2]^{-}(aq) + 4OH^{-}(aq)$$

S52. Zinc scrap should be preferred because zinc is more electropositive than iron.

But zinc is costlier metal than iron so using iron scraps will be preferred.

S53. Purified alumina (Al_2O_3) is mixed with cryolite (Na_3AlF_6) which lowers the melting temperature of electrolyte and also increase its conductivity.

S54. Purified alumina (Al_2O_3) is mixed with cryolite (Na_3AlF_6) which lowers the melting temperature of electrolyte and also increase its conductivity.

S55. Copper is extracted by hydrometallurgy from low grade ores. It is leached out using acid or bacteria. The solution containing Cu^{2+} is treated with scrap iron or H_2.

$$Cu^{2+}(aq) + H_2(g) \longrightarrow Cu(s) + 2H^{+}(aq)$$

S56. Copper is extracted by hydrometallurgy from low grade ores. It is leached out using acid or bacteria. The solution containing Cu^{2+} is treated with scrap iron or H_2.

$$Cu^{2+}(aq) + H_2(g) \longrightarrow Cu(s) + 2H^{+}(aq)$$

S57. Graphite anode is used in the electrometallurgy of aluminium from alumina, Al_2O_3.

Oxygen liberated at high temperature reacts with graphite to form both CO_2 and CO gases and prevent the liberation of O_2 gas at the anode which may react with Al metal to give Al_2O_3 again.

At anode: $C(s) + O^{2-}(melt) \longrightarrow CO(g) + 2e^{-}$

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

S58. Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

S59. Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^{-}$

At cathode: $Zn^{2+} + 2e^{-} \longrightarrow Zn$

S60. Mond's process: Impure nickel is treated with carbon monoxide at 60-80°C to form volatile nickel carbonyl which decomposes to give pure nickel at 180°C.

$$\underset{\text{Impure}}{Ni} + 4CO \longrightarrow \underset{\text{Pure}}{Ni} + 4CO$$

S61. Zone refining is used for refining of semiconductors or other metals of very high purity.

S62. Electropositive metals which cannot be reduced by chemical reduction are easily reduced electrolytically.

S63. Gold is recovered from $[Au(CN)_2]^-$ complex by displacement method using a more electropositive metal zinc.

$$2[Au(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Au(s) + [Zn(CN)_4]^{2-}(aq)$$

S64. NaCN is used for leaching of gold ore in the presence of air to form soluble gold complex from which metal is displaced by adding more reactive metal.

$$4Au(s) + 8CN^-(aq) + 2H_2O(l) + O_2(g) \longrightarrow 4[Au(CN)_2]^-(aq) + 4OH^-(aq)$$

S65. Titanium is refined by van Arkel method and nickel is refined by Mond's process.

S66. The role of CO is to convert impure nickel to volatile nickel tetracarbonyl whereas the impurities are left behind in the solid state. The vapour of nickel tetracarbonyl on heating at 450-470 K decomposes to give pure nickel metal and carbon monoxide.

$$\underset{\text{Impure nickel}}{Ni + 4CO} \xrightarrow{330\text{-}350\,K} \underset{\text{Nickel tetracarbonyl}}{Ni(CO)_4} \xrightarrow{450\text{-}470\,K} \underset{\text{Pure nickel}}{Ni + 4CO(g)}$$

S67.

$$\underset{\text{Impure}}{Ni} + 4CO \xrightarrow{330\text{-}350\,K} Ni(CO)_4$$

$$Ni(CO)_4 \xrightarrow{450\text{-}470\,K} \underset{\text{Pure}}{Ni} + 4CO$$

S68. Iodine forms a volatile compound with titanium which on further heating decomposes to give pure titanium.

$$\underset{\text{(Impure)}}{Ti} + 2I_2(s) \xrightarrow{\Delta} TiI_4 \xrightarrow{\Delta} \underset{\text{(Pure)}}{Ti} + 2I_2$$

S69. Titanium is refined by van Arkel method and nickel is refined by Mond's process.

S70. Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

S71. **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(a) The metal should form a volatile compound with an available reagent.

(b) The volatile compound should be easily decomposable, so that the recovery is easy.

S72. In this method, crude metal is heated in an evacuated vessel with iodine. The metal iodide formed is decomposed on a tungsten filament at high temperature (1800 K) to get pure metal.

$$\underset{\text{Impure}}{Zr} + 2I_2 \longrightarrow ZrI_4 \longrightarrow \underset{\text{Pure}}{Zr} + 2I_2$$

S73. The role of CO is to convert impure nickel to volatile nickel tetracarbonyl whereas the impurities are left behind in the solid state. The vapour of nickel tetracarbonyl on heating at 450-470 K decomposes to give pure nickel metal and carbon monoxide.

$$\underset{\text{Impure nickel}}{Ni} + 4CO \xrightarrow{330\text{-}350\,K} \underset{\text{Nickel tetracarbonyl}}{Ni(CO)_4} \xrightarrow{450\text{-}470\,K} \underset{\text{Pure nickel}}{Ni} + 4CO(g)$$

S74. Cpper is refined by electrolytic refining.

S75. The term chromatography was derived from the Greek word "chroma", meaning colour and "graphy", for writing. It was used for the first time to separate the colour pigments of plants. Chromatography is a technique for analysing or separating mixtures of gases, liquids or dissolved substances.

S76. Mond's process: Impure nickel is treated with carbon monoxide at 60-80°C to form volatile nickel carbonyl which decomposes to give pure nickel at 180°C.

$$\underset{\text{Impure}}{Ni} + 4CO \longrightarrow \underset{\text{Pure}}{Ni} + 4CO$$

S77. The metals such as germanium, silicon, gallium, etc. which are used as semiconductors are purified by zone refining which is based upon the principle that impurities are more soluble in the melt than in the solid state of metals.

S78. In this method, crude metal is heated in an evacuated vessel with iodine. The metal iodide formed is decomposed on a tungsten filament at high temperature (1800 K) to get pure metal.

$$\underset{\text{Impure}}{Zr} + 2I_2 \xrightarrow{870\,K} ZrI_4 \xrightarrow[\text{Tungsten Filament}]{2075\,K} \underset{\text{Pure}}{Zr} + 2I_2$$

S79. Refining of zirconium by van Arkel method.

$$Zr(s) + 2I_2(s) \xrightarrow{870\,K} ZnI_4(g)$$

$$ZrI_4(g) \xrightarrow[\text{Tungsten filament}]{2075\,K} \underset{\text{Pure}}{Zr(s)} + 2I_2(s)$$

S80. In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal.

$$\underset{\text{Impure metal}}{Ti} + 2I_2 \xrightarrow{523\,K} TiI_4$$

$$TiI_4 \xrightarrow{1700\,K} \underset{\text{Pure metal}}{Ti} + 2I_4$$

S81. In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal.

$$\underset{\text{Impure metal}}{Ti} + 2I_2 \xrightarrow{523\,K} TiI_4$$

$$TiI_4 \xrightarrow{1700\,K} \underset{\text{Pure metal}}{Ti} + 2I_4$$

S82. Leaching of bauxite ore to prepare pure alumina:

$$Al_2O_3 + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2Na[Al(OH)_4](aq)$$

$$2Na[Al()H)4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

$$Al_2O_3 \cdot xH_2O(s) \xrightarrow{1470\,K} Al_2O_3(s) + xH_2O(s)$$

S83.

$$\underset{\text{Argetite}}{Ag_2S} + 4NaCN \rightleftharpoons 2Na[Ag(CN)_2] + Na_2S$$

$$3Na_2S + 2H_2O + 5O_2 \longrightarrow 2Na_2SO_4 + 4NaOH + 2S$$

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[An(CN)_4] + 2Ag$$

S84.

Roasting	Calcination
1. It is the process of heating the ore below its melting point with excess of air.	1. It is the process of heating the ore below its melting point in the absence or limited supply of air.
2. Sulphide ore is converted into oxide form. $2ZnS + 3O_2 \xrightarrow{Heat} 2ZnO + 2SO_2\uparrow$ and volatile impurities are removed as oxides SO_2, As_2O_3 etc.	2. Carbonate ores are converted into oxide. $ZnCO_3 \xrightarrow{Heat} ZnO + CO_2\uparrow$ and water and organic impurities are removed.

S85.

Roasting	Calcination
1. It is the process of heating the ore below its melting point with excess of air.	1. It is the process of heating the ore below its melting point in the absence or limited supply of air.
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S86. (a) Carbon is suitable reducing agent for reduction of zinc oxide. Reduction of Cr_2O_3 by carbon is not thermodynamically favourable.

(b) Free energy change for the reduction of copper sulphide to copper by carbon is positive.

Whereas, $\Delta_r G^\circ$ for the reduction of copper oxide to copper by carbon is negative and hence feasible.

S87. (a) Pig iron is mixed with scrap iron and heated in a furnace. After removal of impurities required quantity of spiegel is added to make steel.

(b) Zinc oxide is mixed with coke and clay and brickettes are made. The brickettes are heated at 1673 K to give metallic zinc.

$$ZnO(s) + C(s) \xrightarrow{1673\,K} Zn(s) + CO(g)$$

S88. The copper matte containing Cu_2S and FeS is put in silica lined converter. Some silica is also added and hot air blast is blown to convert remaining FeS to FeO, which is removed as slag with silica.

S89. Wrought iron is the purest form of iron. Steel is an alloy of iron which contains requisite amount of C, Mn, Ni, Cr, etc.

S90. (a) During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides Cu_2O and SO_2.

$$\underset{\text{(Copper pyrites)}}{4CuFeS_2(s)} + 11O_2(g) \longrightarrow 4FeO(s) + 2Cu_2O(s) + 8SO_2(g)$$

To remove FeO, SiO_2 is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO(s)} + \underset{\text{(Acidic oxide)}}{SiO_2(s)} \longrightarrow \underset{\text{Slag}}{FeSiO_3(l)}$$

(b) Impure iron obtained from blast furnace is known as pig iron and cast into pigs (blocks). It contains 4-5 percent of carbon along with some phosphorus, silicon, manganese and sulphur.

Cast iron contains a less percentage of carbon (1.8 to 3 percent) made by melting pig iron with scrap iron and coke using hot air blast.

S91. The metals such as germanium, silicon, gallium, etc. which are used as semiconductors are purified by zone refining which is based upon the principle that impurities are more soluble in the melt than in the solid state of metals.

S92. (a) Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(i) The metal should form a volatile compound with an available reagent.

(ii) The volatile compound should be easily decomposable, so that the recovery is easy.

S93. **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(a) The metal should form a volatile compound with an available reagent.

(b) The volatile compound should be easily decomposable, so that the recovery is easy.

S94. In chemical reduction, metal is obtained by reduction of its ore by a suitable reducing agent, whereas in electrolyic reduction, reduction is carried out by passing electric current through molten ore.

(a) Aluminium is obtained by electrolytic reduction.

(b) Iron is obtained by chemical reduction.

S95. During the leaching process, Au is first oxidised to Au^+ by O_2 of the air which then combines with CN^- ions to form the soluble complex, sodium dicyanoaurate (I).

$$\underset{\text{Gold (Impure)}}{4Au(s)} + 8NaCN(aq) + 2H_2O(l) + O_2(g) \longrightarrow \underset{\substack{\text{Sod. dicynaoaurate (I)} \\ \text{(Soluble complex)}}}{4Na[Au(CN)_2](aq)} + 4NaOH(aq)$$

Gold is then extracted from this complex, by displacement method using a more electropositive zinc metal. In this reaction, Zn acts as a reducing agent. It reduces Au^+ to Au while itself gets oxidized to Zn^{2+} which combines with CN^- ions to form soluble complex, sodium tetracyanozincate (II).

$$\underset{}{2Na[Au(CN)_2](aq)} + Zn \longrightarrow \underset{\text{Gold}}{2Au(s)} + \underset{\text{Sod. tetracyanoaincate (II)}}{Na_2[Zn(CN)_4](aq)}$$

Thus, extraction of Au by leaching with NaCN involves both oxidation and reduction.

S96. Aluminium metal is extracted from bauxite ($Al_2O_3 \cdot 2H_2O$) in two steps.

Stage I (Leaching): The ore is treated with sodium hydroxide solution. Aluminium oxide and silica dissolve to form sodium aluminate and sodium silicate respectively. Iron oxide and TiO_2 is filtered off.

$$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2Na[Al(OH)_4](aq)$$

$$2Na[Al(OH)_4](aq) \xrightarrow{CO_2} Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

The hydrated alumina is filtered, dried and calcined *i.e.*, heated at 1370 K to get pure alumina.

$$\underset{\text{Aluminium hydroxide}}{Al_2O_3 \cdot xH_2O(s)} \xrightarrow{1470\,K} \underset{\text{Pure alumina}}{Al_2O_3(s)} + xH_2O(g)$$

Stage II (Electrolysis): The alumina is dissolved in molten cryolite $Na_3[AlF_6]$ and then electrolysed in a large steel tank lined with graphite which acts as cathode. The anodes are made of carbon. On passing current, molten aluminium is produced at cathode and oxygen gas is evolved at the anode which reacts with carbon anode producing CO and CO_2. The electrolytic reactions may be written as:

Cathode: $2Al^{3+}(\text{melt}) + 6e^- \longrightarrow 2Al(l)$

Anode: $C(s) + O^{2-} \longrightarrow CO(g) + 2e^-$

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

The anode burns away. Therefore, the graphite rods must be replaced from time to time.

S97. (a) Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

S98. (a) **Zone refining** is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) **Refining by liquation:** In this method a low melting metal like tin is heated on a sloping surface of a reverberatory furnace. Metal melts and flows down leaving impurities behind.

S99. (a) Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

(b) **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(i) The metal should form a volatile compound with an available reagent.

(ii) The volatile compound should be easily decomposable, so that the recovery is easy.

S100. (a) Mond's process: Impure nickel is treated with carbon monoxide at 60-80°C to form volatile nickel carbonyl which decomposes to give pure nickel at 180°C.

$$\underset{\text{Impure}}{Ni + 4CO} \longrightarrow \underset{\text{Pure}}{Ni + 4CO}$$

(b) Chromatographic method is based on the principle that different components of a mixture are differently adsorbed on an adsorbent. The adsorbed components are removed (eluted) by using suitable eluent. There are several chromatographic techniques such as paper chromatography, colum chromotagraphy, gas chromatography, etc.

S101. Forth floatation process: The method has been in use for removing gangue from sulphide ores. In this process, a suspension of the powdered ore is made with water. To it collectors and forth stabilisers are added.

Collectors (*e.g.*, pine oils, fatty acids, xanthates, etc.) enhance non wettability of the mineral particles and forth stabilisers (*e.g.*, cresols, aniline) stabilise the forth.

The mineral particles become wet by oils while the gangue particles by water. A rotating paddle agitates the mixture and draws air in it. As a result, forth is formed which carries the mineral particles. The forth is light and skimmed off.

S102. The chief ores of zinc are:

(i) Zinc blends, ZnS (ii) Calamine, $ZnCO_3$ (iii) Zincite, ZnO.

Extraction of zinc: From zinc blende zinc is extracted by roasting followed by reduction with coke.

(a) **Roasting:** The concentrated ore is heated with oxygen at 900°C in reverberatory furnace to convert zinc sulphide to zinc oxide.

$$\underset{\text{(Zinc blende)}}{2ZnS} + 3O_2 \longrightarrow \underset{\text{(Zinc oxide)}}{2ZnO} + 2SO_2$$

(b) **Reduction:** The reduction of zinc oxide is done using coke.

$$ZnO + C \xrightarrow{1673\,K} Zn + CO$$

The metal is distilled off and collected by rapid chilling.

S103. Thermodynamic factor helps us in choosing a suitable reducing agent for the reduction of a particular metal oxide to the metallic state.

Any metal will reduce the oxides of other metals if $\Delta_f G^\circ$ of the oxide of the element is less than $\Delta_f G^\circ$ of the metal oxide to be reduced.

Thus, both Al and Zn can reduce Fe_2O_3 and Mg can reduce Al_2O_3 to al.

S104. Reduction of iron oxide in blase furnace:

(a) **Lower zone of the blast furnace:**

$$C + O_2 \longrightarrow CO_2 + Heat$$
$$C + CO_2 \longrightarrow 2CO$$

Coke is burnt to give temperature up to 2200 K at lower part of the blast furnace.

(b) **Middle zone of the blast furncace:** CO and heat move up in the furnace. The temperature range in the middle zone of the blast furnace is 900-1500 K.

$$FeO + CO \longrightarrow Fe + CO_2$$

Lime stone is also decomposed to CaO which removes silicate impurity of the ore as slag.

$$CaCO_3 \xrightarrow{1100\,K} CaO + CO_2$$
$$C + CO_2 \longrightarrow 2CO$$
$$CaO + SiO_2 \longrightarrow CaSiO_3$$

(c) **Upper zone of the blast furnace:** Temperature range in this zone is 500-800 K.

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$
$$3Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$$
$$Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$$

Impure iron obtained from blast furnace is known as pig iron and cast into pigs (blocks). It contains 4-5 percent of carbon along with some phosphorus, silicon, manganese and sulphur.

Cast iron contains a less percentage of carbon (1.8 to 3 percent) made by melting pig iron with scrap iron and coke using hot air blast.

S105. Reduction of iron oxide in blase furnace:

(a) **Lower zone of the blast furnace:**

$$C + O_2 \longrightarrow CO_2 + Heat$$
$$C + CO_2 \longrightarrow 2CO$$

Coke is burnt to give temperature up to 2200 K at lower part of the blast furnace.

(b) **Middle zone of the blast furncace:** CO and heat move up in the furnace. The temperature range in the middle zone of the blast furnace is 900-1500 K.

$$FeO + CO \longrightarrow Fe + CO_2$$

Lime stone is also decomposed to CaO which removes silicate impurity of the ore as slag.

$$CaCO_3 \xrightarrow{1100\,K} CaO + CO_2$$
$$C + CO_2 \longrightarrow 2CO$$
$$CaO + SiO_2 \longrightarrow CaSiO_3$$

(c) **Upper zone of the blast furnace:** Temperature range in this zone is 500-800 K.

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$
$$3Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$$
$$3Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$$

Impure iron obtained from blast furnace is known as pig iron and cast into pigs (blocks). It contains 4-5 percent of carbon along with some phosphorus, silicon, manganese and sulphur.

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(a) **Lower zone of the blast furnace:**

$$C + O_2 \longrightarrow CO_2 + Heat$$
$$C + CO_2 \longrightarrow 2CO$$

Coke is burnt to give temperature up to 2200 K at lower part of the blast furnace.

(b) **Middle zone of the blast furncace:** CO and heat move up in the furnace. The temperature range in the middle zone of the blast furnace is 900-1500 K.

$$FeO + CO \longrightarrow Fe + CO_2$$

Lime stone is also decomposed to CaO which removes silicate impurity of the ore as slag.

$$CaCO_3 \xrightarrow{1100\,K} CaO + CO_2$$
$$C + CO_2 \longrightarrow 2CO$$
$$CaO + SiO_2 \longrightarrow CaSiO_3 \textbf{ (slag)}$$

(c) **Upper zone of the blast furnace:** Temperature range in this zone is 500-800 K.

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$
$$3Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$$
$$Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$$

Impure iron obtained from blast furnace is known as pig iron and cast into pigs (blocks). It contains 4-5 percent of carbon along with some phosphorus, silicon, manganese and sulphur.

Cast iron contains a less percentage of carbon (1.8 to 3 percent) made by melting pig iron with scrap iron and coke using hot air blast.

S107.(a) **Distillation:** This process is used for volatile metals.

Impure metal is heated in a retort and its vapours are separately condensed in a receiver. The non-volatile impurities are left behind.

e.g., Zn, Cd, Hg, etc. are purified by this method.

(b) Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(c) Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

S108.(a) **Zone refining** is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) **Chromatographic method** is based on the principle that different components of a mixture are differently adsorbed on an adsorbent. The adsorbed components are removed (eluted) by using suitable eluent. There are several chromatographic techniques such as paper chromatography, colum chromotagraphy, gas chromatography, etc.

S109.(a) Mond's process: Impure nickel is treated with carbon monoxide at 60-80°C to form volatile nickel carbonyl which decomposes to give pure nickel at 180°C.

$$\underset{\text{Impure}}{Ni} + 4CO \longrightarrow \underset{\text{Pure}}{Ni} + 4CO$$

(b) Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

S110. Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

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At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

S111.(a) Zinc is refined by electrolytic refining.

In this method, the impure metal is made to act as anode. Strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic both containing solule salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

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(b) **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(i) The metal should form a volatile compound with an available reagent.

(ii) The volatile compound should be easily decomposable, so that the recovery is easy.

S112. The term chromatography was derived from the Greek word “chroma”, meaning colour and “graphy”, for writting. It was used for the first time to separate the colour pigments of plants. Chromatography is a technique for analysing or separating mixtures of gases, liquids or dissolved substances.

The criterion of selecting, the stationary phase depends on the different adsorbing powers of the components of a mixture to be separated.

Generally used adsorbent material is silica gel or alumina. The adsorbent can be spread over a flat glass plate (thin-layer chromatography) or taken in a glass tube (column chromatorgaphy).

In paper chromatography, the stationary phase is water held in the pores of the paper. Here, the separation depends upon the different distribution of the components between water in stationary phase and the element.

S113. (a) Zone refining is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) **Vapour phase refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

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At anode: $Zn \longrightarrow Zn^{2+} + 2e^-$

At cathode: $Zn^{2+} + 2e^- \longrightarrow Zn$

S114. (a) **Zone refining** is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

(b) **Refining by liquation:** In this method a low melting metal like tin is heated on a sloping surface of a reverberatory furnace. Metal melts and flows down leaving impurities behind.

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