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6 General Principles and Processes of Isolation of Elements

I. Multiple Choice Questions (Type-I)

1. In the extraction of chlorine by electrolysis of brine _____ .
   (*i*) oxidation of Cl^- ion to chlorine gas occurs.
   (*ii*) reduction of Cl^- ion to chlorine gas occurs.
   (*iii*) For overall reaction $\Delta G^\ominus$ has negative value.
   (*iv*) a displacement reaction takes place.

Ans. (*i*)

Explanation: $2H_2O(l) + 2Cl^-(aq) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$
The $\Delta G^\ominus$ for this reaction is + 422 kJ. When it is converted to $E^\ominus$ (using $\Delta G^\ominus = -nE^\ominus F$), we get $E^\ominus = -2.2$ V. Naturally, it will require an external e.m.f. that is greater than 2.2 V. But the electrolysis requires an excess potential to overcome some other hindering reactions. Thus, Cl_2 is obtained by electrolysis giving out H_2 and aqueous NaOH as byproducts. Electrolysis of molten NaCl is also carried out. But in that case, Na metal is produced and not NaOH.

2. When copper ore is mixed with silica, in a reverberatory furnace copper matte is produced. The copper matte contains _____ .
   (*i*) sulphides of copper (II) and iron (II)
   (*ii*) sulphides of copper (II) and iron (III)
   (*iii*) sulphides of copper (I) and iron (II)
   (*iv*) sulphides of copper (I) and iron (III)

Ans. (*iii*)

Explanation: the ore is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slags of' as iron silicate and copper is produced in the form of copper matte. This contains Cu_2S and FeS.

$$FeO + SiO_2 \rightarrow FeSiO_3 \text{ (slag)}$$

3. Which of the following reactions is an example of autoreduction?
   (*i*) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$
   (*ii*) $Cu_2O + C \rightarrow 2Cu + CO$
   (*iii*) $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$
   (*iv*) $Cu_2O + \frac{1}{2}Cu_2S \rightarrow 3Cu + \frac{1}{2}SO_2$

Ans. (*iv*)

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Explanation: In this reaction copper (I) oxide is reduced by copper (I) sulphide. Here copper is reduced by itself hence this process is known as autoreduction.

4. A number of elements are available in earth's crust but most abundant elements are _____ .
   (*i*) Al and Fe (*ii*) Al and Cu
   (*iii*) Fe and Cu (*iv*) Cu and Ag

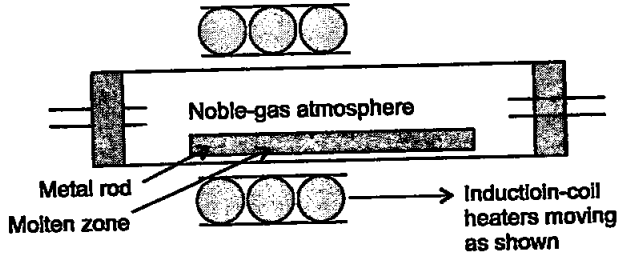
Ans. (*i*)

Explanation: Among metals, aluminium is the third most abundant element in earth's crust (8.3% approx. by weight). It is a major component of many igneous minerals including mica and clays. Iron is the second most abundant metal in the earth's crust.

5. Zone refining is based on the principle that _____ .
   (*i*) impurities of low boiling metals can be separated by distillation.
   (*ii*) impurities are more soluble in molten metal than in solid metal.
   (*iii*) different components of a mixture are differently adsorbed on an adosrbent.
   (*iv*) vapours of volatile compound can be decomposed in pure metal.

Ans. (*ii*)

Explanation: In zone refining method a circular mobile heater is fixed at one end of a rod of the impure metal. The molten zone moves along with the heater which is moved forward. As the heater moves forward, the pure metal crystallises out of the melt and the impurities pass on into the adjacent molten zone (See given Fig.).



6. In the extraction of copper from its sulphide ore, the metal is formed by the reduction of Cu_2O with
   (*i*) FeS (*ii*) CO
   (*iii*) Cu_2S (*iv*) SO_2

Ans. (*iii*)

Explanation: $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

The solidified copper obtained has blistered appearance due to the evolution of SO_2 and so it is called blister copper.

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7. Brine is electrolysed by using inert electrodes. The reaction at anode is _____.

(*i*) $Cl^-(aq.) \rightarrow \frac{1}{2}Cl_2(g) + e^-$; $E^\ominus_{Cell} = 1.36V$

(*ii*) $2H_2O(l) \rightarrow O_2(g) + 4H^+ + 4e^-$; $E^\ominus_{Cell} = 1.23V$

(*iii*) $Na^+(aq.) + e^- \rightarrow Na(s)$; $E^\ominus_{Cell} = 2.71V$

(*iv*) $H^+(aq.) + e^- \rightarrow \frac{1}{2}H_2(g)$; $E^\ominus_{Cell} = 0.00V$

Ans. (*i*)

Explanation: The reaction at anode with lower value of $E^\ominus_{Cell}$ is preferred but due to overvoltage oxygen cannot be obtained in this process.

8. In the metallurgy of aluminium _____.

(*i*) Al^{3+} is oxidised to Al (s).

(*ii*) graphide anode is oxidised to carbon monoxide and carbon dioxide.

(*iii*) oxidation state of oxygen changes in the reaction at anode.

(*iv*) oxidation state of oxygen changes in the overall reaction involved in the process.

Ans. (*ii*)

Explanation: $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$

This process of electrolysis is widely known as Hall-Heroult process. Thus electrolysis of the molten mass is carried out in an electrolytic cell using carbon electrodes. The oxygen liberated at anode reacts with the carbon of anode producing CO and CO_2.

9. Electrolytic refining is used to purify which of the following metals?

(*i*) Cu and Zn (*ii*) Ge and Si

(*iii*) Zr and Ti (*iv*) Zn and Hg

Ans. (*i*)

Explanation: Zinc and copper can be purified by electrolytic method. In this method, the impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal.

The more basic metal remains in the solution and the less basic ones go to the anode mud.

10. Extraction of gold and silver involves leaching the metal with CN– ion. The metal is recovered by _____.

(*i*) displacement of metal by some other metal from the complex ion.

(*ii*) roasting of metal complex.

(*iii*) calcination followed by roasting.

(*iv*) thermal decomposition of metal complex.

Ans. (*i*)

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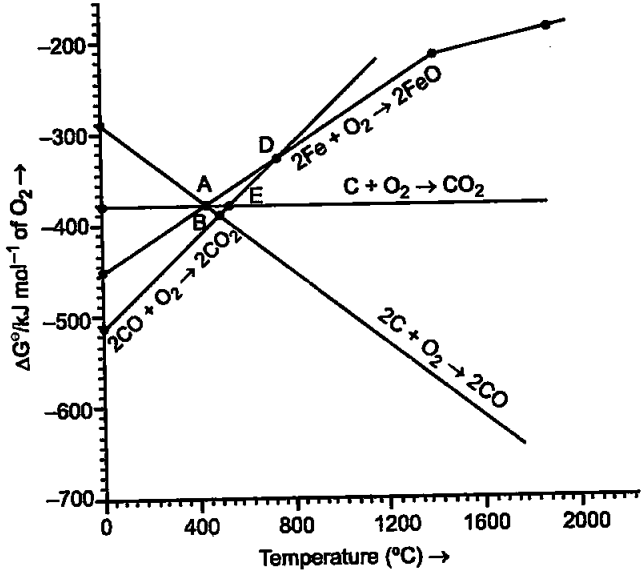
Explanation: Extraction of gold and silver involves leaching the metal with CN^-. This is also an oxidation reaction ($Ag \rightarrow Ag^+$ or $Au \rightarrow Au^+$). The metal is later recovered by displacement method.

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

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

Note: Answer the questions 11-13 on the basis of figure.



11. Choose the correct option of temperature at which carbon reduces FeO to iron and produces CO.
    (*i*) Below temperature at point A.
    (*ii*) Approximately at the temperature corresponding to point A.
    (*iii*) Above temperature at point A but below temperature at point D.
    (*iv*) Above temperature at point A.

Ans. (*iv*)

Explanation: At temperatures above point A, the C, CO line comes below the Fe, FeO line [$\Delta G_{(C, CO)} < \Delta G_{(Fe, FeO)}$]. So in this range, coke will be reducing the FeO and will itself be oxidised to CO.

12. Below point 'A' FeO can _____.
    (*i*) be reduced by carbon monoxide only.
    (*ii*) be reduced by both carbon monoxide and carbon.
    (*iii*) be reduced by carbon only.
    (*iv*) not be reduced by both carbon and carbon monoxide.

Ans. (*i*)

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Explanation: Below the point A, Gibbs free energy change for the formation of CO_2 from CO has lower value than Gibb's free energy change for the formation of FeO. $\Delta G_{(Fe, FeO)}$. Hence FeO will be reduced by CO only below point A.

13. For the reduction of FeO at the temperature corresponding to point D, which of the following statements is correct?
    (*i*) ΔG value for the overall reduction reaction with carbon monoxide is zero.
    (*ii*) ΔG value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive.
    (*iii*) ΔG value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive.
    (*iv*) ΔG value for the overall reduction reaction with carbon monoxide is negative.

Ans. (*i*)

Explanation: At point D, ΔG curve for the formation of CO_2 from CO and FeO from Fe intersect each other therefore, overall reduction of FeO with CO is zero.

II. Multiple Choice Questions (Type-II)

Note: In the following questions two or more options may be correct.

14. At the temperature corresponding to which of the points in Fig. 6.1, FeO will be reduced to Fe by coupling the reaction $2FeO \rightarrow 2Fe + O_2$ with all of the following reactions?
    (*a*) $C + O_2 \rightarrow CO_2$ (*b*) $2C + O_2 \rightarrow 2CO$ and (*c*) $2CO + O_2 \rightarrow 2CO_2$
    (*i*) Point A (*ii*) Point B
    (*iii*) Point D (*iv*) Point E

Ans. (*ii*) and (*iv*)

Explanation: Below the point B and E, FeO will be reduced to Fe by all the three reactions shown above $\Delta G_{(C, CO)}$, $\Delta G_{(C, CO_2)}$, $\Delta G_{(CO, CO_2)}$ lie below $\Delta G_{(Fe, FeO)}$ curve at point B and E.

15. Which of the following options are correct?
    (*i*) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.
    (*ii*) In extraction of silver, silver is extracted as cationic complex.
    (*iii*) Nickel is purified by zone refining.
    (*iv*) Zr and Ti are purified by van Arkel method.

Ans. (*i*) and (*iv*)

Explanation: Cast iron is different from pig iron and is made by melting pig iron with scrap iron and coke using hot air blast.
→ van Arkel method is used for the refining of Zr and Ti

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The crude metal is heated in an evacuated vessel with iodine. The metal iodide being more covalent, volatilises:

$$Zr + 2I_2 \rightarrow ZrI_4$$

The metal iodide is decomposed on a tungsten filament, electrically heated to about 1800 K. The pure metal is thus deposited on the filament.

$$ZrI_4 \rightarrow Zr + 2I_2$$

16. In the extraction of aluminium by Hall-Heroult process, purified Al_2O_3 is mixed with CaF_2 to

(*i*) lower the melting point of Al_2O_3.
(*ii*) increase the conductivity of molten mixture.
(*iii*) reduce Al^{3+} into Al(s).
(*iv*) acts as catalyst.

Ans. (*i*) and (*ii*)

Explanation: In the metallurgy of aluminium, purified Al_2O_3 is mixed with Na_3AlF_6 or CaF_2 which lowers the melting point of the mix and brings conductivity.

17. Which of the following statements is correct about the role of substances added in the froth floation process?

(*i*) Collectors enhance the non-wettability of the mineral particles.
(*ii*) Collectors enhance the wettability of gangue particles.
(*iii*) By using depressants in the process two sulphide ores can be separated.
(*iv*) Froth stabilisers decrease wettability of gangue.

Ans. (*i*) and (*iii*)

Explanation: In froth floatation process, a suspension of the powdered ore is made with water. To it, collectors and froth stabilisers are added. Collectors (e.g., pine oils, fatty acids, xanthates, etc.) enhance non-wettability of the mineral particles and froth stabilisers (e.g., cresols, aniline) stabilise the froth.

18. In the Froth Floatation process, zinc sulphide and lead sulphide can be separated by _____.

(*i*) using collectors.
(*ii*) adjusting the proportion of oil to water.
(*iii*) using depressant.
(*iv*) using froth stabilisers.

Ans. (*ii*) and (*iii*)

Explanation: In froth floatation process it is possible to separate two sulphide ores by adjusting proportion of oil to water or by using 'depressants'. For example, in case of an ore containing ZnS and PbS, the depressant used is NaCN.

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19. Common impurities present in bauxite are _____.

(*i*) CuO (*ii*) ZnO

(*iii*) Fe_2O_3 (*iv*) SiO_2

Ans. (*iii*) and (*iv*)

Explanaion: The principal ore of aluminium, bauxite, usually contains SiO_2, iron oxides and titanium oxide (TiO_2) as impurities.

20. Which of the following ores are concentrated by froth floation?

(*i*) Haematite (*ii*) Galena

(*iii*) Copper pyrites (*iv*) Magnetite

Ans. (*ii*) and (*iii*)

Explanaion: Froth floatation method → is generally used for sulphide ore. Here galena (PbS) and copperpyrites ($CuFeS_2$) are sulphide ores.

21. Which of the following reactions occur during calcination?

(*i*) $CaCO_3 \rightarrow CaO + CO_2$

(*ii*) $2FeS_2 + \frac{11}{2} O_2 \rightarrow Fe_2O_3 + 4SO_2$

(*iii*) $Al_2O_3.x\,H_2O \rightarrow Al_2O_3 + x\,H_2O$

(*iv*) $ZnS + \frac{3}{2} O_2 \rightarrow ZnO + SO_2$

Ans. (*i*) and (*iii*)

Explanation: Calcinaton involves heating when the volatile matter escapes leaving behind the metal oxide. It is generally done in absence of air.

22. For the metallurgical process of which of the ores calcined ore can be reduced by carbon?

(*i*) haematite (*ii*) calamine

(*iii*) iron pyrites (*iv*) sphalerite

Ans. (*i*) and (*ii*)

Explanation: In metallurgical process the oxide ore can be reduced by carbon. Iron pyrite and sphalerite are sulphide ores that cannot be reduced by carbon.

23. The main reactions occurring in blast furnace during extraction of iron from haematite are _____.

(*i*) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(*ii*) $FeO + SiO_2 \rightarrow FeSiO_3$

(*iii*) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

(*iv*) $CaO + SiO_2 \rightarrow CaSiO_3$

Ans. (*i*) and (*iv*)

Explanation:

(*i*) It is the carbon monoxide which is the main reducing agent in the furnace.

(*ii*) This is an endothermic reaction, absorbing heat from the furnace. It is therefore important not to add too much limestone because it would

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otherwise cool the furnace. Calcium Oxide is a basic oxide and reacts with acidic oxides such as Silicon dioxide present in the rock. Calcium oxide reacts with silicon dioxide to give calcium silicate.

24. In which of the following method of purification, metal is converted to its volatile compound which is decomposed to give pure metal?

(*i*) heating with stream of carbon monoxide.

(*ii*) heating with iodine.

(*iii*) liquation. (*iv*) distillation.

Ans. (*i*) and (*ii*)

Explanation: In vapour phase refining method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal.

Mond process for refining Nickel: In this process, nickel is heated in a stream of carbon monoxide forming a volatile complex, nickel tetracarbonyl.

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

The carbonyl is subjected to higher temperature so that it is decomposed giving the pure metal:

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

The metal iodide being more covalent, volatilises:

$$Zr + 2I_2 \rightarrow ZrI_4$$

The metal iodide is decomposed on a tungsten filament, electrically heated to about 1800 K. The pure metal is thus deposited on the filament.

$$ZrI_4 \rightarrow Zr + 2I_2$$

25. Which of the following statements are correct?

(*i*) A depressant prevents certain type of particle to come to the froth.

(*ii*) Copper matte contains Cu_2S and ZnS.

(*iii*) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction.

(*iv*) Zinc can be extracted by self-reduction.

Ans. (*i*) and (*iii*)

Explanation:

(*i*) → depressant prevents certain type of particle to come to the froth for example, in case of an ore containing ZnS and PbS, the depressant used is NaCN.

(*ii*) → Copper matte contains Cu_2S and FeS.

(*iii*) → The solidified copper obtained has blistered appearance due to the evolution of SO_2 and so it is called blister copper.

(*iv*) → Zinc can be extracted from ZnO by reducing it with carbon.

26. In the extraction of chlorine from brine _____.

(*i*) $\Delta G^{\ominus}$ for the overall reaction is negative.

(*ii*) $\Delta G^{\ominus}$ for the overall reaction is positive.

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(*iii*) $E^{\ominus}$ for overall reaction has negative value.
(*iv*) $E^{\ominus}$ for overall reaction has positive value.

Ans. (*ii*) and (*iii*)

Explanation: Extraction of chlorine from brine (chlorine is abundant in sea water as common salt).

$2Cl^-(aq) + 2H_2O(l) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$

$\Delta G^{\ominus}$ for the reaction is 422 kJ. When it is converted to $E^{\ominus}$ (using $\Delta G^{\ominus} = -nE^{\ominus}F$), we get $E^{\ominus} = -2.2$ V. Naturally, it will require an external emf that is greater than 2.2 V. But the electrolysis requires an excess potential to overcome some other hindering reactions.

III. Short Answer Type

27. Why is an external emf of more than 2.2 V required for the extraction of Cl_2 from brine?

Ans. Extraction of chlorine from brine (chlorine is abundant in sea water as common salt).

$$2Cl^-(aq) + 2H_2O(l) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$$

$\Delta G^{\ominus}$ for this reaction is +422 kJ.

When it is converted to $E^{\ominus}$ (using $\Delta G^{\ominus} = -nE^{\ominus}F$), we get $E^{\ominus} = -2.2$ V. Naturally, it will require an external emf that is greater than 2.2 V.

28. At temperatures above 1073 K coke can be used to reduce FeO to Fe. How can you justify this reduction with Ellingham diagram?

Ans. At temperatures above 1073 K (approx.), the C,CO line comes below the Fe,FeO line [$\Delta G_{(C, CO)} < \Delta G_{(Fe, FeO)}$]. So in this range, coke will be reducing the FeO and will itself be oxidised to CO.

29. Wrought iron is the purest form of iron. Write a reaction used for the preparation of wrought iron from cast iron. How can the impurities of sulphur, silicon and phosphorus be removed from cast iron?

Ans. Wrought iron or malleable iron is the purest form of commercial iron and is prepared from cast iron by oxidising impurities in a reverberatory furnace lined with haematite. This haematite oxidises carbon to carbon monoxide:

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

Limestone is added as flux silicon, sulphur and phosphorus are oxidised and passed into the slag. The metal is removed and freed from the slag by passing through rollers.

30. How is copper extracted from low grade copper ores?

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

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

31. Write two basic requirements for refining of a metal by Mond process and by van Arkel Method.

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Ans. Two basic requirements for both processes 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 of metal is easy.

32. Although carbon and hydrogen are better reducing agents but they are not used to reduce metallic oxides at high temperatures. Why?

Ans. Carbon and hydrogen are not used to reduce metallic oxides at high temperatures as they react with metal at high temperature to form carbides and hydrides respectively.

33. How do we separate two sulphide ores by Froth Floatation Method? Explain with an example.

Ans. It is possible to separate two sulphide ores by adjusting proportion of oil to water or by using 'depressants'. For example, in case of an ore containing ZnS and PbS, the depressant used is NaCN. It selectively forms complex with ZnS prevents it from coming to the froth but allows PbS to come with the froth.

34. The purest form of iron is prepared by oxidising impurities from cast iron in a reverberatory furnace. Which iron ore is used to line the furnace? Explain by giving reaction.

Ans. Haematite ore is used to line the furnace. This haematite oxidises carbon to carbon monoxide:

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

35. The mixture of compounds A and B is passed through a column of Al_2O_3 by using alcohol as eluant. Compound A is eluted in preference to compound B. Which of the compounds A or B, is more readily adsorbed on the column?

Ans. Compound 'B' is more readily adsorbed on column. Since compound A is eluted in preference to B.

36. Why is sulphide ore of copper heated in a furnace after mixing with silica?

Ans. The sulphide ore of copper contains iron oxide as impurity. So, it is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slags of' as iron silicate and copper is produced in the form of copper matte. This contains Cu_2S and FeS.

$$FeO + SiO_2 \rightarrow \underset{\text{(Slag)}}{FeSiO_3}$$

Copper matte is then charged into silica lined convertor.

37. Why are sulphide ores converted to oxide before reduction?

Ans. Sulphide ores are very difficult to reduce while metal oxide can be reduced easily.

38. Which method is used for refining Zr and Ti? Explain with equation.

Ans. van Arkel method is very useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like Zr and Ti.

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The crude metal is heated in an evacuated vessel with iodine. The metal iodide being more covalent, volatilises.

$$Zr + 2I_2 \rightarrow ZrI_4$$

Metal iodide electrically heated to about 1800 K. The pure metal is thus deposited on the filament.

$$ZrI_4 \rightarrow Zr + 2I_2$$

39. What should be the considerations during the extraction of metals by electrochemical method?

Ans. For the reduction of molten metal electrolysis is done. Such methods are based on electrochemical principles which could be understood through the equation,

$$\Delta G^{\ominus} = -nE^{\ominus}F$$

Here n is the number of electrons and $E^{\ominus}$ is the electrode potential of the redox couple formed in the system. More reactive metals have large negative values of the electrode potential. So their reduction is difficult. If the difference of two $E^{\ominus}$ values corresponds to a positive $E^{\ominus}$ and consequently negative $\Delta G^{\ominus}$ in equation , then the less reactive metal will come out of the solution and the more reactive metal will go to the solution, e.g.,

$$Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$$

40. What is the role of flux in metallurgical processes?

Ans. Flux is used to remove gangue particle from the ore and it also make the molten mass more conducting.

41. How are metals used as semiconductors refined? What is the principle of the method used?

Ans. Zone refining method is very useful for producing semiconductor and other metals of very high purity, e.g., germanium, silicon, boron, This method is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal. A circular mobile heater is fixed at one end of a rod of the impure metal. The molten zone moves along with the heater which is moved forward. As the heater moves forward, the pure metal crystallises out of the melt and the impurities pass on into the adjacent molten zone. The process is repeated several times and the heater is moved in the same direction. At one end, impurities get concentrated.

42. Write down the reactions taking place in Blast furnace related to the metallurgy of iron in the temperature range 500–800 K .

Ans. At 500 – 800 K (lower temperature range in the blast furnace):

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

43. Give two requirements for vapour phase refining.

Ans. The two requirements for vapour phase refining are:

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

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

44. Write the chemical reactions involved in the extraction of gold by cyanide process. Also give the role of zinc in the extraction.

Ans. Extraction of gold and silver involves leaching the metal with CN^-. This is also an oxidation reaction.

$$(Ag \rightarrow Ag^+ \text{ or } Au \rightarrow Au^+).$$

The metal is later recovered by displacement method.

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

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

In this reaction zinc acts as a reducing agent.

IV. Matching Type

Note : Match the items given in Column I and Column II in the following questions:

45. Match the items of Column I with items of Column II and assign the correct code:

Column I		Column II	
(A)	Pendulum	(1)	Chrome steel
(B)	Malachite	(2)	Nickel steel
(C)	Calamine	(3)	Na_3AlF_6
(D)	Cryolite	(4)	$CuCO_3.Cu(OH)_2$
		(5)	$ZnCO_3$

Code :

(*i*) A (1) B (2) C (3) D (4) (*ii*) A (2) B (4) C (5) D (3)

(*iii*) A (2) B (3) C (4) D (5) (*iv*) A (4) B (5) C (3) D (2)

Ans. (*ii*)

Explanation:

A. Pendulum is made up of nickel steel

B. Malachite – $CuCO_3Cu(OH)_2$

C. Calamine – $ZnCO_3$

D. Cryolyte – Na_3AlF_6

46. Match the items of Column I with the items of Column II and assign the correct code :

Column I		Column II	
(A)	Coloured bands	(1)	Zone refining
(B)	Impure metal to volatile complex	(2)	Fractional distillation
(C)	Purification of Ge and Si	(3)	Mond Process
(D)	Purification of mercury	(4)	Chromatography
		(5)	Liquation

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Code :

(*i*) A (1) B (2) C (4) D (5) (*ii*) A (4) B (3) C (1) D (2)
(*iii*) A (3) B (4) C (2) D (1) (*iv*) A (5) B (4) C (3) D (2)

Ans. (*ii*)

Explanation:

A. Coloured bands are observed in chromatography.
B. Monds process is used to convert impure metal into volatile complex compound.
C. Ge and Si can be purified by zone refining method.
D. Distillation is done for low boiling metal like mercury.

47. Match items of Column I with the items of Column II and assign the correct code :

Column I		Column II	
(A)	Cyanide process	(1)	Ultrapure Ge
(B)	Froth Floatation Process	(2)	Dressing of ZnS
(C)	Electrolytic reduction	(3)	Extraction of Al
(D)	Zone refining	(4)	Extraction of Au
		(5)	Purification of Ni

Code :

(*i*) A (4) B (2) C (3) D (1) (*ii*) A (2) B (3) C (1) D (5)
(*iii*) A (1) B (2) C (3) D (4) (*iv*) A (3) B (4) C (5) D (1)

Ans. (*i*)

Explanation:

A. For the extraction of Au, cyanide process is used.
B. Froth floatation process is used for sulphide ore like for ZnS.
C. Electrolytic reduction can be used for the extraction of Al.
D. Zone refining is used for ultrapure Ge.

48. Match the items of Column I with the items of Column II and assign the correct code :

Column I		Column II	
(A)	Sapphire	(1)	Al_2O_3
(B)	Sphalerite	(2)	NaCN
(C)	Depressant	(3)	Co
(D)	Corundum	(4)	ZnS
		(5)	Fe_2O_3

Code :

(*i*) A (3) B (4) C (2) D (1) (*ii*) A (5) B (4) C (3) D (2)
(*iii*) A (2) B (3) C (4) D (5) (*iv*) A (1) B (2) C (3) D (4)

Ans. (*i*)

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Explanation:

A. Sapphire is a gemstone containing Co

B. Sphalerite single is ZnS

C. NaCN is used as depressant

D. Al_2O_3 is known as corundum

49. Match the items of Column I with items of Column II and assign the correct code :

Column I		Column II	
(A)	Blisterred Cu	(1)	Aluminium
(B)	Blast furnace	(2)	$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$
(C)	Reverberatory furnace	(3)	Iron
(D)	Hall-Heroult process	(4)	$FeO + SiO_2 \rightarrow FeSiO_3$
		(5)	$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

Code :

(*i*) A (2) B (3) C (4) D (1) (*ii*) A (1) B (2) C (3) D (5)

(*iii*) A (5) B (4) C (3) D (2) (*iv*) A (4) B (5) C (3) D (2)

Ans. (*i*)

Explanation:

A. $\rightarrow 2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$ (6.40)
The solidified copper obtained has blistered appearance due to the evolution of SO_2 and so it is called blister copper.

B. Iron is extracted from blast furnace

C. $\rightarrow$ The ore is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slags of' as iron silicate and copper is produced in the form of copper matte.

$$FeO + SiO_2 \rightarrow FeSiO_3$$

D. $\rightarrow$ Hall-Heroult process single is used for the extraction of Al.

V. Assertion and Reason Type

Note : In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(*i*) Both assertion and reason are true and reason is the correct explanation of assertion.

(*ii*) Both assertion and reason are true but reason is not the correct explanation of assertion.

(*iii*) Assertion is true but reason is false.

(*iv*) Assertion is false but reason is true.

(*v*) Assertion and reason both are wrong.

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50. Assertion : Nickel can be purified by Mond process.
Reason : $Ni(CO)_4$ is a volatile compound which decomposes at 460K to give pure Ni.

Ans. (*i*)

Explanation: Nickel is heated in a stream of carbon monoxide forming a volatile complex, nickel tetracarbonyl which on further decomposition gives pure Ni. This process is called Mond process.

$$Ni + 4CO \xrightarrow{330-450\ K} Ni(CO)_4$$

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

51. Assertion : Zirconium can be purificed by van Arkel method.
Reason : ZrI_4 is volatile and decomposes at 1800 K.

Ans. (*i*)

Explanation: van Arkel method is very useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like Zr and Ti. The crude metal is heated in an evacuated vessel with iodine. The metal iodide being more covalent, volatilises and then decomposes at 1800 K to given pure Zr.

$$Zr + 2I_2 \rightarrow ZrI_4$$

$$ZrI_4 \xrightarrow{1800\ K} Zr + 2I_2$$

52. Assertion : Sulphide ores are concentrated by Froth Flotation method.
Reason : Cresols stabilise the froth in Froth Flotation method.

Ans. (*ii*)

Explanation: Sulphide ores are concentrated by froth floatation process. This process is used for removing gangue from sulphide ore.

53. Assertion : Zone refining method is very useful for producing semiconductors.
Reason : Semiconductors are of high purity.

Ans. (*ii*)

Explanation: Zone refining method is very useful for producing semiconductor and other metals of very high purity, e.g., germanium

54. Assertion : Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation by a more electropositive metal.
Reason : Copper is extracted by hydrometallurgy.

Ans. (*ii*)

Explanation: Copper is extracted by hydrometallurgy from low grade ore. Hydrometallurgy involves dissolving the ore in suitable reagent followed by precipitation in this method more electropositive metal is used by which pure metal can be displaced.

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VI. Long Answer Type

55. Explain the following:

(*a*) CO_2 is a better reducing agent below 710 K whereas CO is a better reducing agent above 710 K.

(*b*) Generally sulphide ores are converted into oxides before reduction.

(*c*) Silica is added to the sulphide ore of copper in the reverberatory furnace.

(*d*) Carbon and hydrogen are not used as reducing agents at high temperatures.

(*e*) Vapour phase refining method is used for the purification of Ti.

Ans. (*a*) From Ellingham diagram it is clear that above 710 K $\Delta G_{(C, CO2)} < \Delta G_{(C, CO)}$. So CO_2 is better reducing agent below 710 K whereas CO is better reducing agent above 710 K.

(*b*) Sulphide ores are difficult to reduce that is why it is converted into oxide before reduction.

(*c*) Sulphide ore of copper contains iron oxide as impurity. So the ore is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slags of' as iron silicate and copper is produced in the form of copper matte.

(*d*) At high temperature carbon and hydrogen reacts with metal to form metal carbides and hydrides respectively.

(*e*) Ti can form volatile compound (I_1I_4) with the iodine and the compound is easily decomposible to give extra pure Ti. So the recovery is easy.

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