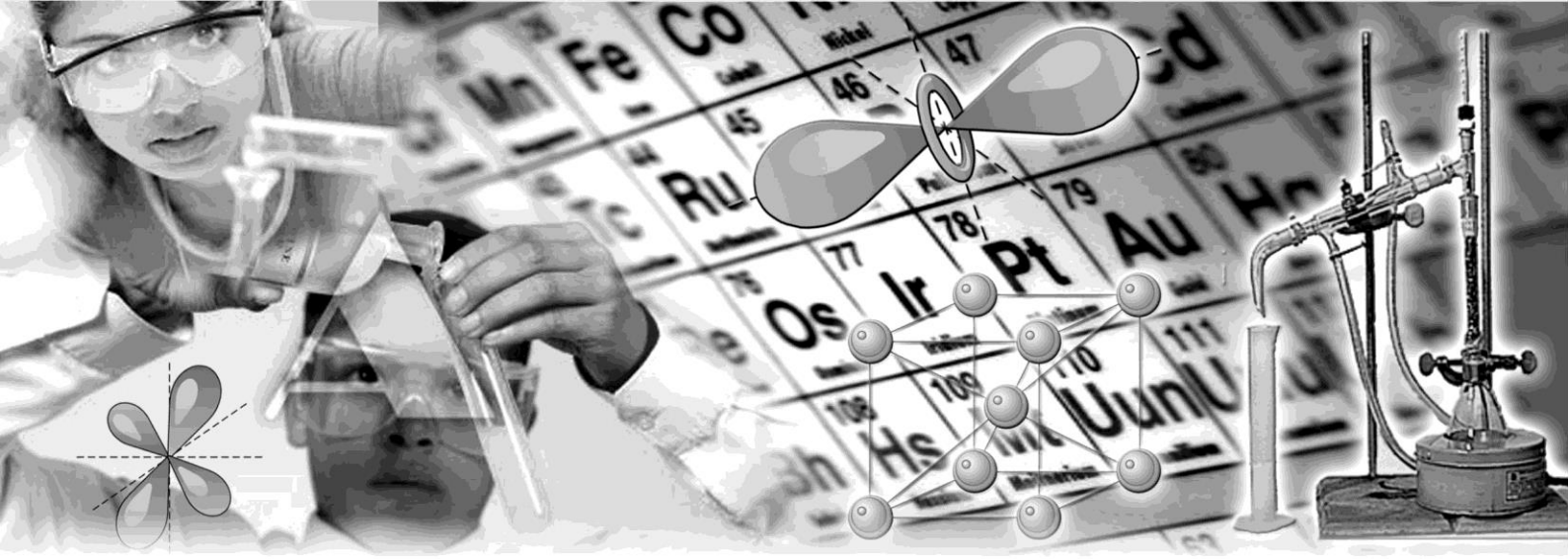


Chapter

16

General Principles of Extraction of Metals

All the materials found in the earth are composed of elements. There are about 112 elements known which constitute the entire matter on the earth. Therefore, the elements are regarded as the building blocks of the universe. These are distributed in all the three main parts of the earth; atmosphere and lithosphere. Among these, lithosphere constitutes the main source of most of the elements. The elements have been broadly divided into metals and non-metals on the basis of their physical and chemical properties.

Occurrence of Metals

Element which have low chemical reactivity generally occur ***native*** or ***free*** or ***metallic*** state. e.g. *Au, Pt,* noble gas etc**.** Element which are chemically reactive, generally occur in the ***combined state***. e.g. halogens, chalcogens etc. The natural materials in which the metals occur in the earth are called ***minerals***. The mineral from which the metal is conveniently and economically extracted is called an ***ore***. *All the ores are minerals but all minerals cannot be ores.* Ores may be divided into four groups,

(1) Metallic core (siderophile) of the earth crust contains (*Mn, Fe, Co, Ni, Cu, Ru, Rb, Pd, Ag, Re, Os, Ir, Pt, Au). Entire composition of metals in earth crust may be given as,*

Al (8.3%); *Ca*(3.6%); *Na* (2.8%); *K* (2.6%); *Mg* (2.1%); *Ti* (0.4%); *Mn* (0.1%); *Fe* (5.1%) other metals (0.1%).

(i) ***Native ores*** **:** These ores contain metals in free state, e.g., silver, gold, platinum, mercury, copper, etc. These are found usually associated with rock or alluvial materials like clay, sand, etc. sometimes lumps of pure metals are also found. These are termed **nuggets**. Iron is found in free state as meteroites which also have 20 to 30% nickel.

(ii) ***Sulphurised and arsenical ores*** **:** These ores consist of sulphides and arsenides in simple and complex forms of metals. Important ores of this group are

Metal	Name of the ore	Composition
Pb	Galena	*PbS*
Zn	Zinc blende	*ZnS*
Hg	Cinnabar	*HgS*
Ag	Argentite or silver glance Pyrargyrite or ruby silver	Ag_2S $3Ag_2S.Sb_2S_3$
Fe	Iron pyrites	FeS_2
Ni	Kupfer nickel	*NiAs*
Cu	Copper pyrites	$CuFeS_2$
	Chalcocite or Copper glance	Cu_2S

(iii) ***Oxidised ores*** **:** In these ores, metals are present as their oxides or oxysalts such as carbonates, nitrates, sulphates, phosphates, silicates, etc.

Important ores of this group are listed below,

Oxides

Haematite	Fe_2O_3
Magnetite	Fe_3O_4
Limonite	$Fe_2O_3.3H_2O$
Bauxite	$Al_2O_3.2H_2O$
Corundum	Al_2O_3
Diaspore	$Al_2O_3.H_2O$
Chromite	$FeO.Cr_2O_3$

Chromeochre	Cr_2O_3
Tinstone (Cassiterite)	SnO_2
Chrysoberyl	$BeO.Al_2O_3$
Cuprite (Ruby copper)	Cu_2O
Pyrolusite	MnO_2
Zincite	ZnO
Rutile	TiO_2
Ilmenite	$FeO.TiO_2$

Carbonates

Magnesite	$MgCO_3$
Lime stone	$CaCO_3$
Dolomite	$CaCO_3.MgCO_3$
Calamine	$ZnCO_3$
Malachite	$CuCO_3.Cu(OH)_2$
Azurite	$Cu(OH)_2.2CuCO_3$
Cerussite	$PbCO_3$
Siderite	$FeCO_3$

Nitrates

Chile saltpetre	$NaNO_3$
Salt petre	KNO_3

Sulphates

Epsom salt	$MgSO_4.7H_2O$
Barytes	$BaSO_4$
Gypsum	$CaSO_4.2H_2O$
Glauber's salt	$Na_2SO_4.10H_2O$
Anglesite	$PbSO_4$
Kainite	$KCl.MgSO_4.3H_2O$
Schonite	$K_2SO_4.MgSO_4.6H_2O$
Polyhalite	$K_2SO_4.MgSO_4.CaSO_4.2H_2O$

Phosphates and Silicates

Lepidolite (an ore of lithium)	$(Li, Na, K)_2 Al_2(SiO_3)_3 (F,OH)_2$
Petalite (an ore of lithium)	$LiAl(Si_2O_5)_2$
Triphylite (an ore of lithium)	$(Li, Na)_3PO_4$, $(Fe, Mn)_3 (PO_4)_2$
Beryl (an ore of berylium)	$3BeO.Al_2O_3.6SiO_2$
Willemite	Zn_2SiO_4
China clay	$Al_2O_3.2SiO_2.2H_2O$
Chlor-apatite	$3Ca_3(PO_4)_2.CaCl_2$
Mica	$K_2O.3Al_2O_3.6SiO_2.2H_2O$
Fluor-apatite	$3Ca_3(PO_4)_2.CaF_2$
Felspar	$KAlSi_3O_8$
Talc	$Mg_2(Si_2O_5).Mg(OH)_2$
Asbestos	$CaMg_3.(SiO_3)_4$

(iv) ***Halide ores*** **:** Metallic halides are very few in nautre. Chlorides are most common. For example.

Common salt $NaCl$; Horn silver $AgCl$

Carnallite $KCl.MgCl_2.6H_2O$

The important fluoride ores are

Fluorspar CaF_2 ; Cryolite Na_3AlF_6

Metals in Biology

Metals are also found in living organisms, e.g.,

(1) Magnesium is found in chlorophyll.

(2) Potassium is present in plant roots.

(3) Manganese, Iron and copper are present in chloroplast. (4) Zinc is present in eyes of cats and cows.

(5) Iron is present in haemoglobin.

(6) Calcium is present in bones.

(7) Vanadium is present in cucumbers.

(8) Chromium is present in prown.

Extraction of Metals: Metallurgy

The extraction of a pure metal from its ore is called ***metallurgy*****.** In order to extract the metal from ores, several physical and chemical methods are used. The method used depending upon chemical properties and nature of the ore from which it is to be extracted. It involves four main steps,

(1) Crushing and grinding of the ore.

(2) Concentration or dressing of the ore.

(3) Reduction to free metal.

(4) Purification or refining of the metal.

(1) **Crushing and grinding of the ore :** Those ores occur in nature as huge lumps. They are broken to small pieces with the help of *crushers or grinders*. These pieces are then reduced to fine powder with the help of a ***ball mill or stamp mill*****.** This process is called ***pulverisation*****.**

(2) **Concentration or dressing of the ore :** The ore are usually obtained from the ground and therefore contained large amount of unwanted impurities, e.g., earthing particles, rocky matter, sand, limestone etc. These impurities are known collectively as ***gangue*** or ***matrix***. It is essential to separate the large bulk of these impurities from the ore to avoid bulk handling and in subsequent fuel costs. The removal of these impurities from the ores is known as ***concentration***. The concentration is done by physical as well as chemical methods.

Physical Methods (i) ***Gravity Separation or levigation*****:** This process of concentration is based on the difference in the specific gravity of the ore and gangue.

Crushed

The sieved ore is either subjected to dry centrifugal separation or is placed in big shallow tanks in which a strong current of water blows. Heavy ore particles settle down to the bottom of the tanks while lighter gangue particles are carried away by the current of water. The process removes most of the soluble and insoluble impurities. For this purpose wilfley table and hydraulic classifier are widely used. The method is particularly suitable for heavy oxide and carbonate ores like *Cassiterite* (SnO_2) and haematite.

(ii) ***Froth floatation process*** **:** In some cases for example, sulphides ores of copper, zinc and lead concentration is brought by this method. In this method advantage is taken of the preferential wetting of the ore by an oil. The finely ground ore is taken in a tank containing water and 1% **of pine oil or terpentine oil**. A strong current of air is blown through the suspension, producing a heavy froth or foam on the surface. The metal sulphide is wetted by the oil but the gangues is not and the sulphide-oil mixture is carried to the surface by films of oil The froth is skimmed off, the gangue settles down on the bottom or remains underneath the froth. By this floatation method it is possible to concentrate over 90% of a sulphite ore to 1/10 of its original bulk.

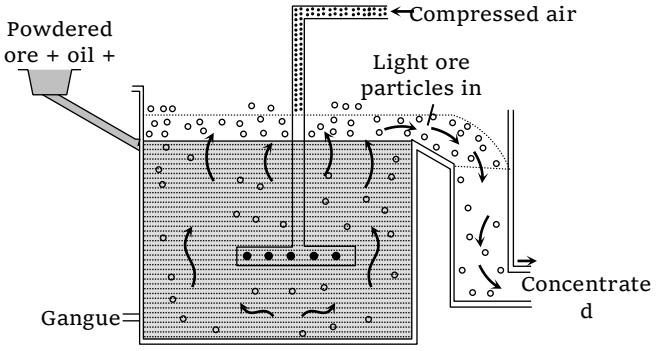


Fig. 16.2. ***Froth floatation process***

(ii) ***Activators and Depressants*** **:** During the floatation process of some ores, these substances are added which activate or depress the floatation property of the minerals and thus help in the separation of minerals present in the ore. For instance, galena (*PbS*) is usually associated with sphalerite (*ZnS*) and pyrites (FeS_2). Concentration of galena is carried out by passing potassium ethyl xanthate (**Collector**) along with sodium cynamide and alkali (**depressants**) where by the floatation property of *ZnS* and FeS_2 is depressed. Mainly *PbS* passes into the froth when air current in flown in, which is collected. After *PbS* is removed with the froth, same $CuSO_4$ (**activator**) is added and air is blown. The floatation property of *ZnS* is increased which is now removed with the froth. The slurry is acidified and process is repeated when FeS_2 passed into the froth and is collected.

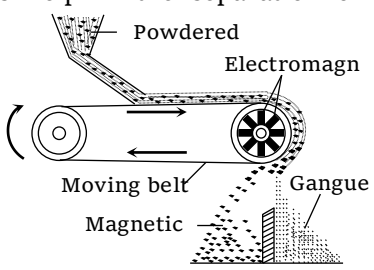


Fig. 16.3 ***Electromagnetic separation***

(iii) ***Electromagnetic separation*** **:** If the mineral and not gangue is attracted by a magnet, it can be concentrated by magnetic separation. For example **chromite** ore, $FeCr_2O_4$ being magnetic can be separated from non–magnetic silicons impurities by this method. Sometimes two minerals occur together, in which one happens to be magnetic. By magnetic separation method the nonmagnetic minerals is separated from the magnetic mineral. For example **tin–stone or cassiterite**, SnO_2 (non-magnetic) containing **wolfram**, $FeWO_4$ (magnetic) is separated by this method. In this method a thin layer of finely ground ore is spread over a rubber belt carried over a pulley in a magnetic field. The gangue particles or the particles of non–magnetic mineral fall off as the belt becomes vertical, and the magnetic particles collect.

Chemical methods (i) ***Calcination*** **:** In this process the concentrated ore is heated in a suitable furnace generally in reveratory furnace much below its **melting point** in absence of air. As a result of which the ore dries up and moisture and volatile impurities are driven off and carbonates are converted into oxides and the ore becomes porous. For example,

$$Al_2O_3.2H_2O \rightarrow Al_2O_3 + 2H_2O$$

$$2Fe_2O_3.3H_2O \rightarrow 2Fe_2O_3 + 6H_2O$$

$$ZnCO_3 \rightarrow ZnO + CO_2 \;\; ; \;\; CaCO_3 \rightarrow CaO + CO_2$$

$$CuCO_3.Cu(OH)_2 \rightarrow 2CuO + CO_2 + H_2O$$

(ii) ***Roasting*** **:** The process of heating the ores strongly in presence of air with or without certain substances, below its melting point is termed as roasting. It differs from calcination in the respect that heating is done in presence of air and at a higher temperature. In this process the **impurities of sulphur and arsenic** etc. are volatilized away as oxides and the ore is converted into oxide. For example zinc oxide is formed by the oxidation of zinc blende,

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(iii) ***Leaching*** **:** It involves the treatment of the ore with a suitable reagent as to make it soluble while impurities remain insoluble. The ore is recovered from the solution by suitable chemical method. For example, the chief ore of aluminium, bauxite ($Al_2O_3.2H_2O$) contains varying amounts of ferric oxides, titanium oxide and silica. Since alumina is amphoteric, it can be separated

from the other two oxides. Finely powdered bauxite is digested with caustic soda solution at 150–170°C under pressure for some hours. Alumina dissolves forming soluble sodium aluminate.

$Al_2O_3.\ 2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

The impurities remain unaffected and separated as insoluble red mud which is filtered off. The filtrate is diluted and some freshly precipitated aluminium hydroxide is added when $Al(OH)_3$ is precipitated as follows,

$NaAlO_2 + 2H_2O \rightarrow NaOH + Al(OH)_3$

The precipitated hydroxide is filtered off and calcified to get highly pure aluminium oxide (alumina).

$$2Al(OH)_3 \xrightarrow{\text{calcination}} Al_2O_3 + 3H_2O$$

Gold and silver are also extracted from their native ores by Leaching (Mac-Arthur forest cyanide process).

(3) **Reduction to free metal :** Some of the methods commonly used to get free metal from the concentrated ore are given below,

(i) ***Smelting*** **:** The process of extracting a metal in the state of fusion is called ***smelting***. In this process the ore is mixed with carbon, obtained after the above reactions and heated in suitable furnace. A suitable *flux* is added during the operation to convert the non–fusible gangue to fusible slag. The metallic oxide is reduced by carbon and the metal may be obtained in the molten state or as vapours which are condensed. Metals like tin, zinc or lead are obtained by this process.

$SnO_2 + 2C \rightarrow Sn + 2CO$; $ZnO + C \rightarrow Zn + CO$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Flux and slag : Flux is a substance that is added during smelting to convert infusible silicons or earthy impurities into fusible material known as slag. **Impurities + Flux = Slag**. The slag is immiscible with the metal and has a low melting point and density. The slag floats on the metal and protects it from oxidation. It is removed from the furnance through the slag hole. If the impurities in the ore are acidic (SiO_2) in nature, a basic flux e.g., *CaO, MgO, FeO* etc. are added; and if the impurities are basic (*CaO, FeO*, etc.) then on acidic flux (SiO_2) is used. The gangue or matrix present in the ore is refractory or non–fusible in nature but it reacts with the flux forming fusible slag which does not mix with the molten metal and forms the upper layer. Slag are usually silicates.

$$\underset{\text{Flux}}{CaO} + \underset{\text{Impurities}}{SiO_2} \rightarrow \underset{\text{Slag}}{CaSiO_3} \quad ; \quad \underset{\text{Impurities}}{SiO_2} + FeO \rightarrow \underset{\text{Slag}}{FeSiO_3}$$

(ii) ***Reduction by Aluminium*** (Gold-schmidt alumino thermic process) **:** The process of reduction is used in the case of those oxides which can not be easily reduced by carbon. In this process, metallic oxides ore are mixed with aluminium powder commonly called as thermite and placed in a steel crucible lined inside with a refractory material and ignited by magnesium ribon. By the use of this process a number of metals such as chromium and manganese are obtained on a commercial scale in highly pure state.

$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$; $2MnO_2 + 4Al \rightarrow 2Al_2O_3 + 3Mn$

Large amount of heat energy is released during reduction, which fuses both the alumina and the metal.

(iii) ***Self reduction process*** **:** This process is also called autoreduction process or air reduction process. The sulphide ores of less electropositive metals like ***Hg, Pb, Cu*** etc., are heated in air as to convert part of the ore into oxide or sulphate which then reacts with the remaining sulphide ore to give the metal and sulphur dioxide. No external reducing agent is used in this process.

(iv) *Electrolytic reduction process* **:** This process is used in the extraction of the alkali and alkaline earth metals, zinc and aluminium. The material from which a metal to be obtained is first smelted by heating and then electrolysed. Sometimes, some other salt is mixed to lower the melting point of the substance taken. For example,

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

At anode (Oxidation) : $Cl^- \xrightarrow{-e^-} Cl$; $Cl + Cl \rightarrow Cl_2$,

At cathode (Reduction) : $Na^+ + e^- \rightarrow Na$

(v) ***Precipitation or metal displacement method*** (Hydrometallurgy) **:** This method is used for extraction of metals such as **cadmium, copper, gold and silver**. A metal having higher electrode potential is added into the solution of a metal of lower electrode potential with the result that the latter is displaced or precipitated.

$CuSO_4 + Fe \rightarrow Cu + FeSO_4$;

$CdSO_4 + Zn \rightarrow Cd + ZnSO_4$

$2K[Ag(CN)_2] + Zn \rightarrow 2Ag + K_2[Zn(CN)_4]$

$2K[Au(CN)_2] + Zn \rightarrow 2Au + K_2[Zn(CN)_4]$

(vi) ***Amalgamation process*** **:** This method is used for the extraction of noble metals like **gold, silver**, etc., from the native ores. the finely powdered ore is brought in contact with mercury which combines with the particles of the metal present in the ore and form amalgam. The metal recovered from the amalgam by subjecting it to distillation, where the mercury distills over leaving behind the metal.

(4) **Purification or refining of metals :** Metals obtained as above are usually impure and need purification. Some of the methods used in the refining of metals are given below,

(i) ***By poling*** : The molten metals is stirred with green wood poles. Wood at the high temperature of the molten metals form hydrocarbons like methane which being about the reduction of any oxide present in the metal e.g., copper oxide present in **the blister copper**. In the case of the tin the impurities are oxidised and float on the molten metal as scum which is removed.

(ii) ***By cupellation*** : In this method the impure metal is heated in a blast of air when impurities are oxidised and blown away. For example, when impure silver is heated in air, lead present in it is oxidised to litharge (*PbO*) and blown away leaving a shining of silver.

(iii) ***By liquation*** : This process is used for refining easily fusible metals like lead and tin. The impure metal is heated on the slopy hearth of a reverberatory furnace. The metal melts and flows down leaving the impurities.

(iv) ***By distillation*** : Some metals have very low melting point and soon vaporize on behind heating, while the associated impurities remains in the solid state. **Zinc, mercury and arsenic** are purified by this method. Vacum distillation gives very pure product and is used in the refining of the metals of IA and IIA Groups.

(v) ***By fractional distillation*** : This process is applied for the separation of **cadmium** from **zinc**. In the metallurgy of zinc, the metal is invariably associated with cadmium. The impure zinc is mixed with powdered coke and heated when the first portion of the condensate contain cadmium while zinc is obtained in the subsequent portions.

(vi) ***By thermal dissociation*** : In this process the metal is first converted into some compound which is then decomposed into pure metal by heating. For example, impure **nickel** is heated with carbon monoxide at 60^oC to form nickel carbonyl $Ni(CO)_4$ which is then decomposed at higher temperature, 150-180^oC to give very pure nickel. Sometimes iron is also purified by this method.

(vii) ***By Electrolytic refining*** : Most of the metals such as **copper, silver, gold, zinc, nickel**, and **chromium** are refined electrolytically. The impure metal is made the anode and a thin sheet of the pure metal the cathode in a suitable electrolytic bath. On passing current the metal from the anode passes in the solution and pure metal from the electrolyte is deposited on the cathode. The electrolyte used in the bath is usually a complex salt of the metal to enable the smooth deposition of pure metal on the cathode.

(viii) ***Special methods***

(a) *Mond's process* : Nickel is purified by this method. Impure nickel is treated with carbon monoxide at 60-80°*C* when volatile compound, nickel carbonyl, is formed. **Nickel carbonyl** decomposes at 180°*C* to form pure nickel and carbon monoxide which can again be used.

(b) *Van Arkel process* : This methods is generally applied for obtaining ultrapure metals. The impure metal is converted into a volatile compound while the impurities are not affected. The volatile compound is then decomposed electrically to get the pure metal. ***Ti, Zr, Hf, Si*** etc., have been refined by this method.

(c) *Zone refining or fractional crystallisation* : Elements such as ***Si, Ge, Ga,*** etc., which are used as semiconductors are refined by this method. Highly pure metals are obtained. The method is based on the difference in solubility of impurities in molten and solid state of the metals. A movable heater is fitted around a rod of the metal. The heater is slowly moved across the rod. The metal melts at the point of heating and as the heater moves on from one end of the rod to the other end, the pure metal crystallises while the impurities pass on the adjacent melted zone.

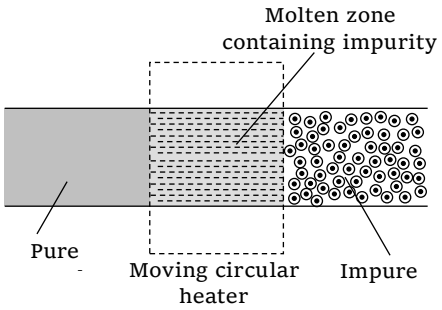


Fig. 16.4. ***Zone refining of metals***

Table 16.1 Summary of the Extraction of Metals

Metal	Main Occurrence	Main method of Extraction
Sodium	Common Salt, $NaCl$	Electrolysis of fused $NaCl$ with $CaCl_2$
Magnesium	Carnallite, $KCl.MgCl_2.6H_2O$ Magnesite $MgCO_3$	Electrolysis of fused $MgCl_2$ with KCl

Calcium	Lime stone, $CaCO_3$ Gypsum, $CaSO_4.2H_2O$	Electrolysis of fused $CaCl_2$ and CaF_2
Aluminium	Bauxite, $Al_2O_3.2H_2O$	Electrolysis of Al_2O_3 in molten Na_3AlF_6 (cryolite)
Copper	Copper pyrites, $CuFeS_2$ Cuprite, Cu_2O	Partial oxidation of sulphide ore $(2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2)$
Silver	Argentite, Ag_2S Native silver	Hydrometallurgy $Ag_2S + 4NaCN \longrightarrow 2NaAg(CN)_2 + Na_2S$ $2NaAg(CN)_2 + Zn \longrightarrow Na_2Zn(CN)_4 + 2Ag$
Zinc	Zinc Blende, ZnS Calamine, $ZnCO_3$	Reduction of ZnO with carbon or electrolysis of $ZnSO_4$ $ZnO + C \longrightarrow Zn + CO$
Lead	Galena, PbS	Reduction of PbO with carbon $PbO + C \longrightarrow Pb + CO$
Tin	Cassiterite, SnO_2	Reduction of SnO_2 with carbon $SnO_2 + 2C \longrightarrow Sn + 2CO$
Iron	Haematite, Fe_2O_3 Magnetite, Fe_3O_4	Reduction of oxide with carbon monoxide $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
Chromium	Chromite, $FeO.Cr_2O_3$	Reduction of Cr_2O_3 with Al $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$
Nickel	Millerite, NiS	Reduction of NiO with CO $NiO + 5CO \longrightarrow Ni(CO)_4 + CO_2$; $Ni(CO)_4 \longrightarrow Ni + 4CO$
Mercury	Cinnabar, HgS	Direct reduction of HgS by heat alone $HgS + O_2 \longrightarrow Hg + SO_2$

Main types of metallurgical processes

Different metallurgical processes can be broadly divided into three main types

(1) **Pyrometallurgy :** Extraction is done using heat energy. The metals like $Cu, Fe, Zn, Pb, Sn, Ni, Cr, Hg$ etc. Which are found in the nature in the form of oxides, carbonates, sulphides are extracted by this process.

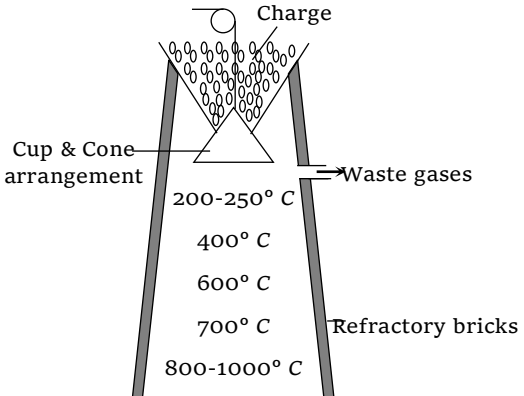
(2) **Hydrometallurgy :** Extraction of metals involving aqueous solution is known as hydrometallurgy. Silver, gold etc are extracted by this process.

(3) **Electrometallurgy :** Extraction of highly reactive metals such as Na, K, Ca, Mg, Al etc. by carrying electrolysis of one of the suitable compound in fused or molten state.

Furnaces

In the extraction of metal different types of furnaces are used. Each furnace has its own characteristics. Some principal furnaces have been described below,

(1) **Blast furnace :** It is a special type of tall cylindrical furnace, about 100 feet high with a diameter of 15-28 feet. It is made of steel sheets lined inside with fire-proof bricks. The charge is added through a cup and cone arrangement at the top. At the upper part of the furnace there is a hole for the escape of the waste gases of the furnace. There are two outlets in the hearth of the furnace, one for tapping the molten metal and the other above it for the slag. The waste gases are heated and a hot air blast under pressure is blown into the furnace by means of bellows or fans through water cooled nozzles ortuyers. The temperature of the furnace varies from **250°C.** to **1500°C.** Thus the charge descends slowly into zone of increasing temperatures. The blast furnace is used for the extraction of metal like **copper and iron**.



(2) **Reverberatory Furnace :** In this furnace fuel burns in a separate part and does not mix with the charge. The furnace may be divided into 3 parts,

(i) ***Fire Grate*** : It is on one side where the fuel burns.

(ii) ***Flue or Chimney*** **:** It is on the other side of the fire grate. The waste gases escape through it.

(iii) ***Hearth*** **:** It is the middle part of the furnace where the charge is heated with the flames and hot gases.

The material to be heated is placed on the hearth or bed of the furnace and is heated by the hot gases or flames produced by the burning of fuel. The waste gases escape out of the chimney. Since the fuel does not come in contact with the charge, the furnace is very suitable for calcination and roasting and is employed for both oxidising and reducing purposes. For oxidation, the material is heated by the current of hot air while for reduction the material is mixed with coke and heated. The furnace find wide application in the extractive metallurgy.

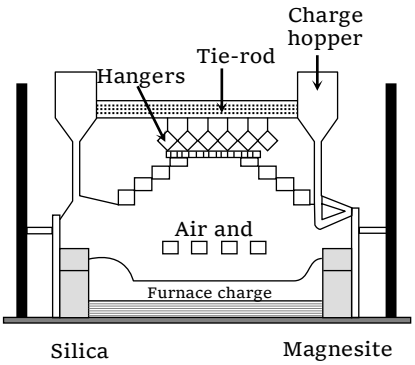


Fig. 16.6. ***Modern reverberatory furnace***

(3) **Electric Furnace :** The fuel burnt furnaces described in this chapter produce temperature in the range of 1000-1500°*C*. Although these furnaces have the great utility in the extraction of metals yet these are unsuitable where higher temperatures are needed. One commonly used electric furnace is **Heroult's furnace** shown in fig. It consists of a steel shell lined inside with dolomite or magnesite. It is provided with movable water jacketed electrodes suspended from the roof or from the sides. Heat is generated by striking an arc between the electrodes, thereby, a temperature of over **3000°*C*** may be reached. The charge melts and the impurities e.g., ***Si, Mn, P*** and ***S*** etc. present in the ore combine with the basic lining to form slag, which is free from sulphur or gas bubbles. **Steel** of very fine quality is prepared by this method. Electric furnaces are largely used where,

(i) Cheap power supply is available. (ii) High temperature are required. (iii) Pure product are required.

As such they find wide applicability in a number of industries such as metallurgy, ceramices plastics chemical and also in the research laboratories. These furnaces are easily operated and involve the problem of the storage of fuel and disposal of fuel waste.

(4) **Muffle Furnace :** In this furnace the material to be heated does not come in the contact with the fuel or flames. A muffle is a chamber made of refractory material and is surrounded by flames and hot gases on all sides. The products of combustion are removed through a door provided in the furnace. Muffle furnace is used for the extraction of **zinc**, preparation of red lead, Pb_3O_4 and for testing the purity of precious metals like **silver** and **gold**. In an electric muffle furnace the chamber is surrounded by resistance coils.

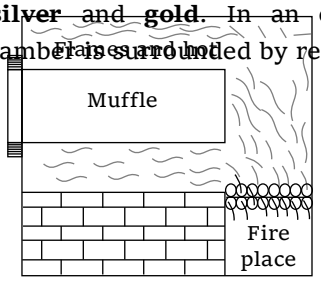


Fig. 16.7. ***Muffle furnace***

(5) **Bessemer Converter :** A Bassemer converter is a pear–shaped 10 or more feet high, open at the top, lined with a refractory material such as silica or magnesia which also acts as a flux. The converter is mounted on trunnions, so that it can be tilted to collect the products formed. There is an arrangement of introducing a hot blast of air from a number of small openings in the bottom of the furnace. The converter is used mostly for manufacturing of **copper of steel from**

pig iron. Passing a current of hot air into the molten metal taken in the converter, the impurities are oxidised and escaped as gases or from slag. The Bessemer process is rapid one and does not take more than 15 minutes in the production of one bath.

(6) **Regenerative Furnace :** These are furnaces in which the heat of the gases escaping out from the chimney is utilized. Most of the furnaces particularly blast furnaces are fitted up with regenerated system which means an economy of the fuel. A flowing column of air is heated by the hot flue gases, it is then brought back to the fire and returned to the furnace. This furnace is largely used in the production of **steel**.

Refractory materials

The materials which can withstand very high temperatures without melting or becoming soft are known as refractory materials. These are not affected by slags formed during the extraction of metals. These are used in the form of bricks for the internal linings of furnaces. Refractory materials used are of three types,

(1) **Acid refractories :** Silica, quartz, silicious sand stones, etc., are the examples.

(2) **Basic refractories :** Lime, dolomite, magnesite, etc., are the examples.

(3) **Neutral refractories :** Graphite, chromite, bone ash, etc., are the examples.

Silica ($92\%\ SiO_2$, $2.7\%\ Al_2O_3$) and quartz, can tolerate temperatures upto about 1750°*C*, bauxite upto 1800°*C*, alumina upto 2000°*C* and magnesite, chromite, etc., upto 2200°*C*. Some carbides such as silicon carbide is used as refractory for special purposes.

Alloys

A metallic product containing two or more metals or sometimes one of the ingredients a non–metal provided that the mixture is homogenous and possesses metallic properties, is known as an alloy. Alloys are usually prepared by melting two or more metals together in the proportions and then allowing the melting to solidify. If one of the metals is mercury the alloy is known as ***amalgam***.

Alloys are prepared with a view to impart some desirable properties which the individual metals do not possess. These are,

(1) **Change in the chemical reactivity :** Sodium acts vigorously with water, but *Na–Hg* amalgam reacts slowly to suit the requirement of a number of chemical reactions.

(2) **Hardness :** Silver, gold and soft metals but become hard when alloyed with copper.

(3) **Melting Points :** Melting points of an alloy may be higher or lower than any of its components. Wood-metal, which is an alloy of *Bi, Pb, Sn* and *Cd* fuses at 60.5°*C*., while none of these metals fuses at this low temperature.

(4) **Change of colour :** Aluminium bronze is an alloy of aluminium and copper. It is of golden, yellow colour and is used in making decoration articles, jewellery and coins while the colour of aluminium is white and that of copper is red.

(5) **Corrosion resistance :** Iron gets corroded soon whereas stainless Steel, an alloy of iron and chromium, resists corrosion.

(6) **Casting :** An alloy of lead and antimony is known as *type metal* is used for casting type required in printing works.

Table 16.2 ***Alloys of Al***

Alloy	Percentage		Important Properties	Uses
Aluminium bronze	*Al* *Cu*	95% 5%	Light, strong alloy with golden lustre, resistant to corrosion	Coins, utensils, jewellary picture frames etc.
Magnalium	*Al* *Mg*	95% 5%	Light, tough and strong	Light instruments, balance beam, pressure cookers etc.
Duralumin	*Al* *Cu* *Mg* *Mn*	95% 4% 0.5% 0.5%	Light, tough, ductile, resistant to corrosive action	Making aeroplanes automobile parts pressure cookers etc.

Table 16.3 ***Alloys of Ag***

Alloy	Percentage composition	Uses
Coinage silver	*Ag* = 90, *Cu* = 10	For making silver coins.
Silver solder	*Ag* = 63, *Cu* = 30, *Zn* = 7	For soldering and joining metals
Dental alloy	*Ag* = 33, *Hg* = 52, *Sn* = 12.5, *Cu* = 2.0, *Zn* = 0.5	For filling teeth

Silver palladium	*Ag* = 40, *Pd* = 60	Potentiometers and winding of some special instruments.

Table 16.4 ***Alloys of Pb and Sn***

Alloy	Percentage Composition	Uses
Solder	*Pb* = 50, *Sn* = 50	For soldering.
Pewter	*Pb* = 20, *Sn* = 80	In making cups, mugs and other utensils.
Type metal	*Pb* = 70, *Sb* = 20 and *Sn* = 10	For making printing type.
Rose metal	*Pb* = 22, *Sn* = 28, *Bi* = 50	For making electric fuses.
Britannia metals	*Sn* = 90, *Sb* = 8, *Cu* = 2	For making table wares.

Table 16.5 ***Alloys of Copper***

Alloy	Percentage Composition	Uses
Brass	*Cu* = 80, *Zn* = 20	For making utensils, condenser tubes, wires parts of machinery etc.
Bronze or Copper bronze	*Cu* = 80, *Zn* = 10, *Sn* = 10	For making cooking utensils, statues, coins etc.
Aluminium bronze	*Al* = 95, *Cu* = 5	Coins, picture frames, cheap jewellery
Gun metal	*Cu* = 90, *Sn* = 10	For making gun barrels.
Bell metal	*Cu* = 90, *Sn* = 20	For making bells, gongs etc.
Constantan	*Cu* = 60, *Ni* = 40	For electrical apparatus
German silver	*Cu* = 60, *Zn* = 20, *Ni* = 20	For making silver wire, resistance wires etc.
Monel metal	*Cu* = 30, *Ni* = 67, *Fe* and *Mn* = 3	For making acid pumps and acid containers.
Phosphor bronze	*Cu* = 95, *Sn* = 4.8, *P* = 0.2	For making springs, electrical equipment
Gold-copper alloy	*Au* = 90, *Cu* = 10	For making gold coins, jewellery, watch cases, spectacle rims etc.

Table 16.6 ***Alloys of Iron***

Name	Percentage	Properties	Uses
Stainless steel	*Fe* = 73%, *Cr* = 18%, *Ni* = 8% and carbon	Resists corrosion	For making utensils, cutlery and ornamental pieces.
Manganese steel	*Fe* = 86%, *Mn* = 13% and carbon	Very hard, resistant to wear and tear.	For Making rock drills, safes etc.
Tungsten steel	*Fe* = 94%, *W* = 5% and carbon	Retains hardness even at high temperatures	For making high speed cutting tools.
Invar	*Fe* = 64%, *Ni* = 36%	Practically no coefficient of expansion.	For making watches, meter scales, pendulum rods etc.

Nickel steel	*Fe* = 98–96%, *Ni* = 2–4%	Resistant to corrosion, hard and elastic.	For making wire cables, gears, drive shafts etc.
Permalloy	*Fe* = 21%, *Ni* = 78% and carbon	Strongly magnetised by electric current, loses magnetism when current is cut off.	For making electromagnets, ocean cables etc.
Chrome steel	*Fe* = 98–96%, *Cr* = 2–4%	High tensile strength	For making axles, ball bearings and cutting tools such as files.
Alnico	*Fe* = 60%, *Al* =12%, *Ni* = 20%, *Co* = 8%	Highly magnetic	For making permanent magnents.

Tips & Tricks

- Pitch blende is the source of *Ra, U* and *Th*.
- Nitrate is least likely to be found in mineral.
- Oxygen is the most abundant element (45.2%)
- Aluminium is the most abundant metal (8.3%)
- Silicon is the second most common element in the universe (27.2%)
- First five element comprise al most 92% by weight
- First ten elements make up over 99.5% of the earth crust.
- Other very abundant element are nitrogen (78% of the atmosphere) and hydrogen which occurs as water in the ocean.
- Diamond consist only carbon.
- Removal of unwanted earthy and silicious impurity from the ore is called ore dressing or concentration.
- *Refractory materials* : These are the substances which can withstand very high temperature without melting or becoming soft.
- Noble metal like *Au, Ag* etc. are obtained by cyanide or amalgamation process.
- Active metal like *Li, Na, K* (alkalimetal) *Cs, Mg, Sr, Ba* (alkaline earth metal) etc are obtained by the electrolysis of their chloride, oxides or hydroxide.
- Heavy metal like *Cu, Zn, Fe, Pb, Sn* etc are obtained by roasting and smelting process.
- Gravity separation is employed for the concentration of oxide ores.
- Slag is used in road making as well as in the manufacture of cement and fertilizers.

Ordinary Thinking

Objective Questions

Occurrence

1. The most abundant element on earth crust is **[MP PMT 1972, 80, 84; DPMT 1986]**

(a) Hydrogen (b) Oxygen

(c) Silicon (d) Carbon

2. Naturally occurring substances from which a metal can be profitably (or economically) extracted are called **[CPMT 1982; MP PET 1996]**

(a) Minerals (b) Ores

(c) Gangue (d) Salts

3. Titanium containing mineral found in our country is **[NCERT 1984; RPET 1999]**

(a) Bauxite (b) Dolomite

(c) Chalcopyrites (d) Elmanite

4. Silicon is main constituent of **[DPMT 1985]**

(a) Alloys (b) Rocks

(c) Animals (d) Vegetables

5. Ore pitch blende is main source of **[DPMT 1985; RPET 1999]**

(a) *Ra* (b) *Ce*

(c) *Th* (d) *Mg*

6. Which of ore is metalloid **[MP PMT 1987]**

(a) *As* (b) *Na*

(c) *Au* (d) *Fe*

7. A mineral is called an ore if **[MP PMT 1990]**

(a) Metal present in mineral is precious

(b) Metal can be extracted from it

(c) Metal can be extracted profitably from it

(d) Metal cannot be extracted from it

8. The highest quantity present in the atmosphere is of **[NCERT 1971, 79; CPMT 1972]**

(a) Oxygen (b) Hydrogen

(c) Nitrogen (d) Ozone

9. Which of the following statement is correct

(a) Bauxite is an ore of aluminium

(b) Magnetite is an ore of manganese

(c) Haematite is an ore of mercury

(d) Pyrites is an ore of phosphorus

10. Carnellite is a mineral of **[CBSE PMT 1988; DPMT 1983; AMU 1999]**

(a) *Ca* (b) *Na*

(c) *Mg* (d) *Zn*

11. The salt which is least likely to be found in minerals is **[DPMT 1984]**

(a) Chloride (b) Sulphate

(c) Sulphide (d) Nitrate

12. Metal which can be extracted from all the three dolomite, magnesite and carnallite is **[MP PET 1985]**

(a) *Na* (b) *K*

(c) *Mg* (d) *Ca*

13. Cinnabar is an ore of **[DPMT 1982, 84; CBSE PMT 1991; MNR 1986; CPMT 1973, 76, 78, 79, 86, 89, 94; UPSEAT 1999]**

(a) *Hg* (b) *Cu*

(c) Pb (d) Zn

14. Metallurgy is the process of **[MP PET 2001]**
(a) Concentrating the ore
(b) Roasting the ore
(c) Extracting the metal from the ore
(d) Adding carbon to the ore in blast furnace

15. What is believed to be the second most common element in the universe **[MP PET 2000]**
(a) Helium (b) Hydrogen
(c) Nitrogen (d) Silicon

16. Which of the following substances consists of only one element **[MP PET 1999, 2000]**
(a) Marble (b) Sand
(c) Diamond (d) Glass

17. Which of the following minerals is not an ore of aluminum
(a) Bauxite (b) Gypsum
(c) Cryolite (d) Corundum

18. An example of halide ore is **[MP PMT 1993]**
(a) Galena (b) Bauxite
(c) Cinnabar (d) Cryolite

19. Which of the following is not an ore **[IIT 1982]**
(a) Bauxite (b) Malachite
(c) Zinc blende (d) Pig iron

20. "Chile saltpetre" is an ore of **[CPMT 1982]**
(a) Iodine (b) Sodium
(c) Bromine (d) Magnesium

21. Which of the following metal is not found in free state
(a) Na (b) Au
(c) Ag (d) Pb

22. Which of the following ore is used for industrial extraction of aluminium in India **[MP PET 1989]**
(a) Corundum (b) Keolin
(c) Cryolite (d) Bauxite

23. Bauxite is an oxide ore of **[BHU 1979; AFMC 1980; Kurukshetra CEE 1998; RPET 1999; CPMT 1976, 2001, 02]**
(a) Barium (b) Boron
(c) Bismuth (d) Aluminium

24. Cryolite is **[AMU 1983]**
(a) Magnesium silicate
(b) Sodium borofluoride
(c) Sodium aluminium fluoride
(d) Magnesium silicate

25. Composition of bauxite is
(a) Al_2O_3 (b) $Al_2O_3.H_2O$
(c) $Al_2O_3.2H_2O$ (d) $Al_2O_3.3H_2O$

26. Main ore of aluminium is **[CPMT 1989, 91, 2001; RPMT 1997; RPET 1999] [CPMT 2002, MP PMT 1999]**
(a) Bauxite (b) Corundum
(c) Cryolite (d) Magnetite

27. Corundum is **[CPMT 1975, 76; DPMT 1983]**
(a) SrO_2 (b) Al_2O_3
(c) $CaCl_2$ (d) Cu_2Cl_2

28. Which is not a mineral of aluminium **[BHU 1974, 79; MNR 1984; DPMT 2002]**
(a) Anhydrite (b) Bauxite
(c) Corundum (d) Diaspore

29. Which of the following mineral does not contain Al **[IIT (Screening) 1992]**
(a) Cryolite (b) Mica
(c) Feldspar (d) Fluorspar

30. An important oxide ore of iron is **[MP PET/PMT 1998; MP PET 1990; MP PMT 1994, 96]**
(a) Haematite (b) Siderite
(c) Pyrites (d) Malachite

31. Which ore is used for the manufacture of iron **[CPMT 1973, 79; RPET 2000]**
(a) Cryolite (b) Bauxite
(c) Haematite (d) Chalcopyrites

32. Formula of magnetite is **[CPMT 1991]**
(a) Fe_2O_3 (b) FeS_2
(c) $FeCO_3$ (d) Fe_3O_4

33. Which of the following is ferrous alloy **[DPMT 1982, 84; CPMT 1989]**
(a) Invar (b) Solder
(c) Magnalium (d) Type metal

34. Which of the following ores does not represent the ore of iron **[CPMT 1989; AIIMS 2002]**
(a) Haematite (b) Magnetite
(c) Cassiterite (d) Limonite

35. The formula of haematite is **[MNR 1994]**
(a) Fe_3O_4 (b) Fe_2O_3
(c) $FeCO_3$ (d) FeS_2

36. Which metal is not silvery white
(a) Ni (b) Cu
(c) Na (d) Sn

37. Azurite is an ore of
(a) Ag (b) Cu
(c) Pt (d) Au

38. Copper can be extracted from **[NCERT 1973; IIT 1978; J & K 2005]**
(a) Kupfernickel (b) Dolomite
(c) Galena (d) Malachite

39. Which of the following ore is called malachite **[CPMT 1989, 93]**
(a) Cu_2S (b) $CuCO_3.Cu(OH)_2$
(c) Cu_2O (d) $CuCO_3$

40. Argentite is a mineral of **[CPMT 1978; MP PMT/PET 1988]**
(a) Copper (b) Silver
(c) Platinum (d) Gold

41. Which one of the following is an ore of silver **[CPMT 1983; MP PET 1989; CBSE PMT 1993]**
(a) Argentite (b) Stibnite
(c) Haematite (d) Bauxite

42. Calamine is **[BHU 1980, 85; CPMT 1990; MNR 1995; UPSEAT 1999]**
(a) $ZnSO_4$ (b) ZnO
(c) $Zn(NO_3)_2$ (d) $ZnCO_3$

43. Important ore of zinc is **[CPMT 1973, 78, 80]**
(a) Calamine (b) Cryolite
(c) Gibsite (d) Malachite

44. Which of the following statement is incorrect **[CPMT 1985]**
(a) Silver glance mainly contains silver sulphide
(b) Gold is found in native state
(c) Zinc blende mainly contain zinc chloride
(d) Copper pyrites also contain Fe_2S_3

45. Commercially important ore of lead from which it is extracted is **[DPMT 1982, 96; MP PMT 2000]**
(a) Siderite (b) Haematite
(c) Galena (d) None of these

46. Which of the following is not an ore of lead **[MP PMT 1993]**
(a) Galena (b) Anglesite
(c) Calamine (d) Cerrusite

47. Galena is
(a) PbO (b) $PbCO_3$
(c) PbS (d) $PbCl_2$

48. An example of an oxide ore is **[MP PET 1996]**
(a) Bauxite (b) Malachite
(c) Zinc blende (d) Felspar

49. Cryolite is an ore of **[MP PMT 1996; BHU 2002; DPMT 1996]**
(a) Iron (b) Silver
(c) Zinc (d) Aluminium

50. Cassiterite is an ore of **[CBSE PMT 1999; DPMT 1996]**
(a) Mn (b) Ni
(c) Sb (d) Sn

51. Which one of the following is the most abundant element in the universe **[NDA 1999]**
(a) Nitrogen (b) Hydrogen
(c) Oxygen (d) Silicon

52. Among the following statements, the incorrect one is **[IIT 1997]**
(a) Calamine and siderite are carbonates
(b) Argentite and cuprite are oxides
(c) Zinc blende and pyrites are sulphides
(d) Malachite and azurite are ores of copper

53. Which one of the following ores is a chloride **[EAMCET 1997; CPMT 2001]**
(a) Horn silver (b) Zincite
(c) Bauxite (d) Felspar

54. Aluminium is most abundant in earth crust yet it is obtained from bauxite because **[CPMT 1997]**
(a) Bauxite is available in larger quantity
(b) Of easy extraction of aluminium from it
(c) Bauxite contains maximum aluminium
(d) Bauxite is less impure

55. An ore of potassium is **[JIPMER 2001]**
(a) Bauxite (b) Solomite
(c) Carnallite (d) Cryolite

56. The molecular formula of cryolite is **[AFMC 1999; MP PET 2002]**
(a) Fe_3O_4 (b) Na_3AlF_6
(c) $Na_2Al_2O_3$ (d) All of these

57. All ores are minerals, while all minerals are not ores because **[Orissa JEE 2002]**
(a) The metal can't be extracted economically from all the minerals
(b) Minerals are complex compounds
(c) The minerals are obtained from mines
(d) All of these are correct

58. Corundum is an ore of **[Kerala (Med.) 2002]**
(a) Copper (b) Boron
(c) Aluminium (d) Sodium

59. Which one of the following is correct **[MP PET/PMT 2002]**
(a) A mineral cannot be an ore
(b) An ore cannot be a mineral
(c) All minerals are ores
(d) All ores are minerals

60. Which ore contains both iron and copper? **[IIT-JEE (Screening) 2005]**
(a) Cuprite (b) Chalcocite
(c) Chalcopyrite (d) Malachite

61. Formula of Felspar is **[MHCET 2004]**
(a) $K_2O.Al_2O_3.6SiO_2$
(b) $K_2O_3.Al_2O_3.6Si_2.O_2.2H_2O$
(c) $Al_2O_3.2SiO_2.2H_2O$
(d) $3MgO.4SiO_2.H_2O$

62. Chile saltpetre is **[MP PET 2004]**
(a) $NaNO_3$ (b) KNO_3
(c) Na_2SO_4 (d) $Na_2S_2O_3$

63. Which of the following is not an ore of magnesium **[CPMT 2004; DCE 2004]**
(a) Magnesite (b) Dolomite
(c) Gypsum (d) Carnalite

64. Which of the following is not a mineral of iron ? **[Kerala PMT 2004]**

(a) Magnetite (b) Siderite
(c) Smithsonite (d) Limonite
(e) Haematite

65. The ore carnalite is represented by structure: **[EAMCET 1987; MP PET 1986, 04; AFMC 2000 Pb. PMT 2004]**

(a) $Na_2Al_2O_3$ (b) Na_3AlF_6
(c) $KCl.MgCl_2 6H_2O$ (d) Fe_3O_4

66. Which of the following metal is sometimes found native in nature **[CPMT 1973, 75; MP PET 1999]**

(a) Al (b) Cu
(c) Fe (d) Mg

67. The most abundant metal in the earth crust is **[BHU 1979, 81; MP PMT 1997; CPMT 1988, 2001; CBSE PMT 2000]**

(a) Na (b) Mg
(c) Al (d) Fe

68. Indicate the mineral from which copper is manufactured **[NCERT 1973]**

(a) Galena (b) Cuprite
(c) Sphalerite (d) Chalcopyrite

69. The principal ores of silver are argentite, horn silver and pyrargyrite. Their formula respectively are

(a) $Ag_2S, AgCl$ and $AgSbS_2$
(b) $AgCl, AgSbS_2$ and Ag_2S
(c) $AgSbS_2, Ag_2S$ and $AgCl$
(d) $AgCl, Ag_2S$ and $AgSbS_2$

70. The most important ore of tin is **[AFMC 2005]**

(a) Cassiterite (b) Cryolite
(c) Cerussite (d) None of these

71. Important ore of *Mg is* **[BCECE 2005]**

(a) Gypsum (b) Carnalite
(c) Magnatide (d) Carnolite

72. Which of the following is a carbonate ore **[AIIMS 2005]**

(a) Pyrolusite (b) Malachite
(c) Diaspore (d) Cassiterite

Concentration

1. Sulphide ores are generally concentrated by **[CPMT 1980, 82; EAMCET 1980; MNR 1981; DPMT 1982; KCET 1993]**

(a) Froth floatation process (b) Magnetic separation
(c) Gravity separation (d) By hand picking

2. Froth floatation process is used for the concentration of **[NCERT 1984; CPMT 1982, 87; MP PMT 1989; BHU 1997; EAMCET 1983; AMU 1984; DPMT 1989; AFMC 2000; MNR 1981; KCET 2000; MP PET 2001; Pb. PMT 2002]**

(a) Oxide ores (b) Sulphide ores
(c) Chloride ores (d) Amalgams

3. A process used for the concentration of ore is **[MP PMT 1990; MP PET 2003]**

(a) Froth floatation (b) Roasting
(c) Electrolysis (d) Bessemerization

4. Magnetic separation is used for increasing concentration of the following **[MP PET 1990]**

(a) Horn silver (b) Calcite
(c) Haematite (d) Magnesite

5. The substance added in water in the froth floatation process is **[EAMCET 1980]**

(a) Soap powder (b) Pine oil
(c) Coconut oil (d) None of the above

6. For which ore of the metal, froth floatation method is used for concentration **[MP PMT 2001]**

(a) Horn silver (b) Bauxite
(c) Cinnabar (d) Haematite

7. Cyanide process is used in the extraction of **[DCE 2002, 03]**

(a) Au (b) Ag
(c) both (a) and (b) (d) Cu

8. Cassiterite is concentrated by **[EAMCET 1998]**

(a) Levigation
(b) Electromagnetic separation
(c) Floatation
(d) Liquifaction

9. Froth floatation process for the concentration of ores is an illustration of the practical application of **[NCERT 1984]**

(a) Adsorption (b) Absorption
(c) Coagulation (d) Sedimentation

10. Iron ore is concentrated by **[MP PMT 1991]**

(a) Froth floatation (b) Electrolysis
(c) Roasting (d) Magnetic treatment

11. An ore of tin containing $FeCrO_4$ is concentrated by **[SCRA 1991]**

(a) Magnetic separation (b) Froth floatation
(c) Electrostatic method (d) Gravity separation

12. One of the following metals forms a volatile compound and this property is taken advantage for its extraction. This metal is **[NCERT 1984]**

(a) Iron (b) Nickel
(c) Cobalt (d) Tungsten

13. Bauxite ore is concentrated by **[MP PET 1994; KCET 1999; UPSEAT 2001]**

(a) Froth flotation
(b) Electromagnetic separation
(c) Chemical separation
(d) Hydraulic separation

14. In extraction of copper, we use

[CPMT 1980; MP PMT 1986]

(a) Cu_2S (b) Pyrites

(c) Silver argentocyanide (d) $CuFeS_2$

15. Which metal is most difficult to be extracted from its oxide

(a) Cs (b) Ag

(c) Zn (d) Mg

16. Copper pyrites are concentrated by

[MNR 1995; UPSEAT 1999; AMU 1999; MP PMT 2003]

(a) Electromagnetic method (b) Gravity method

(c) Froth floatation process (d)All the above methods

17. In the metallurgy of zinc, flux is not used because

(a) Zinc ore has no impurities

(b) Zinc is volatile hence easily separated

(c) Zinc reacts with flux

(d) Flux is volatile

18. Ores like magnetite or tungstates in tin ores are concentrated by

(a) Froth floatation (b) Magnetic separation

(c) Gravity separation (d) Electrostatic separation

19. Froth–floatation method is successful in separating impurities from ores because

(a) The pure ore is lighter than water containing additives like pine oil, cresylic acid etc.

(b) The pure ore is soluble in water containing additives like pine oil, cresylic acid etc.

(c) The impurities are soluble in water containing additives like pine oil, cresylic acid etc.

(d) The pure ore is not as easily wetted by water as by pine oil, cresylic acid etc

20. An ore like zinc blende is concentrated by

[MP PMT 1997]

(a) Froth floatation (b) Magnetic separation

(c) Leaching (d) Washing with water

21. The method of concentrating the ore which makes use of the difference in density between ore and impurities is called

[Pune CET 1998]

(a) Levigation (b) Leaching

(c) Magnetic separation (d) Liquifaction

22. Which of the following ore is best concentrated by froth-flotation method **[AIEEE 2004]**

(a) Galena (b) Cassiterite

(c) Magnetite (d) Malachite

Roasting & Calcination

1. Refractory materials are generally used in furnaces because

[MNR 1980; MP PMT 1986]

(a) They possess great structural strength

(b) They can withstand high temperature

(c) They are chemically inert

(d) They do not require replacement

2. Main function of roasting is **[MP PET/PMT 1988]**

(a) To remove volatile substances

(b) Oxidation

(c) Reduction

(d) Slag formation

3. Roasting is generally done in case of the following

[MP PMT 1985]

(a) Oxide ores (b) Silicate ores

(c) Sulphide ores (d) Carbonate ores

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

[CPMT 1973, 75, 78, 79, 94; DPMT 1982, 84, 86; MP PMT 2000, 01, 02]

(a) Roasting (b) Calcination

(c) Smelting (d) Slagging

5. Which is not basic flux **[CPMT 1986]**

(a) $CaCO_3$ (b) Lime

(c) SiO_2 (d) CaO

6. A substance which reacts with gangue to form fusible material is called

[MP PMT 1990; Kurukshetra CEE 1998] [Kerala CET 2005]

(a) Flux (b) Catalyst

(c) Ore (d) Slag

7. When lime stone is heated strongly, it gives off CO_2. In metallurgy this process is known as **[MP PET/PMT**

(a) Calcination (b) Roasting

(c) Smelting (d) Ore dressing

8. Electric furnaces are lined with magnesia because

(a) It is not affected by acids

(b) It gives oxygen on heating

(c) It melts at very high temperature

(d) It has no effect of electricity

9. Purpose of smelting of an ore is

[MP PMT 1990, 2001; Kurukshetra CEE 1998; RPMT 2000]

(a) To oxidise it

(b) To reduce it

(c) To remove vaporisable impurities

(d) To obtain an alloy

10. Smelting is done in **[DPMT 1979]**

(a) Blast furnace (b) Muffle furnace

(c) Open–hearth furnace (d) Electric furnace

11. In order to bring initial chemical change in the ore, the process of heating of ore below its melting point is known as

(a) Reduction (b) Smelting

(c) Calcination (d) Roasting

12. Matte contains mainly **[KCET 2000]**

(a) Cu_2S and FeS (b) CuS and Fe_2S_3

(c) Fe (d) Cu_2S

13. The substance which is mixed with the ore for removal of impurities is termed as **[MP PMT 1985, 87, 90; CPMT 1996; JIPMER 2002]**

(a) Slag (b) Gangue

(c) Flux (d) Catalyst

14. The cheap and having high melting point compound used in furnace is **[CPMT 1975]**

(a) PbO (b) CaO

(c) HgO (d) ZnO

15. Which of the following substance can be used for drying gases **[EAMCET 1978; MP PET 1999]**

(a) $CaCO_3$ (b) Na_2CO_3

(c) $NaHCO_3$ (d) CaO

16. Which one of the furnaces among the following can produce the highest temperature

(a) Muffle furnace (b) Blast furnace

(c) Reverberatory furnace (d) Electric furnace

17. The process of heating the ore strongly in excess of air so that the volatile impurities are removed and the ore is changed to oxide is known as **[AMU 1985]**

(a) Calcination (b) Roasting

(c) Froth floatation (d) Leaching

18. The role of calcination in metallurgical operations is **[AMU 1984]**

(a) To remove moisture

(b) To decompose carbonate

(c) To drive off organic matter

(d) To achieve all the above

19. Calcination is the process of heating the ore **[CPMT 1982]**

(a) In a blast furnace (b) In absence of air

(c) In presence of air (d) None of these

20. Smelting is termed to the process in which **[MP PMT 1987]**

(a) The ore is heated in the absence of air

(b) Ore is cold

(c) The ore is heated in the presence of air

(d) Ore is melted

21. The metallurgical process in which a metal is obtained in a fused state is called **[IIT 1978; MP PET 1997]**

(a) Smelting (b) Roasting

(c) Calcination (d) Froth floatation

22. Which of the following processes involves smelting **[NCERT 1983]**

(a) $ZnCO_3 \rightarrow ZnO + CO_2$

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

(c) $2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$

(d) $Al_2O_3.2H_2O \rightarrow Al_2O_3 + 2H_2O$

23. Reverberatory furnace is employed in the metallurgical process mainly for **[MP PMT 1994]**

(a) Reduction of oxide ores

(b) Smelting of sulphide ores

(c) Conversion of chloride to sulphate

(d) Getting magnetic materials

24. In metallurgy, flux is a substance used to convert **[EAMCET 1988]**

(a) Infusible impurities to fusible material

(b) Soluble impurities to insoluble impurities

(c) Fusible impurities to infusible impurities

(d) Mineral into silicate

25. In the manufacture of iron lime stone added to the blast furnace, the calcium ion ends in the form of **[MP PMT 1989; CPMT 1989; KCET 1993; IIT 1982; MADT Bihar 1995]**

(a) Slag (b) Gangue

(c) Calcium metal (d) $CaCO_3$

26. Flux added in the extraction of iron is

(a) Silica (b) Felspar

(c) Limestone (d) Flint

27. The smelting of iron in the blast furnace involves all the following process except **[NCERT 1990]**

(a) Oxidation (b) Reduction

(c) Decomposition (d) Sublimation

28. In the manufacture of iron from haematite, the function of lime stone is as **[CPMT 1988; MP PET 1991, 93, 95]**

(a) A reducing agent (b) Flux

(c) Slag (d) Gangue

29. The slag obtained during the extraction of copper from copper pyrites is composed mainly of **[MNR 1993; MP PMT 1997; UPSEAT 2000, 01; IIT-JEE Screening 2001]**

(a) $CaSiO_3$ (b) $FeSiO_3$

(c) $CuSiO_3$ (d) SiO_2

30. Complex is formed in the extraction of **[MP PET 1989]**

(a) Na (b) Cu

(c) Ag (d) Fe

31. Which of the following metal is extracted by amalgamation process

(a) Tin (b) Silver

(c) Copper (d) Zinc

32. The reaction $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ in the metallurgical process of zinc is called **[MP PET 1994]**

(a) Calcination (b) Cupellation

(c) Smelting (d) Roasting

33. Calcination is used in metallurgy for removal of **[AFMC 1995]**

(a) Water and sulphide (b) Water and CO_2

(c) CO_2 and H_2S (d) H_2O and H_2S

34. Which of the following is slag **[CPMT 1994]**

(a) CaO (b) $CaSO_4$

(c) $CaSiO_3$ (d) SiO_2

35. The impurties associated with minerals used in metallurgy are collectively called **[MP PMT 1995; RPMT 1999]**

(a) Slag (b) Flux

(c) Gangue (d) Ore

36. When a metal is to be extracted from its ore, if the gangue associated with the ore is silica, then **[MP PET 1996]**

(a) An acidic flux is needed

(b) A basic flux is needed

(c) Both acidic and basic flux are needed

(d) Neither of them is needed

37. Which statement is correct

(a) Gangues are carefully chosen to combine with the slag present in the ore to produce easily fusible flux to carry away the impurities

(b) Slags are carefully chosen to combine with the flux present in the ore to produce easily fusible gangue to carry away the impurities

(c) Gangues are carefully chosen to combine with the flux present in the ore to produce easily fusible slag to carry away the impurities

(d) Fluxes are carefully chosen to combine with the gangue present in the ore to produce easily fusible slag to carry away the impurities

38. Roasting of copper pyrites ores is for the following purposes

(a) To burn off sulphur, arsenic, antimony etc. as oxides and convert all the iron and copper to their oxides

(b) To burn off arsenic, antimony etc. as oxides and burn off sulphur so that enough of it remains to combine with all the copper

(c) To burn off sulphur partially to leave enough to combine with arsenic, antimony etc. and to convert all the iron and copper to oxides

(d) To melt arsenic and antimony sulphides etc. and remove them by liquation and to burn off sulphur partially to leave enough to combine with copper and iron

39. In the modern blast furnaces, the charge consists of a mixture of

(a) Calcined iron oxides + lime + anthracite coal

(b) Calcined iron oxides + limestone + coke

(c) Hydrated iron oxides + dolomite + coke

(d) Iron pyrites + lime +bituminous coal

40. Roasting involves

(a) Only volatilisation of volatile impurities

(b) Only volatilisation of volatile impurities and decomposition of the ore

(c) Volatilisation of volatile impurities and decomposition and oxidation of the ore

(d) Oxidation and reduction of the ore and slag formation

41. Which of the following ores is subjected to roasting during metallurgical operations for getting the metal oxide

(a) Horn silver (b) Zinc blende

(c) Malachite (d) Limonite

42. A metal obtained directly by roasting of its sulphide ore is **[Pune CET 1998]**

(a) Cu (b) Pb

(c) Hg (d) Zn

43. In blast furnace, the highest temperature is in **[KCET 1998]**

(a) Reduction zone (b) Slag zone

(c) Fusion zone (d) Combustion zone

44. The process of roasting of an ore is carried out in the **[BHU 1999]**

(a) Absence of air (b) Presence of air

(c) Limited supply of air (d) None of these

45. Flux is used to remove **[AIIMS 1999]**

(a) Acidic impurities (b) Basic impurities

(c) All impurities from ores (d) Both (a) and (b)

46. During extraction of Fe ; slag obtained is **[CPMT 2000]**

(a) FeO (b) $FeSiO_3$

(c) $MgSiO_3$ (d) $CaSiO_3$

47. The final step for the extraction of copper from copper pyrite in Bessemere converter involves the reaction **[CPMT 2000]**

(a) $4Cu_2O + FeS \rightarrow 8Cu + FeSO_4$

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

(c) $2Cu_2O + FeS \rightarrow 4Cu + Fe + SO_2$

(d) $Cu_2S + 2FeO \rightarrow 2Cu + 2FeCO + SO_2$

48. Flux is used to remove **[KCET (Med.) 2000; PCET 2004]**

(a) Silica

(b) Metal oxide

(c) All impurities from ores

(d) Silica and undesirable metal oxide

49. Roasting is done in **[AFMC 2001]**

(a) Blast furnace (b) Open hearth furnace

(c) Electric furnace (d) None of these

50. Which of the following fluxes is used to remove acidic impurities in metallurgical process **[KCET (Med.) 200**

(a) Silica (b) Lime stone

(c) Sodium chloride (d) Sodium carbonate

51. Refractory metals are used in construction of furnaces because **[CPMT 2002]**

(a) They can withstand high temperature

(b) They are chemically inert

(c) Their melting point is high

(d) None of these

52. CN^- solution used in extraction of which metal **[RPMT 2002]**

(a) Ag (b) Ti

(c) Zn (d) Sn

53. In a line kiln, to get higher yield of CO_2, the measure that can be taken is **[KCET 2003]**

(a) To remove CaO

(b) To add more $CaCO_3$

(c) To maintain high temperature

(d) To pump out CO_2

54. Which metal is used as a reducing agent in smelting **[MP PET 2003]**

(a) C (b) Al

(c) Zn (d) None of these

55. Inner layer of blast furnace is made of **[MP PMT 1990]**

(a) Graphite bricks (b) Silica bricks

(c) Fire– clay bricks (d) Basic bricks

56. Blast furnace is employed in the smelting of oxide ore with coke and flux in the metallurgy of

(a) Iron (b) Copper

(c) Lead (d) All the above

57. How is limestone used in *Fe* extraction **[Orissa JEE 2004]**

(a) Oxidation of *Fe* ore (b) Reduction of *Fe* ore

(c) Formation of slag (d) Purification of *Fe* formed

58. Heating mixture of Cu_2O and Cu_2S will give **[AIEEE 2005]**

(a) $Cu + SO_2$ (b) $Cu + SO_3$

(c) $CuO + CuS$ (d) Cu_2SO_3

59. Heating of ore in presence of air to remove sulphur impurities is called **[AFMC 2005]**

(a) Calcination (b) Roasting

(c) Smelting (d) None of these

60. The important step in the extraction of metal from carbonate ore is

(a) Calcination (b) Roasting

(c) Electro–reduction (d) Cupellation

Reduction to free Metal

1. Electrometallurgical process is used to extract **[MNR 1985, 89; UPSEAT 2000; MP PMT 2001]**

(a) *Fe* (b) *Pb*

(c) *Na* (d) *Ag*

2. General method for the extraction of metal from oxide ore is **[CPMT 1983; MP PET 2002]**

(a) Carbon reduction (b) Reduction by aluminium

(c) Reduction by hydrogen (d) Electrolytic reduction

3. Function of the flux added during smelting is

(a) To make ore porous

(b) To remove gangue

(c) To make reduction easier

(d) To precipitate slag

4. Alumino–thermic 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

5. In blast furnace iron oxide is reduced by **[MP PMT 1989; KCET 2005]**

(a) Silica (b) CO

(c) Carbon (d) Lime stone

6. Furnaces are lined with calcium oxide because

(a) It gives off oxygen on heating

(b) It gives strong light on heating

(c) It is refractory and basic

(d) It is not affected by acids

7. The substance used in the thermite process of reducing metal ores is **[MP PET 1993; CPMT 2000, 01]**

(a) Aluminium (b) Thorium

(c) Heated Pt gauge (d) Carbon

8. The electrolytic method of reduction is employed for the preparation of metals that **[MP PMT 1991; NCERT 1984; CPMT 1988; KCET 2002]**

(a) Are weakly electropositive

(b) Are moderately electropositive

(c) Are strongly electropositive

(d) Form oxides

9. Which of the following metals cannot be extracted by carbon reduction process **[AMU 1982]**

(a) *Pb* (b) *Al*

(c) *Hg* (d) *Zn*

10. Carbon reduction process is used for the extraction of

(a) *Hg* (b) *Zn*

(c) *Cr* (d) *Fe*

11. Among the following groups of oxides, the group containing oxides that cannot be reduced by carbon to give the respective metals is **[NCERT 1984]**

(a) Cu_2O, K_2O (b) Fe_2O_3, ZnO

(c) CaO, K_2O (d) PbO, Fe_3O_4

12. Which one of the following metals is extracted by thermal reduction process? **[EAMCET 1986]**

(a) Copper (b) Iron

(c) Aluminium (d) Magnesium

13. Chemical reduction is not suitable for converting **[MP PET 1994]**

(a) Bauxite into aluminium (b)Cuprite into copper

(c) Haematite into iron (d) Zinc oxide into zinc

14. In alumino–thermite process, aluminium is used as **[IIT 1983; DPMT 1980; MP PMT 1987; MP PET/PMT 1988; NCERT 1983; UPSEAT 2003]**

(a) Oxidising agent (b) Flux

(c) Reducing agent (d) Solder

15. Which metal is extracted by electrolytic reduction method **[CPMT 1984; MP PET 1997]**

(a) Cu (b) Al

(c) Fe (d) Ag

16. Alumina

(a) Is a good conductor of electricity

(b) Is a bad conductor of electricity

(c) Melts at $200^{o}C$

(d) Is an electrovalent compound

17. Aluminium is prepared in large quantities by **[KCET 1991, 92]**

(a) Heating cryolite in a limited quantity of air

(b) Reducing aluminium oxide with coke

(c) Reducing aluminium oxide with sodium

(d) Electrolysing aluminium oxide dissolved in fused electrolyte

18. Alumina is

(a) $Al(OH)_3$ (b) $AlCl_3$

(c) AlN (d) Al_2O_3

19. Which one of the following is used in the extraction of aluminium by electrolytic process **[CPMT 1978]**

(a) Al_2O_3 (b) $Al(OH)_3$

(c) $AlCl_3$ (d) $Al_2(SO_4)_3$

20. Which technique is used in the manufacture of aluminium from bauxite **[NCERT 1983]**

(a) Reduction with magnesium

(b) Reduction with coke

(c) Electrolytic reduction

(d) Reduction with iron

21. Which of the following processes does not involve a catalyst **[KCET 1991]**

(a) Haber's process (b) Thermite process

(c) Ostwald process (d) Contact process

22. Thermite process is used to extract metals **[KCET 1989]**

(a) When their oxides can't be reduced by carbon

(b) When their carbonates do not yield oxides by thermal decomposition

(c) When their sulphides can't be converted into oxides by roasting

(d) When their melting points are very high

23. Iron is obtained on a large scale from Fe_2O_3 by **[CPMT 1973, 78, 79; Orissa JEE 2005]**

(a) Reduction with Al

(b) Reduction with CO

(c) Reduction with H_2

(d) Reduction with sodium

24. After partial roasting, the sulphide of copper is reduced by **[MP PMT 1993]**

(a) Reduction by carbon (b) Electrolysis

(c) Self–reduction (d) Cyanide process

25. High purity copper metal is obtained by **[MP PMT 1991]**

(a) Carbon reduction (b) Hydrogen reduction

(c) Electrolytic reduction (d) Thermite reduction

26. In the metallurgical extraction of zinc from ZnO the reducing agent used is **[MP PET 1994]**

(a) Carbon monoxide (b) Sulphur dioxide

(c) Carbon dioxide (d) Nitric oxide

27. In order to refine "blister copper" it is melted in a furnace and is stirred with green logs of wood. The purpose is **[MP PET 1996]**

(a) To expel the dissolved gases in blister copper

(b) To bring the impurities to surface and oxidize them

(c) To increase the carbon content of copper

(d) To reduce the metallic oxide impurities with hydrocarbon gases liberated from the wood

28. Aluminium is produced on a large scale by electrolysis of alumina, dissolved in fused cryolite and a little fluorspar. These two electrolytes, *cryolite* and *fluorspar* are respectively

(a) Na_3AlF_6 and CaF_2

(b) AlF_3 and KF

(c) Al_2C_6 and KCl

(d) $KCl.MgCl_2.6H_2O$ and MgF_2

29. Electrometallurgy is used for

(a) Transition metals

(b) Most reactive metals

(c) Noble metals

(d) Soft metals

30. The metal extracted by electrolysis of its fused salt is **[MP PET/PMT 1998]**

(a) Iron (b) Lead

(c) Sodium (d) Copper

31. Alumino–thermic process is used for metallurgy of **[CPMT 1996]**

(a) Pb (b) Ag

(c) Al (d) None of these

32. Which metal can't be obtained from electrolysis **[CPMT 1997; RPET 1999]**

(a) Cu (b) Mg

(c) Cr (d) Ni

33. To obtain chromium from chromic oxide (Cr_2O_3), the method used is **[JIPMER 2001]**

(a) Alumino-thermic process

(b) Electrolytic reduction

(c) Carbon reduction

(d) Carbon monoxide reduction

34. The substance used in the thermite process of reducing metal ores is **[CPMT 2000; KCET 2001; UPSEAT 2001]**

(a) Aluminium

(b) Thorium

(c) Heated platinum gauze

(d) Carbon

35. Heating with carbon in absence of air is known as **[DCE 2002]**

(a) Reduction (b) Carbon-reduction

(c) Smelting (d) Roasting

Refining of crude metal

1. In electrolytic refining of metals, electrolysis of an aqueous solution of its complex salt is done with impure metal as anode and an strip of pure metal as cathode. This method cannot be used for the refining of the metal **[MP PMT 1989]**

(a) Silver (b) Copper

(c) Aluminium (d) Zinc

2. Which method of purification is represented by the equation

$\underset{\text{Impure}}{Ti} + 2I_2 \xrightarrow{500\ K} TiI_4 \xrightarrow{1675\ K} \underset{\text{Pure}}{Ti} + 2I_2$ **[AIIMS 1983]**

(a) Cupellation (b) Poling

(c) Van Arkel (d) Zone refining

3. Cupellation process is used in the metallugry of **[CPMT 1983; MP PET 1994; MP PMT 2000, 02]**

(a) Copper (b) Silver

(c) Aluminium (d) Iron

4. Metals are **[MADT Bihar 1983]**

(a) Electropositive (b) Electronegative

(c) Acceptor of electrons (d) None of these

5. The cyanide process is used for obtaining **[DPMT 1982; CPMT 1976, 84, 90; MNR 1995; MP PET/PMT 1998; AIEEE 2002]**

(a) Na (b) Ag

(c) Cu (d) Zn

6. In electrolytic refining, the impure metal is made is used to make **[MP PET 2003]**

(a) Cathode (b) Anode

(c) Electrolytic bath (d) None of these

7. Of the following, which cannot be obtained by electrolysis of the aqueous solution of their salts **[IIT 1990]**

(a) Ag (b) Mg and Al

(c) Cu (d) Cr

8. Van Arkel method of purification of metals involves converting the metal to a **[BHU 1990]**

(a) Volatile stable compound

(b) Volatile unstable compound

(c) Non volatile stable compound

(d) None of the above

9. Zone refining is a method to obtain **[KCET 1993]**

(a) Very high temperature (b) Ultra pure Al

(c) Ultra pure metals (d) Ultra pure oxides

10. Which one of the following is manufactured by the electrolysis of fused sodium chloride **[CPMT 1979, 83, 9**

(a) $NaOH$ (b) $NaClO$

(c) Na (d) $NaClO_3$

11. A metal which is refined by poling is **[RPET 2000]**

(a) Sodium (b) Blister copper

(c) Zinc (d) Silver

12. Silver obtained from argentiferrous lead containing lead impurity is purified by **[CPMT 1981; MP PMT 1990; EAMCET 1998]**

(a) Distillation (b) Froth floatation

(c) Cupellation (d) Treatment of KCN

13. If the impurity in a metal has a greater affinity for oxygen and is more easily oxidised than the metal, then the purification of metal may be carried out by **[MP PMT 1997]**

(a) Poling (b) Zone refining

(c) Electrolytic refining (d) Cupellation

14. Electric refining is used for refining of **[DPMT 1996]**

(a) Lead (b) Copper

(c) Iron (d) Sodium

15. Zone refining is used for the purification of **[Pune CET 1998**

(a) Cu (b) Au

(c) Ge (d) Ag

16. Mond's process is used for preparing **[MNR 1983]**

(a) Ni (b) H_2SO_4

(c) NH_3 (d) HNO_3

(e) $NaHCO_3$

17. Gold is extracted by hydrometallurgical process based on its property **[KCET 2005]**

(a) Of being electropositive

(b) Of being less reactive

(c) To form complexes which are water soluble

(d) To form salts which are water soluble

Critical Thinking

Objective Questions

1. Black Jack is an ore of **[PCET 2004]**

(a) Cr (b) Sn

(c) *Zn* (d) *Ni*

2. Froth floatation process is used for concentration of

[MNR 1987; IIT 1989; UPSEAT 2000, 02]

(a) Chalcopyrite (b) Bauxite

(c) Haematite (d) Calamine

3. The process of ore dressing is carried out to

[MP PMT 1994]

(a) Remove the siliceous materials

(b) Add flux to the mineral

(c) Convert the ore to oxide

(d) Remove the poisonous impurities

4. Wolframite ore is separated from tinstone ore by the process of

(a) Roasting (b) Electromagnetic

(c) Smelting (d) Calcination

5. Which process of reduction of mineral to the metal is suited for the extraction of copper from its ores with low copper content

(a) Metal displacement (b) Auto reduction

(c) Chemical reduction (d) Electrolytic reduction

6. *Pb* and *Sn* are extracted from their chief ore by

[IIT-JEE Screening 2004]

(a) Carbon reduction and self reduction.

(b) Self reduction and carbon reduction.

(c) Electrolysis and self reduction.

(d) Self reduction and electrolysis.

7. Zone refining is a technique used primarily for which one of the following process

(a) Alloying (b) Tempering

(c) Sintering (d) Purification

8. Method used for obtaining highly pure silicon used as a semiconductor material is**[CBSE PMT 1994]**

(a) Oxidation (b) Electrochemical

(c) Crystallization (d) Zone refining

9. Which is correct **[MADT Bihar 1995]**

(a) Galena : Mg_2CO_3

(b) Cassiterite : $CaCO_3\ MgCO_3$

(c) Dolomite : SnO_2

(d) Magnesite : $MgCO_3$

10. 'Lapis–Lazuli' is a blue coloured precious stone. It is mineral of the class

[NCERT 1980; AIIMS 1980; BHU 1978, 80]

(a) Sodium–alumino silicate (b) Zinc cobaltate

(c) Basic copper carbonate (d) Prussian blue

A R Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : $Al(OH)_3$ is amphoteric in nature

Reason : $Al-O$ and $O-H$ bonds can be broken with equal ease in $Al(OH)_3$ **[IIT 1998]**

2. Assertion : Iron is found in the free state in nature **[AIIMS 2001]**

Reason : Iron is highly reactive element **[BHU 2004]**

3. Assertion : Zinc is used and copper is not used in the recovery of Ag from the complex $[Ag(CN)_2]^-$.

Reason : Zinc is a powerful reducing agent than copper.

4. Assertion : Coke and flux are used in smelting.

Reason : The phenomenon in which ore is mixed with suitable flux and coke is heated to fusion is known as smelting.

5. Assertion : Leaching is a process of reduction.

Reason : Leaching involves treatment of the ore with a suitable reagent so as to make it soluble while impurities remains insoluble.

6. Assertion : Ethyl xanthate is used as a collector in froth floatation process .

Reason : Collectors depress the floatation property of one of the components of the ore and thus help in the separation of different minerals present in the same ore.

7. Assertion : Levigation is used for the separation of oxide ores from impurities.

Reason : Ore particles are removed by washing in a current of water.

8. Assertion : In Hall and Heroult's process, *Al* is extracted by electrolysis of a fused mixture of alumina, cryolite and fluorspar.

Reason : Addition of cryolite and fluorspar lowers the fusion temperature and increases the conductivity of the electrolyte.

9. Assertion : $AgNO_3$ is called lunar caustic.

Reason : In contact with organic matter (skin, cloth paper, etc.) $AgNO_3$ is reduced to metallic silver.

10. Assertion : Wolframite impurities are separated from cassiterite by electromagnetic separation.
Reason : Cassiterite being magnetic is attracted by the magnet and forms a separate heap.

11. Assertion : Lead, tin and bismuth are purified by liquation method.
Reason : Lead, tin and bismuth have low m.p. as compared to impurities.

12. Assertion : Gold is recovered from its solution containing aurocynaide complex by adding zinc dust.
Reason : Zinc is more electropositive than gold.

Answers

Occurrence

1	b	2	b	3	d	4	b	5	ac
6	a	7	c	8	c	9	a	10	c
11	d	12	c	13	a	14	c	15	d
16	c	17	b	18	d	19	d	20	b
21	a	22	d	23	d	24	c	25	c
26	a	27	b	28	a	29	d	30	a
31	c	32	d	33	a	34	c	35	b
36	b	37	b	38	d	39	b	40	b
41	a	42	d	43	a	44	c	45	c
46	c	47	c	48	a	49	d	50	d
51	b	52	b	53	a	54	a	55	c
56	b	57	a	58	c	59	d	60	c
61	a	62	a	63	c	64	c	65	c
66	b	67	c	68	d	69	a	70	a
71	b	72	b						

Concentration

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

Roasting & Calcination

1	b	2	a	3	c	4	a	5	c
6	a	7	a	8	c	9	b	10	a
11	d	12	d	13	c	14	b	15	d
16	d	17	b	18	d	19	b	20	d
21	a	22	b	23	b	24	a	25	a
26	c	27	d	28	b	29	b	30	c
31	b	32	d	33	b	34	c	35	c
36	b	37	d	38	c	39	b	40	c
41	b	42	c	43	d	44	b	45	d
46	d	47	b	48	d	49	a	50	b
51	a	52	a	53	a	54	d	55	c
56	d	57	c	58	a	59	b	60	a

Reduction to free Metal

1	c	2	a	3	b	4	b	5	b
6	c	7	a	8	c	9	b	10	d
11	c	12	b	13	a	14	c	15	b
16	b	17	d	18	d	19	a	20	c
21	b	22	a	23	b	24	c	25	c
26	a	27	d	28	a	29	b	30	c
31	d	32	b	33	a	34	a	35	b

Refining of crude Metal

1	d	2	c	3	b	4	a	5	b
6	b	7	b	8	a	9	c	10	c
11	b	12	c	13	d	14	b	15	c
16	a	17	c						

Critical Thinking Questions

1	c	2	a	3	a	4	b	5	b
6	b	7	d	8	d	9	d	10	a

Assertion & Reason

1	c	2	e	3	a	4	b	5	c
6	c	7	c	8	a	9	b	10	c
11	a	12	a						

Answers and Solutions

Occurrence

1. (b)

Element	% abundance by weight
O	46.6
Si	27.7
Al	8.3
Fe	5.1
Ca	3.6

6. (a) $As \rightarrow$ Metalloid $Na, Au, Fe \rightarrow$ Metals

8. (c) $N_2 = 78\%$; $O_2 = 21\%$

9. (a) Bauxite $Al_2O_3.2H_2O$

10. (c) Carnellite $KCl.MgCl_2.6H_2O$

12. (c) Dolamite $MgCO_3.CaCO_3$

Magnesite $MgCO_3$

Carnallite $KCl.MgCl_2.6H_2O$

16. (c) Diamond made up of carbon only.

17. (b) Bauxite (Al_2O_3), Cryolite (Na_3AlF_6), Corundum (Al_2O_3) } Minerals of Al

Gypsum $(CaSO_4.2H_2O)$

18. (d) Cryolite $(Na_3AlF_6) \rightarrow$ Halide ore

Galena (PbS), Cinnaber (HgS) } Sulphide ore

Bauxite $Al_2O_3.2H_2O \rightarrow$ Oxide ore

19. (d) Pig iron $\rightarrow$ It is the most impure form of iron and contains highest proportion of carbon $(2.5-4\%)$

Malachite $\rightarrow Cu(OH)_2.CuCO_3$

Zinc blende $\rightarrow ZnS$

Bauxite $\rightarrow Al_2O_3.2H_2O$

20. (b) Chile salt petre $\rightarrow NaNO_3$

21. (a) Na is alkali metal highly reactive. Hence present in combined state.

24. (c) Na_3AlF_6 Sodium hexafluoro aluminate (III)

28. (a) Bauxite $(Al_2O_3.2H_2O)$

Corundum (Al_2O_3)

Diaspore $(Al_2O_3.H_2O)$

29. (d) Fluorspar (CaF_2), Cryolite (Na_3AlF_6),

Feldspar $(KAlSi_3O_8)$, Mica $(K_2O.3Al_2O_3.6SiO_2.2H_2O)$

30. (a) Haematite Fe_2O_3

33. (a) Invar Fe = 64% and Ni = 36%

34. (c) Cassiterite (SnO_2), Magnetite (Fe_3O_4), Haematite (Fe_2O_3), Limonite $(Fe_2O_3.3H_2O)$.

36. (b) Copper is a reddish brown metal

37. (b) Azurite $Cu(OH)_2.2CuCO_3$

38. (d) Malachite $(Cu(OH)_2.CuCO_3)$

40. (b) Argentite or silver glance (Ag_2S)

44. (c) Zinc blende is ZnS not $ZnCl_2$

46. (c) Galena (PbS), Anglesite $(PbSO_4)$, Calamine $(ZnCO_3)$, Cerrussite $(PbCO_3)$

52. (b) Cuprite (Cu_2O) and Argentite (Ag_2S)

53. (a) Horn silver $(AgCl)$

55. (c) Carnallite is $KCl.MgCl_2.6H_2O$

56. (b) Cryolite is an ore of Al containing Na_3AlF_6.

58. (c) Corundum (Al_2O_3) is an ore of Al.

59. (d) All minerals are not suitable for the extraction of metals commercially. Thus all ores are minerals, but all minerals are not ores.

60. (c) Among cuprite [Cu_2O], Chalcacite [Cu_2S], Chalcopyrite [$CuFeS_2$] & Malachite [$Cu(OH)_2.CuCO_3$], only Chalcopyrite is an ore which contains both *Fe* and *Cu*

61. (a) Felspar is $K_2O.Al_2O_3.6SiO_2$

62. (a) Chile salt petre is $NaNO_3$ While KNO_3 is Indian salt petre. Na_2SO_4 is Glouber salt and $Na_2S_2O_3$ is known as Hypo.

63. (c) Gypsum $(CaSO_4.2H_2O)$ is an ore of calcium.

Dolomite $(CaCO_3.MgCO_3)$, Magnesite $(MgCO_3)$ and Carnalite $(KCl.MgCl_2.6H_2O)$ are the ores of Magnesium.

64. (c) Magnetite (Fe_3O_4), Siderite $(FeCO_3)$, Limonite $(Fe_2O_3.3H_2O)$ and Haematite (Fe_2O_3) are ores of Iron. Only Smithsonite is not an ore of Iron.

65. (c) Carnalite is an important ore of magnesium. It is

$KCl.MgCl_2.6H_2O$

67. (c) Al is most abundant metal in the earth crust

68. (d) Chalcopyrite $(CuFeS_2)$

70. (a) Cassiterite - SnO_2

Cryolite - Na_3AlF_6

Cerussite - $PbCO_3$

71. (b) Carnalite is the ore of K and Mg its formula is $KCl.MgCl_2.6H_2O$

72. (b) Pyrolusite – MnO_2

Malachite – $CuCO_3.Cu(OH)_2$

Diaspore – $Al_2O_3.H_2O$

Cassiterite – SnO_2

Concentration

1. (a) Froth floatation method is based on the fact that the surface of sulphide ores is preferentially wetted by oil while that of gangue is wetted by water.

4. (c) Haematite (Fe_2O_3)

Iron ores are concentrated by this method

5. (b) Pine oil is foaming agent. Now another substance collector such as potassium ethyl xanthate or amyl xanthate are added.

6. (c) Cinnabar (HgS) the ore of mercury is concentrated by froth floatation process.

7. (c) Cyanide process is used in the extraction of both Silver and Gold because these form complex salts with CN^- ion due to presence of lone pair of electron on nitrogen atom.

8. (b) Cassiterite SnO_2 or tinstone – an ore of tin being non-magnetic can be separated from magnetic impurities like *Fe* and *Mn* from this method.

13. (c) Chemical separation or Leaching.

In this powdered ore is treated with a suitable reagent which can dissolve the ore but not the impurities.

14. (d) Copper pyrite $CuFeS_2$ (Chalcopyrite)

16. (c) Sulphides ores are always concentrated by froth floatation process

20. (a) Froth floatation because it is sulphide ore (ZnS)

22. (a) Here only Galena is PbS (a sulphide ore).

Cassiterite is SnO_2 (oxide ore). Magnetite is Fe_3O_4 (Oxide ore) and Malachite is $Cu(OH)_2.CuCO_3$ (Carbonate ore). The froath floatation process is used to concentrate sulphide ores, based on preferential wetting properties with froating agent and water.

Roasting & Calcination

1. (b) These are the substances which can withstand very high temperature without melting or becoming soft.

2. (a) To remove volatile substances.

$S_8 + 8O_2 \rightarrow 8\,SO_2\uparrow$; $P_4 + 5O_2 \rightarrow P_4O_{10}\uparrow$

$4\,As + 3O_2 \rightarrow 2\,As_2O_3\uparrow$

3. (c) In this process sulphides ores are converted into oxide ores $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2\uparrow$

5. (c) $\underset{\text{Acidic flux}}{SiO_2}$ $\underset{\text{Basic flux}}{CaCO_3}$, lime, CaO

6. (a) (Impurity) $\underset{\text{Infusible}}{\text{Gangue}} + \text{flux} \rightarrow \underset{\text{Fusible}}{\text{Slag}}$

7. (a) $CaCO_3 \rightarrow CaO + CO_2$

Heating the ore in absence of air is calcination.

9. (b) Smelting is a process of reducing metal oxide to metal by means of coke or CO.

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

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

13. (c) Flux is added during smelting it combines with infusible gangue present in the ore to form a fusible mass known as slag. $\text{Flux} + \text{Gangue} \rightarrow \text{Slag}$

15. (d) $CaO \rightarrow$ It is hygroscopic in nature

22. (b) Reduction with carbon is called smelting

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

25. (a) $\underset{\text{Impurity}}{SiO_2} + \underset{\text{Flux}}{CaO} \rightarrow \underset{\text{Slag}}{CaSiO_3}$

26. (c) Impurities of SiO_2 is present in the iron ore so basic flux $CaCO_3$ is added.

$\underset{\text{Flux}}{CaO} + \underset{\text{Impurity}}{SiO_2} \rightarrow \underset{\text{Slag}}{CaSiO_3}$

28. (b) $CaCO_3 \rightarrow CaO + CO_2$; $\underset{\text{Flux}}{CaO} + \underset{\text{Impurity of haematite}}{SiO_2} \rightarrow \underset{\text{Slag}}{CaSiO_3}$

29. (b) $\underset{\text{Impurity}}{FeO} + \underset{\text{Flux}}{SiO_2} \rightarrow \underset{\text{Slag}}{FeSiO_2}$

30. (c) Hydrometallurgy

$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

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

31. (b) $Cu_2Cl_2 + Ag_2S \rightarrow Cu_2S + 2AgCl$

$2AgCl + Hg \rightarrow Hg_2Cl_2 + 2Ag$

$AgCl + Hg \rightarrow Ag + HgCl$

32. (d) Roasting (Sulphide ore is heated in excess of air)

33. (b) $ZnCO_3 \rightarrow ZnO + CO_2$

In calcination ore is heated in absence of air in a reverberatory furnace to remove moisture and CO_2

36. (b) $\underset{\text{Acidic impurity}}{SiO_2} + \underset{\text{Basic flux}}{CaO} \rightarrow \underset{\text{Slag}}{CaSiO_3}$

39. (b) $\underset{1}{CaCO_3} + \underset{4}{\text{Coke}} + \underset{8}{\text{Calcined}}$

41. (b) Zinc blende (ZnS) ;

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

42. (c) When conc. HgS ore is roasted

$HgS + O_2 \xrightarrow{773-873\,K} Hg + SO_2$

At this temperature, mercury vaporises and the vapours are condensed to the liquid metal. Mercury so obtained is about 99.7% pure.

43. (d)

Combustion zone	1800 K
Fusion zone	1600 K
Slage zone	1300 K
Treduction zone	800 K

44. (b) In roasting process, the ore (usually sulphide) alone or mixed with other materials is heated in excess of air.

45. (d) Flux is used to fuse non-fusible impurities presents in ore.

46. (d) During extraction of Fe calcium silicate $(CaSiO_3)$ slag is obtained.

47. (b) In Bessemer converter copper sulphide is partially oxidised to cuprous oxide which further reacts with remaining copper sulphide to form copper and sulphur dioxide. $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

48. (d) Flux is used to remove silica and undesirable metal oxide.

49. (a) Roasting is the process of heating the ore strongly in the presence of excess of air. It is generally carried in a reverberatory or blast furnace.

50. (b) Lime stone which is a flux used to remove acidic impurities in metallurgical process.

52. (a) CN^- solution used in extraction of Ag metal in the cyanide process.

57. (c) Lime stone $(CaCO_3)$ is used for formation of slag in Fe extraction

$\underset{\text{Lime stone}}{CaCO_3} \longrightarrow CaO + CO_2 \uparrow$

$\underset{\substack{\text{Gangue}\\ \text{or}\\ \text{impurity}}}{CaO + SiO_2} \longrightarrow \underset{\text{slag}}{CaSiO_3}$

58. (a) $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$ (Auto-reduction).

This reaction occurs in reverberatory furnace to get metallic copper.

59. (b) Roasting involves heating of the ore either alone or with some other material usually in presence of air below its fusion temperature. In roasting, definite chemical changes like oxidation, chlorination etc., take place

$S + O_2 \rightarrow SO_2$

60. (a) Calcination $ZnCO_3 \rightarrow ZnO + CO_2$

Reduction to free metal

1. (c) Because Na is very reactive and can not be extracted by means of the reduction by C, CO etc. So extracted by electrolysis.

2. (a) Carbon reduction, $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

3. (b) $\text{Flux} + \text{Gangue} \rightarrow \text{Slag}$

4. (b) Alumino thermite process involves reduction of oxides such as Fe_2O_3, Mn_3O_4, Cr_2O_3 etc. to metals with aluminum. $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr \quad \Delta H = -\text{ve}$

5. (b) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

7. (a) A mixture of Al powder and metallic oxide $(Cr_2O_3, Mn_3O_4 \text{ etc})$ is called thermite.

9. (b) Al is highly electropositive. It can be obtained by electrolytic reduction.

10. (d) $Fe_2O_3 + 3C \rightarrow 3CO + 2Fe$

13. (a) Bauxite into aluminium because Al is a strong reducing agent it has strong affinity with oxygen than carbon

20. (c) Electrolytic reduction Hall and Heroult process.

23. (b) $Fe_2O_3 + 3CO \rightarrow 3CO_2 + 2Fe$

24. (c) Self reduction :- Reduction of oxide ore of a metal by its own sulphide $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

26. (a) $ZnO + CO \rightarrow CO_2 + Zn$

27. (d) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

$3Cu_2O + \underset{\substack{\text{(From green}\\ \text{logs of wood)}}}{CH_4} \rightarrow 6Cu + 2H_2O + CO$

30. (c) Sodium $\rightarrow$ Highly reactive metal

33. (a) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$

34. (a) In thermite process a mixture of aluminium powder and ferricoxide in the rate of 1 : 3 is used.

35. (b) Heating with carbon in absence of air is known as carbon reduction.

This is used in Iron metallurgy.

$$Fe_2O_3 + C \xrightarrow{\text{(in blast furnace)}} Fe$$

Refining of crude metal

2. (c) Van Arkel method *Ti* and *Zn* are refined by this method. It is used for obtaining ultra pure metals.

3. (b) Cupellation method is used when the impure metals contain impurity of another metal which forms volatile oxide.

4. (a) Metals are electropositive elements because they have tendency to loose e^- and forms + *ve* ions

$$Na \rightarrow Na^+ + e^-$$

6. (b) Impure metal as anode and pure metal as cathode.

7. (b) *Mg* and *Al* can not be obtained by the electrolysis of aqueous solution of their salts because instead of metal H_2 gas is liberated at cathode.

8. (a) $Ti + 2I_2 \xrightarrow{500\,K} \underset{\text{Volatile Stable compound}}{TiI_4} \xrightarrow{1700\,K} \underset{\text{Pure metal}}{Ti} + 2I_2$

9. (c) Zone refining is employed for preparing extremely pure metals.

It is based on the principle that when a molten solution of the impure metal is allowed to cool the pure metal crystallises out while the impurities remain in the melt. Ex : Semiconductors like *Si, Ge* and *Ga* are purified by this method.

10. (c) $\underset{\text{(fused)}}{2NaCl} \rightarrow 2Na^+ + 2Cl^-$

Anode: $2Cl^- \rightarrow 2e^- + Cl_2$ (oxidation)

Cathode: $2Na^+ + 2e^- \rightarrow 2Na$ – (reduction)

11. (b) Poling is used for purification of metal which contain their own oxide as impurity

e.g. Cu_2O in Cu ; SnO_2 in Sn

12. (c) Cupellation : If metal possess the impurity of another metal which forms volatile oxide. Then cupellation method is used.

16. (a) Mond's process

$$\underset{\text{Impure}}{Ni} + 4CO \xrightarrow{\text{heat}} [Ni(CO)_4] \xrightarrow{\text{Decompose}} \underset{\text{Pure}}{Ni} + 4CO$$

17. (c) Hydrometallurgy is the process of dissolving the metal or its ore by the action of a suitable chemical regent followed by recovery of the metal either by electrolysis or by the use of a suitable precipitating agent.

$$4Au + 8KCN + 2H_2O + \underset{\text{air}}{O_2} \rightarrow 4K[Au(CN)_2] + 4KOH$$

$$2K[Au(CN)_2] + Zn \rightarrow 2Au + K_2[Zn(CN)_4]$$

Critical Thinking Questions

1. (c) Black Jack (ZnS), also called zinc blend, is an ore of Zinc.

2. (a) Chalcopyrities is contain sulphur that's why it is concentrated by froth floatation process.

3. (a) Removal of silicious matter from ores is known as dressing or concentration of ore.

4. (b) Wolframite ore $[FeWO_4]$ is present in tin stone as impurities and it has same mass per unit volume as that of tin stone. So it is separated by electromagnetic separator because wolframite is magnetic in nature hence it gets attracted by magnet while tin stone doesn't

5. (b) Auto reduction is used for the extraction of copper from its ore with low copper content.

6. (b) PbO & $PbSO_4$ get reduced by PbS itself which is already present in mixture so because the reduction took place by mixture itself, hence is known as self reduction.

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

$$PbSO_4 + PbS \xrightarrow{\Delta} 2Pb + 2SO_2 \uparrow$$

7. (d) Zone refining is a method of purification used for semiconductors like Si, Ge and *Ga*.

8. (d) By the process of zone refining pure silicon is obtained which is used in semiconductor.

9. (d) $MgCO_3$ is the formula of magnesite.

10. (a) Lapis lazuli is the aluminium silicate present in earth rocks as blue stone.

Assertion and Reason

2. (e) Iron is highly reactive element, therefore, it is found in combined state. Here assertion is false but reason is true.

3. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

4. (b) Both assertion and reason are true but reason is not the correct explanation of assertion. Non fusible mass present in ore in mixing

with suitable flux are fused which are then reduced by coke to give free metal.

5. (c) Assertion is false but reason is true. Leaching is a process of concentration.

6. (c) Assertion is true but reason is false. Collectors absorbs themselves on polar groups to grains of ores and thus derive them on the surface to pass on into the froth.

7. (c) Assertion is true but reason is false.

Oxide ores being heavier than the earthy or rocky gangue particles settle down while lighter impurities are washed away.

8. (a) Both assertion and reason are true and reason is the correct explanation of assertion

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

Silver nitrate is called lunar caustic because when it comes in contact with organic substances (e.g. skin, clothes) and reduced to metallic silver which is white like the iron lunar.

10. (c) Assertion is true but reason is false.

Wolframite being magnetic is attracted by the magnetic roller and forms a heap under it.

11 (a) Both assertion and reason are true and reason is correct and reason is the correct explanation of assertion.

Liquation process is based on the difference in fusibility of the metal and impurities. When the impurities are less fusible than the metal itself, the process is employed.

12. (a) Au is recovered from the solution by the addition of electropositive metal.

$$2NaAu(Cu)_2 + Zn \longrightarrow \underset{\text{Soluble complex}}{Na_2Zn(CN)_4} \; 2Au \downarrow$$

General Principles of Extraction of Metals

SET Self Evaluation Test - 16

1. The region in which main metals are found in earth is called

(a) Atomophil (b) Lithophil

(c) Calcophil (d) Siderophil

2. Which metal is found in free state

(a) Iron (b) Gold

(c) Aluminium (d) Sodium

3. Which metal is found in Khetri region of Rajasthan

(a) Iron (b) Copper

(c) Gold (d) Lead

4. **Sapphire** is mineral of **[BHU 1977]**

(a) Cu (b) Zn

(c) Al (d) Mg

5. Of the following substances the one which does not contain oxygen is **[JIPMER 1997]**

(a) Bauxite (b) Epsom salt

(c) Cryolite (d) Dolomite

6. The chief impurity present in red bauxite is : **[DCE 2004]**

(a) SiO_2 (b) Fe_2O_3

(c) K_2SO_4 (d) NaF

7. In the froth floatation process for the purification of ores, the ore particles float because **[MP PMT 1984; NCERT 1981; CPMT 1987; MNR 1992; UPSEAT 2002]**

(a) They are light

(b) Their surface is not easily wetted by water

(c) They bear electrostatic charge

(d) They are insoluble

8. Difference in density is the basis of **[Kerala (Med.) 2002]**

(a) Ultrafiltration

(b) Molecular sieving

(c) Gravity separation

(d) Molecular attraction

9. Mark the wrong statement

(a) Wrought iron is prepared by heating cast iron in a reverberatory furnace

(b) The impurities present in cast iron are oxidised by air

(c) The impurities are oxidised by Fe_2O_3

(d) CO burns with blue flame and the Si, Mn and other impurities form slag with silica

10. Thomas slag is **[RPET 2003]**

(a) $CaSiO_3$ (b) $Ca_3(PO_4)_2$

(c) $MnSiO_3$ (d) $CaCO_3$

11. Which is correct **[MADT Bihar 1995]**

(a) Aluminium : Calamine

(b) Copper : Malachite

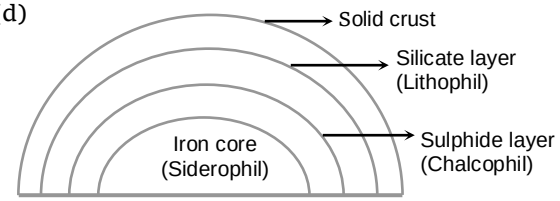
(c) Magnesium : Calamine

(d) Zinc : Carnellite

Answers and Solutions

(SET -16)

1. (d)



Different zones of the earth

2. (b) Gold, *Ag* and *Pt* are called noble metals. They are unreactive and found in free state.

3. (b) Copper metal is found in khetri region of Rajasthan with that it is also found in singhbhum and Hazaribagh district in Bihar, Agnigundala in Andhra pradesh, Malanjkh in M.P.

4. (c) Saphire (Blue colour) is mineral of Al.

5. (c) Cryolite (Na_3AlF_6)

6. (b) Red bauxite has chief imnpurity of Fe_2O_3.

7. (b) Ore particles are wetted by oil. Hence, float on the surface.

8. (c) Levigation or gravity separation is used when the ore particles are heavier than the earthy or rocky gangue particles.

9. (b) The wrong statement is that the impurities present in cast iron are oxidised by air.

10. (b) Thomas slag $Ca_3(PO_4)_2$ is used as a valuable fertilizer.

11. (b) Malachite is an ore of copper.

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