CHAPTER

5 Metals and Non-metals

1. **Metals and Non-metals :** There are more than 114 elements present in the periodic table. These elements can be broadly classified into two categories i.e., metals and non-metals. Out of 114 elements, 22 are non-metals.
2. **Physical properties of metals :**
   (i) They are usually shiny i.e. have a metallic luster.
   (ii) Metals have a high density
   (iii) Metals are ductile i.e. they can be drawn into wires.
   (iv) Metals are malleable i.e. they can be founded into thin sheets.
   (v) Metals are good conductors of electricity.
   (vi) Metals have high melting point and are generally in solid state at room temperature.
   (vii) Metals are good conductors of heat and sound.
3. **Uses of mxetals :**
   (i) Metals are very important for modern humans it is not possible to imagine our life without them.
   (ii) Metals are used in manufacturing of bridges, railways, aeroplanes, diesel mobile units (DMU), electric mobile units (EMU), motor cars, electric motors, telephones, televisions, interplanetary space vehicles, or even common articles like cooking utensils and coins.
   (iii) Metals are very important for the economy of a country. Some metals, such as titanium, chromium, manganese and zirconium are strategic metals. These metals and their alloys find wide applications in atomic energy, space science projects, jet engines and high grade steels.
   (iv) Gold and silver ornaments are obtained from small pieces of metals by hammering.
4. **Noble metal :** Noble metals are metals that are resistant to corrosion or oxidation, unlike most base metals. Examples include tantalum, gold, platinum, and rhodium.
5. **Precious metal :** A precious metal is a rare metallic chemical element of high economic value precious metals include the platinum group metals: ruthenium, rhodium, palladium, osmium, iridium, and platinum, of which platinum is the most widely traded.
6. **Alloy :** An alloy is a mixture of two or more elements in solid solution in which the major component is a metal. Most pure metals are either too soft, brittle or chemically reactive for practical use. Combining different ratios of metals as alloys modify the properties of pure metals to produce desirable characteristics. The aim of making alloys is generally to make them less brittle, harder, resistant to corrosion, or have a more desirable color and luster. Examples of alloys are steel (iron and carbon), brass (copper and zinc), bronze (copper and tin), and duralumin (aluminium and copper).

	Alloy	Composition	Uses
1.	Brass	Cu = 80%, Zn = 20%	For making utensils and cartridges.
2.	Bronze	Cu = 90%, Sn = 10%	For making statues, medals, ships, coins and machines
3.	Solder	Sn = 50%, Pb = 50%	For joining metals, solding wire and electronic components etc.
4.	Duralumin	Al = 95.5%, Cu = 3%, Mn = 1.0%, Mg = 0.5%	Used in bodies of aircrafts, kitchen ware and automobile parts etc.
5.	German Silver	Cu = 60%, Zn = 20%, Ni = 20%	For making utensils and ornaments
6.	Gun metal	Cu = 90%, Sn = 10%	For Gears and castings etc.
7.	Bell metal	Cu = 80%, Sn = 20%	For bells, gangs etc.
8.	Magnalium	Al = 90%, Mg = 10%	For balance beams, light instruments.
9.	Type metal	Pb = 82%, Sb = 15%, Sn = 3%	For casting type
10.	Stainless steel	Fe, Ni, Cr, C	For utensils, cutlery etc.

7. Physical properties of non-metals :

(i) They are dull, however diamond, graphite and iodine are lustrous.

(ii) They are poor conductors of heat and electricity. Graphite is a good conductor.

(iii) They are weak and brittle (they easily break or shatter).

(iv) They have a low density (they feel light for their size).

(v) They do not make a ringing sound when they are hit.

(vi) Melting points and boiling points are usually low.

(vii) Non-metals are usually soft. (Diamond is an exception, it is quite hard. It is a crystalline solid).

(viii) They exist in allotropic forms.

8. Uses of Non-Metals

(i) Oxygen is essential for survival of life.

(ii) Hydrogen is used to convert vegetable oil into vegetable ghee by hydrogenation.

(iii) Nitrogen is used to preserve food and for manufacturing proteins by plants.

(iv) Carbon in the form of diamond is used for cutting rocks and in the form of graphite as electrode and in manufacturing of lead pencils.

(v) Sulphur is used in vulcanization of rubber, as fungicide and in manufacture of dyes, gun powder etc.

(vi) Chlorine is used as water disinfectant and in the manufacture of pesticides like gammaxene.

9. Extraction of Metals

(i) **Minerals:** The natural substance in which the metals or their compounds occur in the earth is called minerals.

(ii) **Ores:** The minerals from which the metals can be conveniently and economically extracted are called ores.

(iii) **Native ores:** These ores contain metals in the free state, *e.g.*, silver, gold, platinum, etc.

(iv) **Metallurgy:** The whole process of obtaining a pure metal from one of its ore is known as metallurgy.

(v) **Gangue or matrix:** Ores usually contain soil, sand, stones and others useless silicates. These undesired impurities present in ores are called gangue or matrix.

(vi) The removal of unwanted earthy and silicious impurities from the ore is called **ore-dressing or concentration of ores** and the process used to concentrate an ore is called the **benefication process**.

(vii) Concentration of ore is achieved by

(a) physical methods, and

(b) chemical methods

(viii) **Physical methods are:**

(a) **Hand-picking:** It is used in the case when the impurities are quite distinct from the ore so that these may be differentiated by naked eye.

(b) **Hydraulic washing or Levigation or Gravity separation:** The separation is based on the difference in the specific gravities of the gangue particles and the ore particles.

(c) **Electromagnetic separation:** When one component either the ore or impurity is magnetic in nature, this method can be used for separation.

(d) **Froth floatation process:** This method is used for the concentration of sulphide ores.

(ix) **Chemical method (Leaching)** 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.

(x) **Extraction** process used to obtain metals in free state from concentrated ores is called extraction.

(xi) **Extraction of crude metal from the concentrated ore involves following chemical processes.**

(a) **Conversion of ore into metallic oxides.**

- Calcination involves heating the ore below its fusion temperature in the absence of air. It can remove moisture from hydrated oxide or CO_2 from carbonates. It makes the ore porous.
- Roasting is the heating of the ore in the presence of air below its fusion temperature.

(b) **Reduction to free metal:**

- **Smelting:** This involves the reduction of the ore to the molten metal at a high temperature. For the extraction of electropositive metals such as Pb, Fe, Sn, powerful reducing agent like C, H_2 CO, Al, Mg, etc., are used.
- **Self reduction process :** These processes are also called auto-reduction process.
- **Electrolytic process:** The oxides of highly electropositive metals like Na, K, Mg, Ca, Al, etc., are extracted by electrolysis of their oxides, hydroxides or chlorides in fused state. For example, Al is obtained by the electrolysis of alumina mixed with cryolite.

(xii) **Refining** is the process of purifying the extracted metals.

(xiii) **Chromatography** is based on the principle that the different components of a mixture are adsorbed to different extents on an adsorbent.

The table given here lists some common ores of some metals

Sl. No.	*Name of the ore*	*Formula of the ore*	*Type of ore*	*Metal obtained from the ore*
1.	Bauxite	$Al_2O_3.2H_2O$	Oxide	Aluminium (Al)
2.	Haematite	Fe_2O_3	Oxide	Iron (Fe)
3.	Magnetite	Fe_3O_4	Oxide	Iron (Fe)
4.	Zincite	ZnO	Oxide	Zinc (Zn)
5.	Cuprite	Cu_2O	Oxide	Copper (Cu)
6.	Litharge	PbO	Oxide	Lead (Pb)
7.	Malachite	$CuCO_3.Cu(OH)_2$	Carbonate	Copper (Cu)
8.	Magnesite	$MgCO_3$	Carbonate	Magnesium (Mg)
9.	Lime stone	$CaCO_3$	Carbonate	Calcium (Ca)
10.	Cinnabar	HgS	Sulphide	Mercury (Hg)
11.	Chalcopyrite	$CuFeS_2$	Sulphide	Copper (Cu)
12.	Zinc blende	ZnS	Sulphide	Zinc (Zn)
13.	Galena	PbS	Sulphide	Lead (Pb)
14.	Common salt	NaCl	Chloride (Halide)	Sodium (Na)
15.	Fluorspar	CaF_2	Fluoride (Halide)	Calcium (Ca)
16.	Horn silver	AgCl	Chloride (Halide)	Silver (Ag)
17.	Chalcocite	Cu_2S	Sulphide	Copper (Cu)

10. Corrosion of Metals : Corrosion is an oxidation reaction with atmospheric oxygen in the presence of water on the surface of a metal. Rusting is

$$Fe(s) + \frac{3}{2}O_2(g) + xH_2O(\ell) \longrightarrow Fe_2O_3.xH_2O(s)$$

i.e., rust is hydrated iron (III) oxide.

11. Prevention of Corrosion : Iron and steel (alloy of iron) are most easily protected by paint which provides a barrier between the metal and air/water. Moving parts on machines can be protected by a water repellent oil or grease layer. Other important methods are

(i) Alloying : Iron or steel along with other metals can also be protected by 'alloying' or mixing with other metals (e.g., chromium) to make non-rusting alloys.

(ii) Galvanizing : Coating iron or steel with a thin zinc layer is called 'galvanizing'.

12. Purity of Gold :

24-Carat gold : The carat (abbreviation ct or Kt) is a measure of the purity of gold alloys. Carat is used to refer to the measure of mass for gemstones.

EXERCISE

1. The most abundant metal in the earth's crust is -
   (a) iron (b) copper
   (c) aluminium (d) mercury
2. The only metal that is liquid at room temperature is -
   (a) mercury (b) sodium
   (c) zinc (d) tungsten
3. Chemically rust is
   (a) hydrated ferric oxide only
   (b) hydrated ferrous oxide only
   (c) ferric oxide only
   (d) ferrous oxide only
4. Alumina is chief ore of which of the following metal?
   (a) Na (b) K
   (c) Ca (d) Al
5. Horn silver is
   (a) an oxide ore of silver
   (b) a sulphite ore of silver
   (c) a carbonate ore of silver
   (d) a chloride ore of silver
6. Naturally occuring substances from which a metal can be profitably (or economically) extracted are called?
   (a) Minerals (b) Ores
   (c) Gangue (d) Salts
7. Cinnabar is an ore of
   (a) Hg (b) Cu
   (c) Pb (d) Zn
8. Which of the following is not an ore ?
   (a) Bauxite (b) Malachite
   (c) Zinc blende (d) Pig iron
9. Which of the following mineral does not contain Al ?
   (a) Cryolite (b) Mica
   (c) Feldspar (d) Fluorspar
10. Formula of magnetite is
   (a) Fe_2O_3 (b) FeS_2
   (c) $FeCO_3$ (d) Fe_3O_4
11. Which ore contains both iron and copper?
   (a) Cuprite (b) Chalcocite
   (c) Chalcopyrite (d) Malachite
12. Calcination is the process of heating the ore
   (a) in a blast furnace (b) in absence of air
   (c) in presence of air (d) none of these
13. Which of the following is an oxide ore?
   (a) Bauxite (b) Cuprite
   (c) Haematite (d) All of these
14. Removal of impurities from ore is known as -
   (a) crushing and grinding
   (b) concentration of ore
   (c) calcination
   (d) roasting
15. Which reducing agent is used in chemical reduction?
   (a) C (b) CO
   (c) Al (d) All of these
16. Aluminium is used in thermite welding because -
   (a) aluminium is a light metal
   (b) aluminium has more affinity for oxygen
   (c) aluminium is a strong oxidising agent
   (d) aluminium is a reactive metal
17. The process of extraction of metal from its ores, is known as
   (a) concentration (b) calcination
   (c) purification (d) metallurgy
18. The process to heat the ore in the presence of excess supply of air below its melting point is called
   (a) roasting (b) calcination
   (c) smelting (d) liquation
19. Brass is a mixture of
   (a) copper and zinc
   (b) copper and tin
   (c) copper, nickel and zinc
   (d) aluminium, copper and traces of Mg and Mn
20. Sodium is obtained by the electrolysis of
   (a) an aqueous solution of sodium chloride
   (b) an aqueous solution of sodium hydroxide
   (c) fused sodium chloride
   (d) fused sodium sulphate
21. The chief ore of aluminium is
   (a) bauxite (b) cryolite
   (c) alunite (d) feldspar
22. One of the constituents of amalgam is
   (a) aluminium (b) copper
   (c) iron (d) mercury
23. The metal used to built bridges is
   (a) gold (b) silver
   (c) platinum (d) iron
24. Which of the following is a good conductors of heat and electricity?
   (a) Graphite (b) Oxygen
   (c) Chlorine (d) Nitrogen

25. Metals are
(a) malleable (b) ductile
(c) Both (a) and (b) (d) Neither (a) nor (b)

26. Which of the following have low melting and boiling points?
(a) Phosphorus (b) Sodium
(c) Iron (d) Both (a) and (b)

27. Which of the following non-metals has shining lustrous surfaces?
(a) Graphite and phosphorus
(b) Graphite and iodine
(c) Iodine and phosphorus
(d) Phosphorus and chlorine

28. Metals like Gold, Platinum which do not easily react are called
(a) active metals (b) dull metals
(c) noble metals (d) bright metals

29. The metalloids include the elements
(a) Boron, Silicon (b) Arsenic, Antimony
(c) Germanium, Tellurium (d) All of these

30. Select the property that is associated with non-metals.
(a) Low density
(b) Low melting point
(c) Poor conductor of electricity
(d) All of the above

31. Which of the following non-metals sublimes on heating ?
(a) Fluorine (b) Chlorine
(c) Bromine (d) Iodine

32. Which of the following statement regarding metals is true?
(a) All metals are solid in nature.
(b) Metals can be used to make handle of cooking utensils
(c) Generally most of metals have high melting and boiling points.
(d) Gold is used generally to make electrical wires.

33. Which of the following statement is false?
(a) Metals are good conductors of heat and electricity.
(b) Gold, Silver and Zinc are most malleable metals.
(c) Mercury is the only liquid metal.
(d) Bromine is the only liquid non-metal.

34. Which of the following statement regarding non-metals is true?
(a) Non-metals are of two types only solids and gases.
(b) Non-metals reacts with oxygen to form basic oxides generally.
(c) Non-metals are non-lustrous with dull apppearence. Graphite, an allotrope of carbon and iodine have shining lustrous surfaces.
(d) Non-metals replace hydrogen from acids.

35. Which of the following statements regarding non-metals is false?
(a) 11 non-metals are in gaseous state.
(b) Gas carbon is a good conductor of heat and electricity.
(c) The black material inside a pencil is metal lead.
(d) All non-metals are non-sonorous in nature.

36. Consider the following elements:
(i) Copper (ii) Gold
(iii) Platinum (iv) Silver
Which of the above elements exist free in nature?
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i), (ii) and (iv) (d) (iii) and (iv)

37. Consider the following statements:
Nitrogen is an essential constituent of
(i) soils (ii) animals
(iii) plants
Which of the statements given above is/are correct ?
(a) (iii) only (b) (i) and (iii) only
(c) (i) and (ii) only (d) (i), (ii) and (iii)

38. When iron is left exposed in open air, it gets rusted. Which constituent(s) of air is /are responsible for rusting iron?
(i) Oxygen gas present in air
(ii) Moisture present in air
(iii) Carbon dioxide gas present in air
Select the correct answer using the code given below :
(a) (i) only (b) (ii) only
(c) (i) and (ii) (d) (ii) and (iii)

39. Aluminium is used for making cooking utensils. Which of the following properties of aluminium are responsible for the same ?
(i) Good thermal conductivity
(ii) Good electrical conductivity
(iii) Ductility
(iv) High melting point
(a) (i) and (ii) (b) (i) and (iii)
(c) (ii) and (iii) (d) (i) and (iv)

40. Silicon is used in –
(a) solar energy devices (b) semiconductors
(c) transistors (d) all of these

41. Which of the following is not a atomic characteristics of metal –
(a) malleable (b) electropositive nature
(c) ductile (d) none of these

42. Pure gold is –
(a) 24 carats (b) 22 carats
(c) 20 carats (d) 18 carats

43. What is anode mud –
(a) fan of anode
(b) metal of anode
(c) impurities collected at anode in electrolysis during purification of metals
(d) all of these

44. The best mealleable metal is –
(a) aluminium (b) silver
(c) gold (d) lead

45. German silver is a mixture of –
(a) copper and zinc
(b) copper and tin
(c) copper, nickel and zinc
(d) aluminium, copper and traces of Mg and Mn.

46. Graphite is a/an –
(a) alloy (b) metal
(c) metalloid (d) non-metal

47. Which of the following metals constitutes the alloy magnalium –
(a) Al, Cu (b) Al, Fe
(c) Al, Mg (d) Al, Mn

ANSWER KEY									
1	(c)	**11**	(c)	**21**	(a)	**31**	(d)	**41**	(d)
2	(a)	**12**	(b)	**22**	(d)	**32**	(c)	**42**	(a)
3	(a)	**13**	(d)	**23**	(d)	**33**	(b)	**43**	(c)
4	(d)	**14**	(b)	**24**	(a)	**34**	(c)	**44**	(c)
5	(d)	**15**	(d)	**25**	(c)	**35**	(c)	**45**	(c)
6	(b)	**16**	(b)	**26**	(d)	**36**	(c)	**46**	(d)
7	(a)	**17**	(d)	**27**	(b)	**37**	(d)	**47**	(c)
8	(d)	**18**	(a)	**28**	(c)	**38**	(c)		
9	(d)	**19**	(a)	**29**	(a)	**39**	(d)		
10	(d)	**20**	(c)	**30**	(d)	**40**	(d)		

HINTS AND SOLUTIONS

2. (a) Mercury is the only element even being metal is liquid at room temperature.
3. (a) As the chemical formula of rust is $Fe_2O_3 . xH_2O$
5. (d) Chemical formula of horn silver is AgCl.
7. (a) Cinnabar (HgS) is a sulphide ore of mercury
8. (d) Pig iron $\rightarrow$ It is the most impure form of iron and contains highest proportion of carbon (2.5–4%). Rest all are ore.
   Malachite $\rightarrow Cu(OH)_2.CuCO_3$,
   Zinc blende $\rightarrow$ ZnS,
   Bauxite $\rightarrow Al_2O_3.2H_2O$
9. (d) Fluorspar (CaF_2), Cryolite (Na_3AlF_6), Feldspar ($KAlSi_3O_8$) and Mica ($K_2O.3Al_2O_3.6SiO_2.2H_2O$)
11. (c) Among cuprite [Cu_2O], Chalcocite [Cu_2S], Chalcopyrite [$CuFeS_2$] and Malachite [$Cu(OH)_2\ CuCO_3$], only Chalcopyrite is an ore which contains both Fe and Cu.
13. (d) Bauxite – Al_2O_3 Halmatite – Fe_2O_3
    Cuprite – Cu_2O
16. (b) $Fe_2O_3(s) + 2Al(s) \longrightarrow Al_2O_3(s) + 2Fe(l)$
19. (a) Brass is a maxture of 80% Cu & 20% Zn.
21. (a) Bauxite is $Al_2O_3.2H_2O$.
23. (d) Steel an alloy of iron and carbon is used for manufacturing bridges.
24. (a) Graphite is the only non-metal, which is a good conductor of heat and electricity.
25. (c) Metals are both melleable and ductile. Metals can be drawn into thin sheets and wires.
26. (d) Phosphorus is a non-metal and non-metals have low melting and boiling points. Although, sodium is a metal, it has low melting and boiling point.
27. (b) Graphite which is crystalline form of carbon and iodine are the only two non-metals which has shining lustrous surfaces.
28. (c) Noble metals are those metals which do not react easily and lie at the bottom of the activity series.
29. (a) Both boron and silicon are metalloids.
31. (d) Iodine is a sublime substance
32. (c) Mercury being a metal is liquid at room temperature. Metals are good conductor of heat therefore cannot be used to make handle it will result into burns. Gold cannot be used to make electrical wires it is very expensive therefore metals like copper is used for it.
33. (b) Gold and Silver are most malleable metals whereas zinc metal is non-malleable and brittle.
35. (c) The black material inside a pencil is not metal lead. Actually it is graphite, a non-metal.
36. (c) Cu, Au, Ag are known as coinage metals and occur free in nature. Becuase of nobility they are frequently found in their natives state.
37. (d) Nitrogen is a essential constituent of all vegetables and animal proteins. Soil contains nitrogen as ammonium salts.
38. (c) Both oxygen and moisture present in air cause rusting of iron.
41. (d) All are characteristics of metal.
45. (c) German silver is a mixture of Cu (60%), Zn (20%) and Ni (20%).
47. (c) Magnalium is a mixture of 90% Al and 10% Mg.