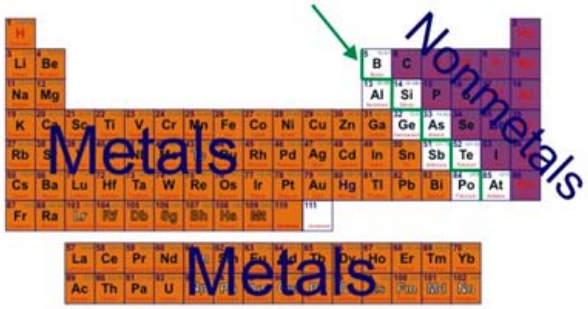
8 Metals and Non-metals

There are about 115 chemical elements known at present, (22 non-metals, 8 metalloids and the remaining metals). On the basis of their properties all the elements can be divided into three main groups (1) Metals, (2) Non-metals and (3) Metalloids.

Elements that border on the amphoteric line (shown in green) are metalloids. They have characteristics of both metals and non-metals. Aluminium (Al), however, definitely has mostly metallic characteristics, and boron (B) is mostly non-metallic.



Subgroup	Definition/Location
Metals	
Alkali Metals	Series of very reactive metals group 1 on periodic table (with the exception of gydrogen)
Alkaline Earth Metals	Series of reactive metals (less reactive than alkali metals). Group 2 on periodic table
Transition Metals	Series of elements that exhibit characteristics of metals, though less reactive and less metallic than the first two groups of metals. Groups 3–12 on periodic table
Metalloids	
Elements that exhibit metallic characteristics as well as some non-metallic characteristics, such as reactivity (whether as metal or nonmetal) depending on which element it's reacting with groups 13–16, but only the highlighted ones next to stair steps on periodic table.	

Subgroup	Definition/Location
	Non-metals
Halogens	Series of elements that are most reactive for nonmetals due to their near-stable electron configuration (a valence shell of 7 electrons) Group 17 on periodic table
Noble Gases	Series of elements that are inert (nonreactive) due to stable electron configuration (a full valence shell of 8 electrons) Group 18 on periodic table

Metals	**Nonmetals**
1. Have luster	1. Are dull
2. Are malleable and ductile	2. Are brittle
3. Conduct heat and electricity	3. Do not conduct heat or electricity very well
4. Tend to lose electrons	4. Tend to gain electrons

1. Metals: Elements that conduct heat and electricity, and are malleable and ductile. They are also lustrous, hard, strong, heavy and sonorous, e.g.: Fe, Al, Cu, Ag, Au, Zn, Su, Pb, Hg etc. Mercury is a liquid metal.

During Chemical Reactions:

- Metal can from positive ions by loosing electrons;
- They form basic oxides.
- Most abundant metal – Aluminium.

2. Non-metals: Elements that do not conduct electricity and heat and are neither malleable nor ductile. They are brittle, dull appearance and non-sonorous, e.g. C, S, P, Si, H_2, O_2.

During Chemical Reactions:

- Non-metals from negative ions by gaining electrons;
- They form acidic oxides.
- Most abundant non-metal – Oxygen.

3. Metalloids share characteristics of both metals and non-metals and are also called semimetals. Metalloids are typically semi-conductors, which mean that they both insulate and conduct electricity. This semi-conducting property makes metalloids very useful as a computer chip material. Examples of metalloid elements are Silicon and Boron.

Table: 8.1 Physical Properties of Metals and Non-metals

Physical Property	Metals	Non-metals
State	Solid at room temp. Exceptions; Hg and Ga are liquid	Mostly gases. Exceptions; C, S, P, I_2 (solid) and Br_2 (liquid)
Melting and Boiling point	Very high. Exceptions; Na, K, Hg (low melting & boiling point), Ga, Cs (low melting point but high boiling point)	Very low. Exceptions; C, Si, B (high boiling point)
Hardness	Generally hard. Exception; Na and K are soft.	Solid non-metals are brittle. Exception; Diamond (hardest)

Density	High density. Exceptions; Li, Na, K (lower than water, 1 g/cm^3)	Low density. Exception; Diamond
Conductivity	Good conductor of heat and electricity. Exceptions; Bi and W are poor conductors of electricity.	Bad conductors of heat and electricity. Exception; Graphite and gas carbon allotropic form of carbon are good conductor of electricity.
Lustre (shining property**)**	lustrous	Not lustrous Exceptions: I_2 and graphite.
Tensile strength	High. Exception; Zn	Do not have tensile strength
Malleability(which they can be beaten into thin sheets**) Ductility (**which they can be drawn into thin wires**)**	Generally malleable and ductile	Neither malleable nor ductile.
Sonorousness (which they produce a ringing sound**)**	Give sonorous sound when struck.	Non-sonorous
Occurrence	Found in combined state. Exception; Noble metals (free state)	Found in free state as well as in the combined state.

Table: 8.2 Chemical Properties of Metals and Non-metals

Chemical properties	**Metals**	**Non-metals**
Nature	Electropositive $[M \rightarrow M^+ + e^-]$; $(M^+ M^{2+} M^{3+})$	Electronegative $X + e^- \rightarrow X;[X^-, X^{2-}, X^{3-}]$
Reaction with O_2 $O + 2e^- \rightarrow O^{2-}$ [Element + Oxygen $\rightarrow$ Oxide]	**Metal oxides; Basic** (Na_2O, MgO etc.), **Amphoteric** (Al_2O_3, ZnO) Ionic	**Non-metal oxides; Acidic** $(CO_2, SO_2, NO_2$ etc) **Neutral** $(H_2O, CO$ etc) Covalent
Reaction with water	Metal + $H_2O \rightarrow$ Metal oxide/ hydroxide + $H_2 \uparrow$ Al and Fe reacts with steam to form metal oxide e.g. Al_2O_3, Fe_3O_4	Non-metals + $H_2O \rightarrow$ No reaction
Reaction with diluted acids	Metal + Acid$\rightarrow$ Metal salt + H_2 with $H_2SO_4 \rightarrow$ sulphates HCl $\rightarrow$ Chlorides $HNO_3 \rightarrow$Nitrates	No reaction [S reacts with conc. acids] $S + 2H_2SO_4 \rightarrow 2H_2O + 2SO_2$ $S + HNO_3 \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$
Reaction with Chlorine	Metal + Chlorine $\rightarrow$ Metal chloride [ionic] (NaCl, KCl)	Non-metals + Chlorine $\rightarrow$ Non-metal chloride [covalent (CCl_3, PCl_3)
Reaction with Hydrogen	Na, K, Ca with hydrogen $\rightarrow$ Hydrides (NaH, KH, CaH_2)	Non-metals + $H_2 \rightarrow$ Hydrides [covalent] (NH_3, H_2S)

Properties of Ionic Compounds

- **Physical nature:** solid and hard due to strong force of attraction (generally brittle).
- **Melting point (MP) and boiling point (BP):** Have high MP and BP, as large amount of heat energy is required to break strong ionic attraction.
- **Solubility:** Soluble in water and insoluble in kerosene and petrol.
- **Conduction of electricity:** Ionic compounds in solid state; does not conduct electricity.

Reason: Ions cannot move due to rigid solid structure. Ionic compounds conduct electricity in molten state.

Reason: Ions can move freely since the electrostatic forces of attraction between the oppositely charged ions are overcome due to heat.

Reactivity Series: The arrangement of metals in a vertical column in the order of decreasing reactivities is called reactivity series of metals.

K – is most reactive;
Gold – is least reactive

- **Metals which are more reactive than hydrogen are:** K, Na, Ca, Mg, Al, Zn, Fe, Sn, Pb

- **Metals which are less reactive than hydrogen are:** Cu, Hg, Ag, Au
- **Occurrences of metals: Major source;** earth crust and sea-water minerals, elements or compounds which occur naturally in the earth's crust are minerals.

Extraction of Metals:

Metallurgy: It is a branch of chemistry which deals with the extraction of metals from their ores and refining of metals.

Major steps involved in the extraction of a metal:

- Concentration of Ore (Enrichment)
- Conversion of concentrated ore into metal
- Refining of impure metal.

Concentration – (Removal of gangue from the ore)
Processes used for concentration are based on the differences between the physical or chemical properties of the gangue and the ore.

Extracting metals low in the activity series:

They are very uncreative oxides of these metals can be reduced to metals by heating alone.

$$\underset{\text{(Cinnabar)}}{2HgS} + 3O_2 \xrightarrow{\text{Heat}} 2HgO + 2SO_2$$

$$2HgO \xrightarrow{\text{Heat}} 2Hg + O_2$$

Extracting metals in the middle of the activity series:

These metals are moderately reactive Present as sulphides or carbonates prior to reduction, the metal sulphides and carbonates must be converted into metal oxides.

Sulphide Ore	Carbonate Ore
↓	↓
$ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$	$Zn + CO_3 \longrightarrow ZnO + CO_2$
Calci	Roastin
Excess of air	Limited air

Metal oxides are then reduced to the corresponding metals by using suitable reducing agent such as carbon.

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

Sometimes displacement reactions can also be used in extracting metals towards the top of the activity series. They are very reactive, have more affinity for oxygen than carbon.

Minerals that contain very high percentage of a particular metal and these metals can be extracted economically on a large scale.

E.g.: Bauxite ore $\rightarrow$ Aluminium;

Haematite $\rightarrow$ Iron

Aluminum:

- Aluminum is a light metal $(\rho = 2,7 g/cc)$; is easily machinable; has wide variety of surface finishes; good electrical and thermal conductivities; highly reflective to heat and light.
- Versatile metal; can be cast, rolled, stamped, drawn, spun, roll-formed, hammered, extruded and forged into many shapes.
- Aluminum can be riveted, welded, brazed, or resin bonded.
- Al is the second most widely used metal after iron. Important ores of alumininum ore is Bauxite $(Al_2O_3.2H_2O)$ and Cryolite (Na_3AlF_6).
- Corrosion resistant; no protective coating needed, however it is often anodised to improve surface finish, appearance.
- Al and its alloys; high strength to weight ratio (high specific strength) owing to low density.
- Such materials are widely used in aerospace and automotive applications where weight savings are needed for better fuel efficiency and performance.
- Al-Li alloys are lightest among all Al alloys and find wide applications in the aerospace industry.

Iron

- It is the second most abundant metal in the earth crust. Iron is quite reactive.
- It exist in the combined state as Carbonate, $FeCO_3$ (Siderite), Sulphide, FeS_2 (iron pyrite), Oxide, Fe_2O_3 (Haematite), Fe_3O_4 (Magnetite).
- Haematite is the chief ore of iron.
- The ore is first washed, dried and ground to powder then treated with stream of water to remove gangue; hydraulic washing.
- After this, ore is mixed with coke and lime-stone to form a mixture known as charge, which is introduced in a big furnace called blast furnace.
- The molten iron obtained from blast furnace is allowed to solidify in moulds or casts, it is called pig iron. It can be converted into in a bessemer converter after this the carbon is added to make steel.

Metallurgical Process:

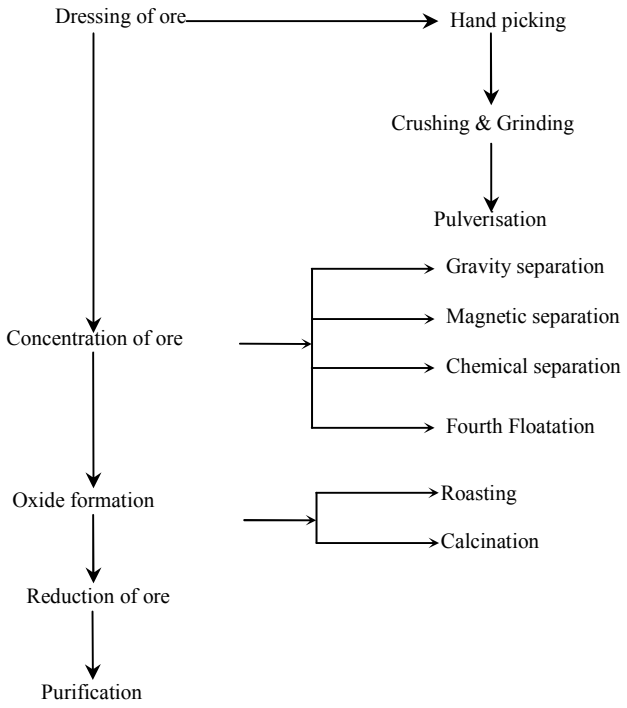


Table: 8.3 Refining of Metals

Process of purification	Metal to be refined	Process
Distillation	Iron, zinc, mercury	Heated above its boiling point in the absence of air. The metal vaporises, leaving behind the impurities.
Liquation	Lead, tin (metal with low melting point)	Heated above its melting point and the metal melts, flows down the hearth and is collected at the bottom.
Polling	Copper with cuprous oxide as impurity	Molten copper is stirred with wooden poles which emit wood gas (CO and H_2) which reduces copper oxide to copper.
Oxidation	Iron with oxidisable impurities	Oxygen blown through molten metal where the impurities get converted to gaseous oxide and removed. $C + O_2 \longrightarrow CO_2 \uparrow$
Electrolytic refining	Aluminium, copper	A block of impure is taken as the anode and a thin strip of pure metal is taken as the cathode. On the passing current, the metal ions from the anode dissolve in the electrolyte, go towards the cathode and get discharged there. At Anode $Cu_{(impure)} \rightarrow Cu^{2+}{}_{(aq)} + 2e^-$ At Cathode $Cu^{2+}{}_{(aq)} + 2e^- \rightarrow Cu(S)_{Pure}$

The impurities settle down at the bottom of the anode are called **anode mud.** Van Arkel method is used for the purification of **titanium** and **zirconium** by converting them into their volatile iodides which decomposes to give pure metal. **Corrosion** is a slow oxidation of metal to its oxide or hydrated oxide, corrosion in case of iron is called rusting $(Fe_2O_3 \times H_2O)$. For rusting two necessary conditions are presence of water and oxygen. The rusting of iron speeds up in the presence of acidc oxides in air or salts in water. Rusting can be prevented by using:

- Paints and polish
- Greasing/oiling
- Coating with plastics
- Galvanisation (coating iron with zinc)
- Alloy formation

Alloy is a homogenous mixture of two or more metals or non-metals. It is prepared by dissolving a metal or non-metal in the molten metal. Alloying of metal changes its physical properties and decreases its chemical reactivity. Alloy of any metal with mercury is called an amalgam.

- Pure iron is soft and streches on heating. It becomes hard and strong when it is mixed with carbon.
- Pure gold (24 carat) is very soft and hence, it is not suitable for making jewellery. It is mixed with silver or copper to increase its tensile strength.

Table: 8.4

Major components	Alloy	Composition	Uses
Copper (Cu)	Brass	Cu(60–80%) Zn (20–40%)	For making shells of ammunition utensils, electrical switches, statues, cooling pipe, etc.
	Bronze	Cu; 80%, Zn; 10%, Sn; 10%	For making shells, staues, coins and utensils.
	Gun metal	Cu;88%, Sn;10%, Zn;1%, Pb;1%	For making barrels of guns, gears and bearings.
	German silver	Cu (30–60%) Zn (20–30%) Ni (15–20%)	For making imitation silver jewellery, utensils etc.
	Bell metal	Cu; 80%, Sn; 20%	For making bells.
Iron (Fe)	Stainless steel	Fe; 83%, C; 1%, Cr; 15%; Ni; 1%	For making utensils and surgical instruments.
	Mangnese steel	Fe; 84%, Mn; 15%, C; 1%	For making safes, armours and rock cutters.
	Tungsten steel	Fe (79–84%) W (15–20%) C (1%)	For making high speed tools.
	Alnico	Fe; 50%, Al; 20%, Ni; 20%; Co; 10%	For making powerful magnets.
Aluminium (Al)	Duralumin	Al; 95%, Cu; 4%, Mn;0.5%, Mg; 0.5%	For making aircraft frames, rockets, speed boats, automobiles.
	Magnalium	Al; 95%, Mg; 5%	For making aeroplane parts, home appliances, mirrors and scientific instruments.
Nickel (Ni)	Monel metal	Cu; 28%, Ni; 67%, Fe; 5%	For making sinks, doors and window screws.
Tin (Sn)	Solder	Sn (50–60%) Pb (50–40%)	Soldering purpose.
Lead (Pb)	Type metal	Pb; 75%, Sn; 5%, Sb; 20%	For making moulds.

- **Steels:** Alloys of iron-carbon; May contain other alloying elements. Several grades are available.
- **Low Alloy** (< 10 wt%)
  Low Carbon (< 0.25 wt% C)
  Medium Carbon (0.25 to 0.60 wt%)
  High Carbon (0.6 to 1.4 wt%)
- **High Alloy**
  Stainless Steel (> 11 wt% Cr)
  Tool Steel
- **Quenching** is the process hard steel can be further hardened by heating it to red hot and then cooling by pluning it into the cold water.

- **Tempering** is the process quenched steel is reheated and allowed to cool slowly, it becomes *elastic* and much less brittle.
- **Annealing** is the process steel is heated to bright red hot, and is then cooled slowly. Annealed steel is soft.

Cement ($CaOFe_2O_3SiO_2Al_2O_3$)

Oxides		Sources
SiO_2 (silicon dioxide)	–	cap rock
CaO (calcium oxide)	–	limestone
Al_2O_3 (aluminum oxide)	–	clay
Fe_2O_3 (ferric oxide)		

Oxides used to calculate theoretical cementitious compounds: C_3S, C_2S, C_3A and C_4AF

Compounds

- Tricalcium silicate (Ca_3SiO_5) hardens rapidly and is largely responsible for initial set and early strength. In general, the early strength of portland cement concrete is higher with increased percentages of C_3S.
- Dicalcium silicate (Ca_2SiO_4) hardens slowly and contributes largely to strength increases at ages beyond 7 days.
- Tricalcium Aluminate ($Ca_3Al_2O_6$) liberates a large amount of heat during the first few days of hardening and, together with C_3S and C_2S may somewhat increase the early strength of the hardening cement (this effect being due to the considerable heat of hydration that this compound evolves). It does affect set times.
- Tetracalcium Aluminoferrite (C_4AF) contributes very slightly to strength gain. However, acts as a flux during manufacturing. Contributes to the colour effects that makes cement gray.

When steel, rods, bars or other hard material embedded in the wet concrete. As the concrete sets, it sticks to those materials to form **RCC** (reinforced concrete cement).

Glass:

- **Glass:** inorganic, non-crystalline (amorphous) material.
- **Range:** soda-lime silicate glass for soda bottles to the extremely high purity silica glass for optical fibers.
- Widely used for windows, bottles, glasses for drinking, transfer piping and receptacles for highly corrosive liquids, optical glasses, windows for nuclear applications.
- The main constituent of glass is silica (SiO_2). The most common form of silica used in glass is sand.
- Sand fusion temp to produce glass 1700°C. Adding other chemicals to sand can considerably reduce the fusion temperature.
- Sodium carbonate (Na_2CO_3) or soda ash, ($75\%SiO_2 + 25\%Na_2O$) will reduce the fusion temperature to 800°C.
- Other chemicals like Calcia (CaO) and magnesia (MgO) are used for stability. Limestone ($CaCO_3$) and dolomite ($MgCO_3$) are used for this purpose as source of CaO and MgO.

Table: 8.5 Compositions and Characteristics of Some Common Glasses

Glass type	Composition (wt%)						Characteristics
	SiO_2	Na_2O	CaO	Al_2O_3	B_2O_3	Other	
Fused silica	> 99.5	–	–	–	–	–	High MP, thermal shock resistant
96% Silica	96	–	–	–	4	–	Thermal shock and chemicaly resistant laboratory ware
Borosilicate	81	3.5	–	2.5	13	–	Thermal shock and chemical oven ware
Container	74	16	5	1	–	4MgO	Low MP, formable and durable
Fiberglass	55	–	16	15	10	4MgO	Ease of drawing used in FRP
Optical flint	54	1	–	–	–	37PbO, $8K_2O$	High density, high refractive index-optical lenses
Glass ceramic	43.5	14	–	30	5.5	$6.5TiO_2$, $0.5As_2O_3$	Strong, thermal shock resistant oven ware

- **Polymers:** Chain of H-C molecules. Each repeat unit of H-C is a monomer, e.g., ethylene (C_2H_4), Polyethylene $(-CH_2-CH_2)_n$
- **Thermosets:** **T**hermoset plastics always remain in a permanent solid state.
- **Thermoplasts:** It is a type of material, which becomes soft when heated and hard when cooled. Thermoplastics can be remelted.
- **Plastics:** Moldable into many shape and have sufficient structural rigidity. Plastics are one of the most commonly used class of materials. They are used in clothing, housing, automobiles, aircraft, packaging, electronics, signs, recreation items, and medical implants.
- **Natural plastics:** Hellac, rubber, asphalt, and cellulose.

Table: 8.5 Characteristics and Applications of Some Common Thermoplastics

Material	Characteristics	Applications
Polyethylene	Chemically resistant, tough, low friction coeff., low strength	Flexible bottles, toys, battery parts, ice trays, film wrapping materials
Polyamide (Nylon)	Good strength and toughness, abrasion resistant, liquid absorber, low friction coefficient	Bearings, gears, cams, bushings and jacketing for wires and cables
Fluorocarbon (Teflon)	Chemically inert, excellent electrical properties, relatively weak	Anticorrosive seals, chemical pipes and valves, bearings, anti-adhesive coatings, high temp electronic parts
Polyester (PET)	Tough plastic film, excellent fatigue and tear strength, corrosion resistant	Recording tapes, clothing, automotive tyrecords, beverage containers
Vinyl	Low-cost general purpose material, rigid, can be made flexible	Floor coverings, pipe, electrical wire insulation, garden hose, phonograph records
Polystyrene	Excellent electrical prop and optical clarity, good thermal and dimensional stability	Wall tile, battery cases, toys, lighting panels, housing appliances

Multiple Choice Questions

1. Metals generally form
a. Basic oxides **b.** Acidic oxides
c. Neutral oxides **d.** None

2. Which of the following is a basic oxide?
a. N_2O **b.** H_2O **c.** CO_2 **d.** CaO

3. The most abundant element in the universe is
a. Helium **b.** Oxygen **c.** Hydrogen **d.** Silicon

4. The most abundant metal on the earth is
a. Iron **b.** Gold
c. Copper **d.** Aluminium

5. The most abundant elemet in the sun's atmosphere is
a. Xenon **b.** Argon **c.** Oxygen **d.** Hydrogen

6. The most abundant acidic gas present in the atmosphere is:
a. CO_2 **b.** SO_2 **c.** NO **d.** NO_2

7. An example of a metal which is a liquid at room temperature
a. Zinc **b.** Copper **c.** Mercury **d.** Bromine

8. A metal, which melts on the palm
a. Potassium **b.** Sodium **c.** Zinc **d.** Gallium

9. Which of the following metals exist in their native state in nature?
a. Cu and Au **b.** Au and Zu
c. Au and Ag **d.** Ag and Cu

10. Sodium is a
a. Silvery white and very soft metal
b. Colourless and hard metal
c. Silvery white and very hard metal
d. Colourless and very soft metal

11. Gold is used in making ornaments because it is
a. Lusturous **b.** Unreactive
c. Malleable **d.** All of the above

12. Hydrogen is not found in free in the nature because hydrogen is a
a. Reactive element **b.** Non-reactive element
c. Electropositive element **d.** None of these

13. Hydrogen loses its electron to form H^+, in this respect, it resembles
a. Halogens **b.** Alkali metals
c. Transition element **d.** Alkaline earth metal

14. You are given two statements (i) and (ii), select the correct inference from this:
Statements (i) Metals conduct heat.
Statements (ii) Diamond is the best conductor of heat.
a. Hence diamond is a metal
b. Statement (i) is correct
c. Statements (i) and (ii) is correct
d. None of the above

15. Metals are
a. Malleable and ductile
b. Non-malleable and ductile
c. Brittle and ductile
d. Non-malleable and non-ductile

16. A metal which is poor conduction of heat
a. Lead **b.** Zinc **c.** Gold **d.** Iron

17. Which element is an important component of transistors?
a. Sodium **b.** Copper
c. Germanium **d.** Radium

18. Non-metals form
a. Ionic halides **b.** Covalent halides
c. Coordinate halides **d.** None of these

19. The bond between two identical non-metal atoms has a pair of elecrons
a. Unequally shared between the two
b. Transferred freely from are atom to another
c. With identical spins
d. Equally shared between these

20. A lustrous non-metals is:
a. Diamond **b.** Sulphur
c. Phosphorus **d.** Iodine

21. The correct order of decreasing metallic character is
a. Cl > Si > Al > Mg > Na **b.** Na > Mg > Al > Si > Cl
c. Al > Na > Si > Ca > Mg **d.** Na > Al > Mg > Cl > Si

22. The correct order of increasing non-metallic order is
a. F < O < C < Be < Li **b.** F < C < O < Be < Li
c. F < O < Be < C < Li **d.** Li < Be < C < O < F

23. Arrange the following metal in the increasing order of their reactivity towards water: Zinc; Iron; Magnesium; Sodium
a. Iron < magnesium < sodium < zinc
b. Iron < zinc < magnesium < sodium
c. Magnesium < iron < sodium < zinc
d. Sodium < iron < magnesium < zinc

24. Which of the following set of elements is written in order of their increasing metallic character?
a. Be, Mg, Ca **b.** Na, Li, K
c. Mg, Al, Si **d.** C, O, N

25. Which of the following metals do not react with cold as well as hot water?
a. Na **b.** Ca **c.** Mg **d.** Fe

26. A list of metals arranged in the order of their decreasing activities is known as
a. Periodic table **b.** Reactivity series
c. Newland's law of octaves **d.** All of these

27. Sodium metal should be stored in
a. Alcohol **b.** Water
c. Kerosene oil **d.** HCl

28. Sodium is kept immersed in kerosene oil because
a. It reacts with moisture in the air
b. Immersing in kerosene cuts off the supply of air
c. The reaction of sodium with air is very violent
d. All of the above.

29. Metalloids include the elements
a. Boron, silicon **b.** Arsenic, antimony
c. Germanium, tellurium **d.** All of the above

30. Lunar caustic is
a. AgS **b.** AgBr **c.** AgCl **d.** $AgNO_3$

31. Philosopher's wool is
a. ZnO **b.** $HgCl_2$ **c.** $ZnCO_3$ **d.** Hg_2Cl_2

32. Water gas is a mixture of
a. CO and N_2 **b.** CO_2 and H_2
c. CO and H_2 **d.** CO_2 and N_2

33. Iron burns in air to form
a. FeO **b.** Fe_3O_4 **c.** Fe_2O_3 **d.** FeO_2

34. What should be added to pure iron to make stainless steel?
a. Nickel and cobalt
b. Cadmium and chromium
c. Nickel and cadmium
d. Chromium and nickel

35. Substance used in glazing pottery is
a. ZnO **b.** $ZnCl_2$ **c.** Alum **d.** Calomel

36. The process of protecting iron by coating with zinc is:
a. Smelting **b.** Rusting
c. Galvanising **d.** None of these

37. Ordinary glass is a mixture of
a. Sodium silicate, calcium silicate
b. Sodium silicate, calcium silicate and silica
c. Sodium silicate and silica
d. None of these

38. In the above table arrange the metals A, B, C and D in increasing order of reactivity
a. D < A < C < B **b.** D < C < B <A
c. D < C < A < B **d.** C < D < A < B

39. What are the ions present in Na_2O?

a. Na^+, O **b.** Na^{2+}, O_2 **c.** Na^{2+}, O **d.** Na^+, O_2

40. Among the following select the metal found free in nature.

a. Au **b.** Cu **c.** Na **d.** Mg

41. The metal refined-electrolytically is

a. Al **b.** Na **c.** Fe **d.** Cu

42. Which of the following metals on reacting with sodium hydroxide solution produce hydrogen gas?

(A) Cu (B) Al (C) Fe (D) Zn

a. (B) and (C) **b.** (B) and (D)

c. (A) and (D) **d.** (B) only

43. Match the following.

(i) Sodium	(a) On burning produces an acidic gas.
(ii) Phosphorus	(b) Reacts neither with acids nor bases.
(iii) Copper	(c) It is so soft that it can be cut with a knife.
(iv) Charcoal	(d) Burns spontaneously on exposure to air.
	(e) Acquires a dull green coating on exposure to air.

Which of the following shows the correct matching?

a. (i) – (c), (ii) – (e), (iii) – (b), (iv) – (a)

b. (i) – (d), (ii) – (a), (iii) – (c), (iv) – (b)

c. (i) – (d), (ii) – (e), (iii) – (c), (iv) – (b)

d. (i) – (c), (ii) – (d), (iii) – (e), (iv) – (a)

44. Oil of vitriol is

a. H_2SO_3 **b.** H_2SO_4 **c.** $H_2S_2O_7$ **d.** $H_2S_2O_8$

45. The formula of Oleum is

a. H_2SO_4 **b.** $H_2S_2O_7$ **c.** $H_2S_2O_3$ **d.** $H_2S_2O_6$

46. Which of these metals cannot be obtained by reduction using C as reducing agent?

a. Copper **b.** Zinc **c.** Lead **d.** Potassium

47. The reaction used to join railway tracks involves reducing agent

a. Al **b.** Mg **c.** C **d.** CO

48. Aluminium is extracted from

a. Hematite **b.** Bauxite **c.** Calamine **d.** Magnetite

49. The colourless gas liberated in the purification of bauxite by Hall's process is:

a. H_2 **b.** NH_3 **c.** CO_2 **d.** SO_2

50. Metallurgy is the process of

a. Extracting metals from the ore

b. Roasting the ore

c. Liquefaction of nitrogen

d. Adding carbon to the ore in blast furnace

51. In the metallurgy of iron using blast furnace the slag is

a. $FeSiO_3$ **b.** $CaSiO_3$ **c.** $CaCO_3$ **d.** $CaSO_3$

52. In the blast furnace/the flux is:

a. Acidic **b.** Basic

c. Amphoteric **d.** Not matter

53. The iron obtained from blast furnace is

a. Steel **b.** Cast iron

c. Pig iron **d.** Wrought iron

54. Iron is tougher than sodium because

a. Iron atom is smaller

b. Iron atom are more tightly packed

c. Metallic bands are stronger in iron

d. None of these

55. What is the chemical name of the slag coming out of blast furnace?

a. Calcium carbonate **b.** Calcium formate

c. Calcium silicate **d.** Calcium acetate

56. Smelting is done in

a. Electric furnace **b.** Muffle furnace

c. Blast furnace **d.** Open-hearth furnace

57. The concentration of chromite is done by

a. Gravity separation **b.** Magnetic separation

c. Froth floatation **d.** Handpicking

58. P_2O_5 is mainly used as

a. Oxidising agent **b.** Reducing agent

c. Dehydrating agent **d.** Hydrating agent

59. The molecular formula of rhombic sulphur is:

a. S **b.** S_2 **c.** S_4 **d.** S_8

60. Hypo is

a. $Na_2S_2O_3.5H_2O$ **b.** $NaHSO_4$

c. Na_2CO_3 **d.** $2CaSO_4H_2O$

61. Hypo is used in photography for

a. Developing negatives **b.** Picture printing

c. The colouring of picture **d.** The fixation of negative

62. Sapphire and ruby are minerals of
a. Cu **b.** Al **c.** Zn **d.** Hg

63. Purest form of iron is
a. Cast iron **b.** Pig iron
c. Steel **d.** Wrought iron

64. Cinnabar is an ore of
a. Pb **b.** Zn **c.** Hg **d.** Cu

65. Chile saltpeter is an ore of
a. Iodine **b.** Sodium
c. Magnesium **d.** Gold

66. Ores mined from the earth are usually contaminated with large amounts of impurities such as soil, sand, etc called_____
a. Gravel **b.** Gangue **c.** Sand **d.** Granite

67. Which of them is not an ore of silver?
a. Ag_2S **b.** $AgNO_3$
c. AgCl **d.** None of them

68. Van Arkel method of purification of metals involves converting the metal into
a. Volatile stable compound
b. Volatile unstable compound
c. Non-volatile stable compound
d. None of these

69. Liquation is used to refine
a. Iron **b.** Copper **c.** Tin **d.** Gold

70. The slag formed in the extraction of copper from copper pyrites is:
a. $CaSiO_3$ **b.** $FeSiO_3$ **c.** FeS **d.** $Ca_3(PO_4)_2$

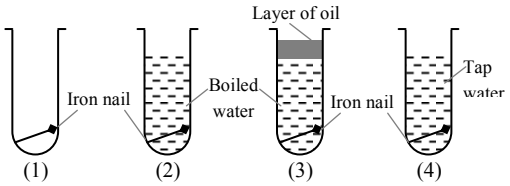
71. Copper is purified by
a. Distillation **b.** Liquation
c. Carbon-reduction **d.** Electrolytic refining

72. An amalgam of metal has which other element?
a. C **b.** Ag **c.** Mg **d.** Hg

73. Blister copper is
a. Pure copper
b. Ore copper
c. Alloy copper
d. Copper having 2% impurities

74. Gold as alloyed with which metal to make it harder?
a. Cu **b.** Hg **c.** Ag **d.** C

75. In which test tubes, the rusting of iron nail will take place?



a. 1 and 2 **b.** 1, 2 and 3
c. 2 and 3 **d.** 2, 3 and 4

76. Match the items in Column-I with those in Column–II

Column I	Column II
(A) Electric Fuse	**1.** Chemical Effect
(B) Relay	**2.** Electric Discharge
(C) CFL	**3.** Magnetic Effect
(D) Button Cell	**4.** Heating Effect

Which of the following shows the correct matching?
a. A→ 3; B→ 2; C→ 1; D→ 4
b. A→ 2; B→ 1; C→ 3; D→ 4
c. A→ 4; B→ 3; C→ 2; D→ 1
d. A→ 4; B→ 2; C→ 3; D→ 1

77. 'Kajal' is the form of
a. Coke **b.** Charcoal
c. Carbon black **d.** Asphalt

78. The substance used to reduce iron ore to iron in the lower part of the blast furnace is:
a. Coke **b.** Charcoal
c. Carbon monoxide **d.** Carbon black

79. Pick the correct statement:
a. All ore are minerals
b. All minerals are ore
c. A mineral cannot be an ore
d. An ore cannot be a mineral

80. The materials listed below:
A. Water (distilled)
B. Solution of common salt
C. Mercury
D. Caustic soda solution
E. Glycerine
A set of materials consisting of good conductor of electricity is
a. A, B, C **b.** A, D, E
c. C, A, E **d.** B, C, D

81. Which of the following alloys contains Tin?
a. Brass **b.** Solder
c. Duralumin **d.** Steel

82. Name an alloy that used in powerful magnets
a. Magnalium **b.** Bronze
c. Duralumin **d.** Alnico

83. Permanent magnets can be made from
a. Ni steel **b.** Cobalt steel
c. Stainless steel **d.** Wrought iron

84. VA group elements are known as
a. Halogens **b.** Normal elements
c. Chalcogens **d.** Pnictogen

85. The carbon content in steel is
a. 0.1–5.0% **b.** 2.0–2.5%
c. 0.1–1.5% **d.** Less than 0.1

86. The red or orange coating that forms on the surface of iron when exposed to air and moisture for some time is called
a. Galvanisation **b.** Electroplating
c. Rust **d.** Reduction

87. Rust is a mixture of
a. FeO & $Fe(OH)_2$ **b.** FeO & $Fe(OH)_3$
c. Fe_2O_3 & $Fe(OH)_3$ **d.** Fe_3O_4 & $Fe(OH)_3$

88. Galvanisation is a method of protecting iron from rusting by coating with a thin layer of
a. Aluminium **b.** Zinc
c. Copper **d.** Nickel

89. The metal which is more hard and corrosion resistant is
a. Nickel **b.** Iron **c.** Platinum **d.** Tungsten

90. The composition of gun metal is
a. Cu; 30% – Ni; 67% – Fe+, Mn; 3%
b. Cu; 80% – Sn; 20%
c. Cu; 88% – Sn; 10% – Zn; 1% – Pb; 1%
d. Cu; 50% – Zn; 25% – Ni; 25%

91. The international standards of weight and measures are made of
a. Gold–silver alloys **b.** Platinum–iridium alloys
c. Copper–gold alloys **d.** Platinum–iron alloys

92. Which of the following compounds is used as drying agent?
a. Gypsum **b.** Calcium oxide
c. Calcium chloride **d.** None of these

93. Plaster of Paris is obtained by heating
a. Gypsum **b.** Limestone
c. Sodium carbonate **d.** Calcium carbonate

94. Gypsum is added to cement because
a. It makes the cement very hard
b. It increases the pace of setting of cement
c. It slow down the initial setting of cement when water is added
d. None of these

95. RCC is
a. The crushed cement in which more gravel is added
b. The concrete having an iron framework inside it as a support
c. Prepared by adding calcium chloride to the limestone and calcium silicate
d. None of the above

ANSWERS

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
a	d	b	d	d	a	c	b	c	a
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
d	a	b	b	a	c	c	b	d	d
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
b	d	b	a	d	b	c	d	a	d
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
a	c	c	d	a	c	a	b	d	a
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**
d	b	d	b	b	d	a	b	c	a
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
b	b	c	c	c	c	b	c	d	a
61.	**62.**	**63.**	**64.**	**65.**	**66.**	**67.**	**68.**	**69.**	**70.**
d	b	d	c	b	b	d	a	c	b
71.	**72.**	**73.**	**74.**	**75.**	**76.**	**77.**	**78.**	**79.**	**80.**
d	d	d	a	a	c	a	a	a	d
81.	**82.**	**83.**	**84.**	**85.**	**86.**	**87.**	**88.**	**89.**	**90.**
b	d	d	d	c	c	c	b	d	c
91.	**92.**	**93.**	**94.**	**95.**					
b	b	a	c	b					

□ □ □