CHAPTER
10

Inorganic Chemistry

Classification of Elements

- In 1896 Mendeleef gave a periodic law. "The properties of elements are periodic function of their atomic masses".
- There were seven periods (horizontal rows) and eight groups (vertical columns) in the Periodic Table of Mendeleef having 63 known elements at that time.
- According to **Modern Periodic Law** "the properties of elements are periodic function of their atomic numbers."
- There are eighteen vertical columns, known as groups and seven horizontal rows, known as periods.
- **Periodic properties** The properties which are repeated at regular intervals are known as periodic properties. Atomic and ionic size, electron affinity, ionization potentials, electronegativity, electropositive character, acidic or basic character, metallic nature etc., are some important periodic properties.

Characteristics of Periods

- The number of valence electrons in elements increases from 1 to 8 on moving from left to right in a period.
- The elements in a period have consecutive atomic numbers.
- The valency of element increases from 1 to 4 and then decrease to 0 (zero) on moving from left to right in a period.
- Atomic size, electropositive character, metallic character, reducing nature of elements and basic nature of oxides all decrease from left to right in a period.
- Electronegative nature, non-metallic nature, acidic nature of oxides, ionization potential increase from left to right in a period. In a period, electronegativity and electron affinity also increase from left to right.

Characteristics of Groups

- All the elements of a group of the Periodic Table have the same number of valence electrons and hence, have almost similar chemical properties.
- Atomic radius, electropositive nature, metallic nature, reducing nature of elements and the basic nature of oxides increase from top to bottom in a group.
- Electronegative nature, ionization potential, electron affinity, electronegativity, non-metallic nature and acidic nature of oxides decrease down a group with increasing atomic number.

Hydrogen and its Compounds

- Hydrogen is the first element in Periodic Table.
- Hydrogen has three isotopes protium or ordinary hydrogen ($_1H^1$), deuterium or heavy hydrogen ($_1H^2$ or $_1D^2$), tritium ($_1H^3$ or $_1T^3$).
- **Tritium is the radioactive isotope of hydrogen.**
- Water is the neutral oxide of hydrogen.
- Pure water freezes at 0°C and boils at 100°C. This abnormal high boiling point is due to association of H_2O molecules through hydrogen bonding.
- **Water** is a polar compound (dipole moment −1.85 D) and possesses a high dielectric constant *i.e.*, 81.
- Zeolite is used to purify water (**Permutit-method**).
- Water is a universal solvent because of its tendency to form H-bond and polar nature.
- **Water has very high specific heat and thus, widely used as a coolant.**
- Water which lather with soap is called **soft** and which does not, is called **hard**.
- Hardness of water may be due to the presence of bicarbonates of calcium or magnesium (**temporary hardness**) or due to the presence of chlorides and sulphates of Ca or Mg. (permanent hardness)
- Temporary hardness is removed by boiling or by adding lime water (Clark's process).
- Permanent hardness is removed by adding sodium carbonate (Na_2CO_3) or calgon (sodium hexa metaphosphate, $[Na_2(Na_2[PO_3)_6]$ or zeolite which is also called permutit (hydrated sodium aluminium silicate, $Na_2Al_2Si_2O_8 \cdot xH_2O$).
- From sea water, pure water is obtained by a process, called reverse osmosis, *i.e.*, by applying pressure higher than the osmotic pressure towards the solution side. This process is also called desalination of sea water.
- **Heavy water** (D_2O, mol. wt. = 20) is the oxide of heavy hydrogen. It is used as a moderator in nuclear reactors.
- In H_2O_2 oxygen is in minus one (−1) oxidation state, (−1) which is the intermediate oxidation state of oxygen.

- H_2O_2 behaves as an oxidising, reducing and bleaching agent.
- Lead painting become blacken in air due to the formation of PbS by the action of H_2S present in air, H_2O_2 is used to wash PbS. H_2O_2 oxidised PbS to $PbSO_4$.

Elements of I Group (Alkali metals)

- These metals are soft.
- Lithium is the lightest metal.
- Alkali metals are stored under kerosene or paraffins to protect them from action of air.
- Lithium shows diagonal relationship with magnesium.
- In Castner process metallic sodium is prepared by electrolysis of molten NaOH.
- **Sodium chloride (NaCl)** or common salt is used in our daily diet, as a preservative for pickles, meat and fish. It is also used in the manufacture of NaOH, Cl_2 gas and soap.
- **Sodium** is used in yellow light lamps.
- **Sodium hydroxide** (NaOH) or caustic soda is used in the soap dyes and artifical silk industries and in the refining of bauxite mineral.
- **Sodium bicarbonate ($NaHCO_3$) or baking soda** is used in effervescent drinks and fruit salts, in fire extinguishers. It is also used in the form of sesquicarbonate, it is used for wool washing. Baking soda when mixed with a mild edible acid like tartaric acid, is called **baking powder**. It is used to make cake soft and spongy.
- **Sodium carbonate decahydrate** ($Na_2CO_3 \cdot 10H_2O$) or **washing soda** is used in the manufacture of glass, soap, washing powder, and for sofrening hard water.
- **Sodium sulphate** ($Na_2SO_4 \cdot 10H_2O$) is Glauber's salt. It is used as purgative.
- **Sodium thiosulphate ($Na_2S_2O_3 \cdot 5H_2O$) is also known as hypo.** It is used in photography as a fixing agent because it removes the undecomposed AgBr as soluble silver thiosulphate salt.
- **$_{29}Cu$, $_{47}Ag$, $_{79}Au$ are the elements of IB group. These elements are called coinage or currency metals.**
- They are *d*- block, transitional elements.
- These are very hard, malleable and ductile metals.
- They have high density and high m.p and b.p.
- $CuSO_4$ is used as a mordant in dyeing. Copper sulphate pentahydrate is blue in colour and is called **blue vitriol**. $CuSO_4$ is used to test the presence of water.
- Copper is alloyed with gold and silver for making ornaments.
- $AgNO_3$ is the **lunar caustic**. It is stored in dark brown bottles because it is photosensitive.
- Au, Ag, Pt, etc., metals which remain unaffected by the action of other strong acids dissolve in aqua-regia (which is a mixture of HCl and HNO_3 in 3 : 1)

Elements of II Group

- II A subgroup elements are Be, Mg, Ca, Sr, Ba and Ra. They are called **alkaline earth metal** and are *s*-block elements.
- Calcium of this family is most abundant elements in earth crust.
- **$Mg(OH)_2$ is called milk of magnesia and used as an antacid.**
- **$MgSO_4$** is used as a mordant in dyeing and tanning industry. It is also used as a purgative.
- Beryllium shows diagonal relationship with aluminium.
- **Calcium oxide (CaO)**, also called quicklime, gives hissing sound when dissolved in water. It is used in the manufacture of glass, calcium chloride, cement, mortar, bleaching powder, calcium carbide, slaked lime. It is also used in the extraction of iron and as a drying agent for ammonia and alcohol.
- **Calcium hydroxide (slaked lime) [$Ca(OH)_2$]**, is used in the manufacture of bleaching powder, caustic soda and soda lime and for softening of hard water.
- When $CaCO_3$ is dipped in water, the bubbles evolve, due to the evolution of carbon dioxide.
- **Calcium sulphate is gypsum** ($CaSO_4 \cdot 2H_2O$). It loses a part $\left(\frac{2}{3}\right)$ of its water of crystallization when heated at 120°C to form $[CaSO_4]_2H_2O$ which is known as **plaster of Paris.**
- **Gypsum** is used in the preparation of building plaster and anhydrite.
- $CaSO_4$ is used for the manufacture of ammonium sulphate **(sindri fertilizer)** and sulphuric acid.
- Plaster of Paris is a white powder, which sets into hard mass called gypsum on hydration with water so it is used in making casting for statues, toys, for plastering factured bones, etc.
- **Cement** has the following composition: Calcium oxide (CaO 50-60%), alumina (Al_2O_3 5-10%), and magnesium oxide (MgO, 2-3%). Raw materials used for its preparation are limestone and clay.
- **Zinc ($_{30}Zn$), cadmium ($_{48}Cd$) and mercury ($_{80}Hg$) are the three elements present in II B subgroup.** They are *d*-block elements.
- Zinc is used in making alloys like brass, bronze, German silver etc.
- Zinc is deposited on the surface of iron articles by the process called galvanization.
- Mercurous chloride or calomel (Hg_2Cl_2) is used for making calomel electrode which is a reference electrode.
- **Mercury, Hg is filled in CFL lamps.**

Elements of IIIA Group (Boron Family)

- Elements are $_5B$, $_{13}Al$, $_{31}Ga$, $_{49}In$ and $_{81}Tl$.
- Boron is a semi-metal. Rest of elements are metals.

- Boron halides are Lewis acids, $BBr_3 > BCl_3 > BF_3$.
- **Borax, suhaga or tincal** is $Na_2B_4O_7 \cdot 10H_2O$.
- All compounds are used in making aeroplanes.
- Aluminium sulphate is used as a mordant in dyeing.

Elements of IVA Group

- The IVA group consists of elements carbon ($_6C$), silicon ($_{14}Si$), germanium ($_{32}Ge$), tin ($_{50}Sn$) and lead ($_{82}Pb$).
- All are *p*-block elements.
- The stability and volatility of tetrahalide of carbon decrease with increasing molecular weight of the tetrahalide *e.g.*

$$\underset{\text{Thermally most volatile}}{CF_4} > CCl_4 > CBr_4 > \underset{\substack{\text{Least stable} \\ \text{Least volatile}}}{CI_4}$$

Carbon

- Carbon has two crystalline allotropes : diamond and graphite.

Diamond

- It is the purest form of carbon.
- It is hardest substance and is a bad conductor of electricity.
- It is used in making jewellery.

Graphite

- Large amounts of graphite are prepared artificially by Acheson process.
- Graphite is a good conductor of heat and electricity.
- It is used in nuclear reactor as a moderator.

Coal and Charcoal

- Coal is the amorphous variety of carbon.
- Coal is used as fuel. Coals are of following type :
  (a) Peat (60% carbon)
  (b) Lignite or brown coal (70% carbon)
  (c) Bituminous (78-83% carbon)
  (d) Anthracite (90% carbon)
- It is used in the manufacture of fuel gases like-water gas, producer gas and semi-water gas.
- Charcoal (animal charcoal) is used as a fuel and also as a decorant in the purification of water, decolourising sugar solution and in gas masks.

Carbon Dioxide (CO_2)

- Air contains CO_2 to an extent of 0.03% by the volume. CO_2 is an acidic oxide of carbon.
- Solid CO_2 is technically known as dry ice (drikold). It produces very low temperature (– 100°C) with ether, hence gives an excellent freezing mixture.

Silicon

- It is the second most abundant element in the earth's crust.
- Crystalline form of SiO_2 (silica) is quartz. SiO_2 is soluble in HF.

Glass

- Amorphous and transparent solid, obtained by solidification of various silicates and borates.
- Various varieties of glass are : Coloured glass, hard glass, high refractive index glass, pyrex glass, crook's glass.
- Coloured glass can be obtained by adding following compounds.

Compounded added	Colour imparted
Cobalt oxide	Blue
Cuprous oxide	Red
Cadmium sulphide	Lemon yellow
Chromium oxide	Green
Auric chloride	Ruby
Manganese dioxide	Purple

Types of glasses	Uses
Soft glass	Window panes, bottles, test tubes etc.
Hard glass	Combustion tubes etc.
Crook's glass	(absorbs UV rays) used for making lenses
Pyrex glass	Cooking utensils
High refractive index glass	Lenses, cut glasses
Glass laminates	Bullet proof materials

Glass Wool

It is an insulating material, obtained from fibre glass arranged into a texture similar to wood. It is produced or rolls in slabs with different thermal and mechanical properties.

Elements of VA Group
(Nitrogen Family-Pnicogens)

- Elements are $_7N$, $_{15}P$, $_{33}As$, $_{51}Sb$ and $_{83}Bi$.
- Phosphorus is the most abundant element of this family in the earth's crust.
- **Nitrogen is an essential component of explosives.**
- NH_3 is an alkaline gas, extremely soluble in water and is dried over quicklime.
- Oxides of nitrogen when dissolves in water, give oxyacids *e.g.* NO_2 when dissolves in water, gives HNO_3 (nitric acid).
- Nitric acid is a strong acid and used in the synthesis of fertilizers and explosives.
- Red phosphorus is largely used in match industry and in the manufacture of phosphor bronze-an alloy of Cu, Sn and P.

Elements of VIA Group
(Oxygen Family-Chalcogens)

- Elements are $_8O$, $_{16}S$, $_{34}Se$, $_{52}Te$ and $_{84}Po$.
- Most abundant element of the family is oxygen.

- Common oxidation state of oxygen is (−2).
- ...of vitriol is H_2SO_4.
- ...SO_4 is a dibasic acid and is a dehydrating agent. It is used ...mixing explosives.
- ...zone (O_3) is an allotrope of oxygen. It is diamagnetic gas.
- ...SO_2 is a bleaching agent. Its bleaching action is due to ...duction and is temporary.
- ...xides of sulphur causes acid rain in the atmosphere.

...ements of VII Group (Halogens)

- ...ements are $_9F$, $_{17}Cl$, $_{35}Br$, $_{53}I$ and $_{85}At$.
- ...F has maximum electronegativity
- ...Chlorine is prepared by oxidation of HCl with MnO_2, ...MnO_4, $K_2Cr_2O_7$ etc.
- ...Chlorine has maximum electron affinity in the ...halogens.
- ...Order of reactivity of halogens $F_2 > Cl_2 > Br_2 > I_2$
- ...Order of electronegativity F > Cl > Br > I.
- ...Order of acidic strength HI > HBr > HCl > HF.
- ...Iodine is a powerful antiseptic and used as a **tincture of iodine (a solution of iodine in alcohol)**.

...ements of VIIIth Group

- ...ements are
  ...$_{26}Fe$, $_{27}Co$, $_{28}Ni$ (Ferrous metals)
  ...$_{45}Rh$, $_{46}Pd$ (Light platinum metals)
  ...$_{76}Ir$, $_{78}Pt$ (High platinum metals)
- ...All of these are *d*-block elements.
- ...Pig iron is obtained from blast furnace. It is most impure form of iron.
- ...Pig iron is very hard, but brittle. It cannot be welded. It contains maximum amount of carbon (2.5% to 4.3%).
- ...Wrought iron is the purest form of iron. It contains 0.1 to 0.25% carbon. Wrought iron is soft, ductile and malleable, so it can be welded.
- ...Steel is the most important form of iron. It contains 0.2 to 1.5% carbon.
- ...Iron is present in haemoglobin (blood) and its oxidation state in haemoglobin is +2.
- ...Rusting of iron is an electrochemical process. Rust is chemically hydrated ferric oxide $Fe_2O_3 \cdot xH_2O$.
- ...Fe_2O_3 is called jeweller's rough.

...ements of Zero Group

- ...ements are $_2He$, $_{10}Ne$, $_{18}Ar$, $_{36}Kr$, $_{54}Xe$ and $_{86}Rn$.
- ...Argon is the most abundant inert gas in air.
- Helium was discovered by Frankland and Lockyer. He-III is abundant on the lunar surface and holds the potential to put an end to the energy crisis of the earth.
- Argon was discovered by Rayleigh and Ramsay.
- Ne, Kr and Xe were discovered Ramsay and Traverse.
- Radon was discovered by Dorn and is not present in air.
- All of these elements are colourless monoatomic gases.
- Their electronegativity and electron affinity are zero.

Gas	Uses
Helium	with oxygen for deep seadives filling balloons and in low temperature applications.
Neon	In advertising signs.
Argon	Light bulbs
Krypton/Xenon	Photographic flash TV tubes

Some Important Ores

Metal	Ores	Chemical composition
Sodium	Rock salt	$NaCl$
	Chile salt petre	$NaNO_3$
	Borax	$Na_2B_4O_7 \cdot 10H_2O$
Potassium	Carnallite	$KCl \cdot MgCl_2 \cdot 6H_2O$
	Sylvine	KCl
Magnesium	Magnesite	$MgCO_3$
	Asbestos	$CaSiO_3 \cdot 3MgSiO_3$
Calcium	Lime stone	$CaCO_3$
	Gypsum	$CaSO_4 \cdot 2H_2O$
	Fluorspar	CaF_2
Aluminium	Bauxite	$Al_2O_3 \cdot 2H_2O$
	Cryolite	Na_3AlF_6
	Feldspar	$KAlSi_3O_8$
	Mica	$KAlSi_2O_{10}(OH)_2$
Iron	Haematite	Fe_2O_3
	Magnetite	Fe_3O_4
	Iron pyrites	FeS_2
	Siderite	$FeCO_3$
Copper	Copper glance	Cu_2S
	Copper pyrites	$CuFeS_2$
	Malachite	$Cu(OH)_2 \cdot CuCO_3$
	Azurite	$2CuCO_3 \cdot Cu(OH)_2$
Silver	Silver glance	Ag_2S
	Horn silver	$AgCl$
	Ruby silver	$Ag_2S \cdot Sb_2S_3$
Gold	Sylvanite	$AuAgTe_4$
Zinc	Zinc blende	ZnS
	Calamine	$ZnCO_3$
	Zincite	ZnO
Mercury	Cinnabar	HgS
Tin	Cassiterite	SnO_2
Lead	Galena	PbS
	Cerrusite	$PbCO_3$
	Anglesite	$PbSO_4$

Some Important Alloys

Alloys	Composition	Important uses
Solder	Tin and lead	Soldering.
Bronze	Copper and tin	Making utensils, statues, coins etc.
Type metal	Tin, lead and antimony	Used in printing.
Bell metal	Copper, tin	Making bells.
Gun metal	Copper, tin and zinc	Gears and bearing.
Brass	Copper, zinc	Utensils, condenser, tubes, cartridge caps etc.
Aluminium Bronze	Copper and aluminium	Coins, picture, cheap jewellery.
German silver	Copper, zinc, nickel	Utensils, resistance wires.
Constantan	Copper, nickel	Electrical apparatus.
Dental alloy	Silver, mercury, tin, zinc	For filling teeth.
Stainless steel	Iron, chromium, nickel,	Utensils, bicycle parts etc.
Magnalium	Magnesium and aluminium	Automobile and aeroplane parts.
Nichrome	Nickel, iron, chromium, manganese	In making coins of heater.
Misch metal	Cerium, lanthanum, neodymium, praseodymium and other lanthanoids	In making cigarette lighters.

Some Important Compounds

Common name	Chemical name	Formula
Aqua-fortis	Nitric acid	HNO_3
Aqua-regia	Nitric acid + hydrochloric acid	Conc. HNO_3 + conc. HCl (in 1 : 3 ratio)
Baking soda	Sodium bicarbonate	$NaHCO_3$
Brine	Sodium chloride solution	NaCl solution
Blue vitriol	Copper sulphate	$CuSO_4 \cdot 5H_2O$
Bone ash	Calcium phosphate	$Ca_3(PO_4)_2$
Bleaching powder	Calcium oxy-chloride	$CaOCl_2$
Caustic soda	Sodium hydroxide	NaOH
Chile salt petre	Sodium nitrate	$NaNO_3$
Dry ice	Solid carbon dioxide	CO_2
Epsom salt	Hepta hydrate magnesium sulphate	$MgSO_4 \cdot 7H_2O$
Foul air	Nitrogen	N_2
Grain alcohol	Ethyl alcohol	C_2H_5OH
Grape sugar	Dextrose	$C_6H_{12}O_6$
Gypsum	Calcium sulphate	$CaSO_4 \cdot 2H_2O$
Green vitriol	Ferrous sulphate	$FeSO_4 \cdot 7H_2O$
Gammexane	Benzene hexa chloride	$C_6H_6Cl_6$
Heavy water	Deuterium oxide	D_2O
Halite	Sodium chloride	NaCl
Lime stone (pearl)	Calcium carbonate	$CaCO_3$
Laughing gas	Nitrous oxide	N_2O
Milk of magnesia	Magnesium hydroxide	$Mg(OH)_2$
Milk of lime (slaked lime)	Calcium hydroxide	$Ca(OH)_2$
Oil of vitriol	Sulphuric acid	H_2SO_4
Plaster of Paris	Calcium sulphate hemihydrate	$CaSO_4 \cdot \frac{1}{2}2H_2O$
Phosgene	Carbonyl chloride	$COCl_2$
Paris green	(Double salt)	$Cu(C_2H_8O_2)_2$
Pearl white		BiOCl
Quartz or sand	Silicon dioxide	SiO_2
Quick silver	Mercury	Hg
Quicklime	Calcium oxide	CaO
Red lead	Lead tetroxide	Pb_3O_4
Stranger gas	Xenon	Xe
Spirit of salt	Hydrochloric acid	HCl
Soda ash	Sodium carbonates	Na_2CO_3

Common name	Chemical name	Formula
Salt cake	Sodium sulphate	Na_2SO_4
Tear gas	Chloropicrin	CCl_3NO_2 (or chloro compounds or NH_3)
Vinegar	Dilute acetic acid	CH_3COOH
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3 \cdot 10H_2O$
Water glass	Sodium silicate	Na_2SiO_3
White vitriol	Zinc sulphate	$ZnSO_4 \cdot 7H_2O$

Points to be Remember

- In the from of minerals metals occur in nature.
- Ores are the minerals from which metal is extracted beneficially
- Gangue or matrix is the impurities associated with ore
- Roasting is the process of heating are (mainly sulphide ore) in excess of air which calcination is heating the ore (carbonate or hydroxide ore) in absence or limited supply of air.
- Zero group element are called inert gases or rare gases.
- Flux is added to gangue to convert it into slag.

Exercise

1. Gypsum ($CaSO_4 \cdot 2H_2O$) is added to clinker during cement manufacturing to **(CDS 2011 II)**
   (a) decrease the rate of setting of cement
   (b) bind the particles of calcium silicate
   (c) facilitate the formation of colloidal gel
   (d) impart strength to cement

2. Magnalium is an alloy of magnesium with
   (a) silicon (b) chlorine
   (c) aluminium (d) calcium

3. Bleaching powder is
   (a) $CaSO_4 \cdot 2H_2O$ (b) $CaOCl_2$
   (c) $CaCO_3$ (d) CaO

4. **Statement I** On mixing with water, plaster of Paris hardens.
   Statement II By combining with water, plaster of Paris is converted into gypsum. **(CDS 2011 II)**
   (a) Statement I and statement II are true and statement II is the correct explanation of statement I.
   (b) Statement I and statement II are true and statement II is not the correct explanation of statement I.
   (c) Statement I is true but statement II is false.
   (d) Statement I is false but statement II is true.

5. What is the main constituent of a Pearl? **(CDS 2011 II)**
   (a) Calcium carbonate and magnesium carbonate
   (b) Calcium sulphate only
   (c) Calcium oxide and calcium sulphate
   (d) Calcium carbonate only

6. Composition of bauxite is
   (a) $Al_2O_3 \cdot 2H_2O$ (b) $Al_2O_3 \cdot H_2O$
   (c) $Al_2O_3 \cdot 4H_2O$ (d) $Al_2O_3 \cdot 3H_2O$

7. The substance added to blast furnace for removing gangue is
   (a) clay (b) ore
   (c) flux (d) slag

8. Sodium thiosulphate ($Na_2S_2O_3$) solution is used in photography to **(CDS 2011 II)**
   (a) remove reduced silver
   (b) reduce silver bromide (AgBr) grain to silver
   (c) remove undecomposed AgBr as a soluble silver thiosulphate complex
   (d) convert the metallic silver to silver salt

9. Atomicity of phosphorus is
   (a) 1 (b) 2 (c) 3 (d) 4

10. Noble gas is
    (a) monoatomic (b) diatomic
    (c) triatomic (d) pentaatomic

11. Which of the following occurs in the native state?
    (a) Silver (b) Copper
    (c) Both Ag and Au. (d) Carbon

12. **Statement I** Oxides of sulphur and nitrogen present in high concentration in air are dissolved in rain drops.
    Statement II Oxyacids of sulphur and nitrogen make rain water acidic. **(CDS 2011 II)**
    (a) Statement I and statement II are true and statement II is the correct explanation of statement I.
    (b) Statement I and statement II are true and statement II is not the correct explanation of statement I.
    (c) Statement I is true but statement II is false.
    (d) Statement I is false but statement II is true.

13. Diamond is a
    (a) metallic crystal
    (b) molecular crystal
    (c) ionic crystal
    (d) covalent crystal

14. Most abundant metal in earth's crust is
    (a) carbon (b) steel
    (c) iron (d) aluminium

15. The purest form of carbon is
(a) diamond (b) graphite
(c) steel (d) solder

16. Which one among the following substances evolves heat when dissolved in water? **(CDS 2011 I)**
(a) Potassium nitrate (b) Sodium chloride
(c) Glucose (d) Calcium oxide

17. Which one among the following metals is used for making boats because it does not corrode by sea water? **(CDS 2011 I)**
(a) Tungsten (b) Nickel
(c) Antimony (d) Titanium

18. Monel metal is an alloy of
(a) Cu + Al (b) Cu + Ni
(c) Cu + Al (d) Mg + Zn

19. Baking soda is
(a) K_2CO_3 (b) Na_2SO_4
(c) $NaHCO_3$ (d) NaOH

20. The percentage of carbon is highest in
(a) tool steels (b) steel
(c) cast iron (d) solder

21. Heavy water implies **(CDS 2011 I)**
(a) water which is used in heavy industries such as thermal power plants
(b) water which contains SO_4^{2-} and Cl^- of calcium and magnesium
(c) it is deuterated water
(d) it is water of maximum density

22. Water is a good coolant and is used to cool the engines of cars, buses, trucks etc. It is because water has a **(CDS 2011 I)**
(a) high specific heat (b) low surface tension
(c) high boiling point (d) low expansivity

23. Carnallite is an ore of
(a) Cu (b) Co
(c) Mg (d) Al

24. Silicon is
(a) alloy (b) metal
(c) conductor (d) semiconductor

25. The formula of plaster of Paris is
(a) $CaSO_2 \cdot 2H_2O$ (b) $2CaSO_4 \cdot H_2O$
(c) $2CaSO_2 \cdot 8H_2O$ (d) $CaSO_4 \cdot 8H_2O$

26. Which one of the following is not a periodic property *i.e.*, does not show any trend on moving from one side to the other in the Periodic Table? **(CDS 2010 II)**
(a) Atomic size (b) Valency
(c) Radioactivity (d) Electronegativity

27. **Statement I** During the setting of cement, the structure has to be cooled by spraying water.
Statement II The constituents of cement undergo hydration during setting of cement and it is an exothermic reaction. **(CDS 2010 II)**
(a) Statement I and statement II are true and statement II is the correct explanation of statement I.
(b) Statement I and statement II are true and statement II is not the correct explanation of statement I.
(c) Statement I is true but statement II is false.
(d) Statement I is false but statement II is true.

28. Gypsum is
(a) $CaSO_4 \cdot 2H_2O$ (b) $2CaSO_4 \cdot H_2O$
(c) $CaSO_4 \cdot 3H_2O$ (d) $3CaSO_4 \cdot 2H_2O$

29. Quicklime is
(a) $CaSO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $CuSO_4$

30. Bone black is obtained by
(a) treating bones with H_2SO_4
(b) destructive distillation of bones
(c) heating bones
(d) heating wood

31. Which among the following elements is abundant on the lunar surface and holds the potential to put an end to the energy crisis of the earth? **(CDS 2010 I)**
(a) Helium-I (b) Helium-II
(c) Helium-III (d) Helium-IV

32. The coil in a heater is made of **(CDS 2010 I)**
(a) nichrome (b) tungsten
(c) copper (d) iron

33. Chief ore of iron is
(a) bauxite (b) magnetite
(c) haematite (d) dolomite

34. Match Column I with Column II and select the correct answer using the codes given below the Columns.

Column I (Alloy)	Column II (Constituent)
A. Solder	1. Iron and carbon
B. Brass	2. Copper and zinc
C. Bronze	3. Copper and tin
D. Steel	4. Lead and tin

(CDS 2010 I)

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	4	2	3	1
(c)	1	3	2	4
(d)	4	3	2	1

35. If a limestone piece is dipped in water, bubbles evolve. The bubbling is due to **(CDS 2010 I)**
(a) hydrogen (b) oxygen
(c) water vapour (d) carbon dioxide

36. Which one of the following is used as a mordant in dyeing and tanning industry? **(CDS 2009 I)**
(a) Magnesium oxide
(b) Magnesium carbonate
(c) Magnesium chloride
(d) Magnesium sulphate

37. Iron used for casting is
(a) steel (b) wild steel
(c) pig iron (d) wrought iron

38. Producer gas is mixture of
(a) $CO + H_2$ (b) $CO + O_2$
(c) $CO + N_2$ (d) $CO_2 + O_2$

39. Which is found in transistors?
(a) Ge (b) Ag
(c) Pb (d) Kr

40. Which one of the following is the softest? **(CDS 2009 I)**
(a) Sodium (b) Aluminium
(c) Iron (d) Copper

41. Which one of the following is the secondary source of light in a fluorescent lamp? **(CDS 2009 I)**
(a) Neon gas (b) Argon gas
(c) Mercury vapour (d) Fluorescent coating

42. Ordinary water, when compared to the heavy water used in nuclear reactors is
(a) several times lighter
(b) marginally lighter
(c) half as heavy
(d) as heavy because chemically both are the same

43. Gypsum is added to Portland cement to
(a) accelerate the process of setting
(b) harden it
(c) retard the process of setting
(d) improve hydratability of cement

44. Which one of the following when dissolved in H_2O gives hissing sound? **(CDS 2009 I)**
(a) Limestone (b) Slaked lime
(c) Sodalime (d) Quicklime

45. Which one of the following is correct? Setting of plaster of Paris is **(CDS 2009 I)**
(a) dehydration
(b) oxidation with atmospheric oxygen
(c) hydration leading to another hydrate
(d) combination with atmospheric CO_2

46. Nitrous oxide is called
(a) laughing gas (b) tear gas
(c) producer gas (d) methane gas

47. Which one of the following substances is used in the manufacture of safety matches? **(CDS 2009 I)**
(a) Red phosphorus
(b) White phosphorus
(c) Phosphorus trioxide (P_2O_3)
(d) Black phosphorus

48. Stainless steel is a/an
(a) element (b) compound
(c) alloy (d) None of these

49. What is the jeweller's rouge? **(CDS 2008 I)**
(a) Ferric oxide (b) Ferrous oxide
(c) Ferrous carbonate (d) Ferric carbonate

50. Which one is the mineral of aluminium?
(a) Malachite (b) Azurite
(c) Bauxite (d) Galena

51. Sodium is usually kept under
(a) air (b) CCl_4
(c) kerosene (d) water

52. 'Misch metal' is widely used in the manufacture of which of the following? **(CDS 2008 I)**
(a) Material of car brake
(b) Smoke detectors
(c) Cigarette lighters
(d) Emergency lights

53. As which one of the following, does carbon occur in its purest form in nature? **(CDS 2008 I)**
(a) Carbon black (b) Graphite
(c) Diamond (d) Coal

54. Match Column I with Column II and select the correct answer using the codes given below the Columns. **(CDS 2007 I)**

Column I (Mineral)	Column II (Industries in which largely used)
A. Limestone	1. Cement
B. Copper	2. Electrical goods
C. Bauxite	3. Manufacture of aeroplanes
D. Manganese	4. Steel

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	1	2	3	4
(c)	3	2	1	4	(d)	1	4	3	2

55. BaO is a
(a) amphoteric oxide (b) neutral oxide
(c) acidic oxide (d) basic oxide

56. Which one of the following vitamins contains cobalt?
(a) Vitamin B_1 (b) Vitamin B_2
(c) Vitamin B_6 (d) Vitamin B_{12}

57. German silver is an alloy of **(CDS 2007 I)**
(a) gold and silver
(b) copper and silver
(c) copper, zinc and silver
(d) copper, zinc and nickel

58. Consider the following statements about graphite.
1. It is a good conductor of electricity.
2. It is an allotropic modification of carbon.
3. It has a high refractive index.
4. It is present in the non-volatile part of crude petroleum.

Which of the above statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1, 3 and 4

59. The fixer used for developing a photographic film is chemically
(a) a reducing agent (b) an oxidising agent
(c) a neutralising agent (d) a complexing agent

60. Which one of the following is a mordant used in dyeing?
(a) Calcium hydroxide (b) Aluminium sulphate
(c) Calcium carbonate (d) Zinc phosphate

61. Which of the following metals are present in haemoglobin and chlorophyll, respectively?
(a) Fe and Mg (b) Fe and Zn **(CDS 2007 II)**
(c) Mg and Zn (d) Zn and Mg

62. The following substances are used in low temperature applications
(a) liquid helium (b) liquid nitrogen
(c) dry ice (d) liquid air

63. Permanent magnets can be made from
(a) cobalt (b) aluminium
(c) zinc (d) lead

64. Consider the following statements.
1. Nitric acid is used in the production of fertilizers.
2. Sulphuric acid is used in the production of explosives.
Which of the statements given above is/are correct? (CDS 2007 II)
(a) Only 1 (b) Only 2
(c) Both 1 and 2 (d) Neither 1 nor 2

65. Match Column I (Gas) with Column II (Main chemical components) and select the correct answer using the codes given below the Columns.

Column I	Column II
A. Water gas	1. CH_4
B. Producer gas	2. $CO + H_2$
C. Coal gas	3. $H_2 + CH_4 + CO$
D. Gobar gas	4. $CO + N_2$

Codes

	A	B	C	D
(a)	4	2	1	3
(c)	2	4	3	1

	A	B	C	D
(b)	4	2	3	1
(d)	2	4	1	3

66. The most electronegative element among the following is
(a) fluorine (b) oxygen
(c) sodium (d) sulphur

67. Consider the following elements.
1. Cobalt 2. Gold
3. Nickel 4. Silver
Which of these are magnetic substances?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 4 (d) 3 and 4

68. The element which form ions in dimeric state is
(a) Hg (b) Cu
(c) Be (d) Ni

69. Diamond used in jewellery is
(a) a compound (b) a metal
(c) a mixture of compounds (d) an element

70. Dry ice is
(a) supercooled ice
(b) solid water with zero humidity
(c) solid carbon dioxide
(d) solidified ammonia

71. Which one of the following varieties of coal has the highest amount of carbon in it?
(a) Anthracite (b) Bituminous
(c) Lignite (d) Peat

72. Glauber's salt is
(a) Na_2CO_3 (b) $NaHCO_3$
(c) $Na_2SO_4 \cdot 10H_2O$ (d) NaCl

73. Which one of the following minerals occurs abundantly in the earth's crust?
(a) Bauxite (b) Silica (c) Manganese (d) Iron

74. Which one of the following elements is used in the manufacture of the safety matches?
(a) Graphite (b) Phosphorus
(c) Silicon (d) Sodium

75. Lead painting and lead articles when exposed to atmosphere turn black due to reaction with
(a) carbon dioxide (b) hydrogen sulphide
(c) oxygen (d) sulphur dioxide

76. Which of the following has largest electron affinity?
(a) F (b) Cl
(c) Br (d) I

77. Which of the following is not a trasition metal?
(a) Silver (b) Lead
(c) Tungsten (d) Manganese

78. The element which exist in liquid state at room temperature
(a) Na (b) Br
(c) Hg (d) Ga

79. Zero group elements are also called
(a) noble gases (b) rare earth elements
(c) alkali metals (d) Transition metals

Directions (For Q 80 to 84)
(A) A and R are correct and R is the correct explanation of A.
(B) A and R are correct and R is not the correct explanation of A.
(C) A is correct but R not.
(D) A is correct but A not.

80. **Assertion (A)** Activated charcoal is used in gas masks.
Reason (R) Gas repelling capacity of activated charcoal is much more than ordinary charcoal.
(a) C (b) B
(c) A (d) D

81. **Assertion (A)** Water boils at 100°C.
Reason (R) Water has intermolecular hydrogen bonding.
(a) B (b) D
(c) A (d) C

82. **Assertion (A)** It is dangerous to pour water on hot oil while cooking.
Reason (R) Boiling point of water is higher than that of cooking oil.
(a) D (b) C
(c) B (d) A

83. **Assertion (A)** Water can exist in all the three states i.e., solid, liquid and gas.
Reason (R) Water has low dielectric constant.
(a) D (b) C
(c) A (d) B

84. **Assertion (A)** Electrical resistance of carbon rod decreases with rise in temperature.
Reason (R) Electrical property of carbon is same as of all solids.
(a) D (b) B
(c) A (d) C

85. Water gas is a mixture of
(a) C and N_2 (b) Co and N_2
(c) Co and H_2 (d) Co_2 and N_2

86. The process of extraction of metal from ore is called
(a) calcination (b) conductivity
(c) concentration (d) metallurgy

The process of heating ore in absence of air is called
(a) smelting (b) decomposition
(c) roasting (d) calcination

Naturally occurring metal containing compound is called
(a) matrix (b) ore
(c) gangue (d) mineral

Long form of Periodic Table is based on the properties of elements as a function of
(a) atomic size (b) atomic mass
(c) electronegativity (d) atomic number

Which of the following properties generally decreases along a period?
(a) Atomic size (b) Electron affinity
(c) Ionisation energy (d) Electronegativity

The elements belonging to second period are called
(a) normal elements (b) noble gases
(c) transition elements (d) None of the above

The arrangement of elements in Modern Periodic Table is done by
(a) Rutherford (b) Bohr
(c) Mendeleef (d) Moseley

Match Column I with Column II and select the correct answer using the codes given below the Columns.

Column I	Column II
A. Nitrolim	1. Carcinogen
B. Asbestos	2. Electromagnet
C. Alnico	3. Propellant
D. Zinc oxide	4. Fertilizer
	5. Fluorescent paint

Codes

	A	B	C	D		A	B	C	D
(a)	4	1	3	2	(b)	2	5	4	1
(c)	4	1	2	5	(d)	3	4	2	5

Arrange the following in the descending order of their carbon content.
I. Cast iron II. Wrought iron III. Steel
(a) I, II, III (b) II, I, III
(c) III, II, I (d) I, III, II

Match Column I (ores) with Column II (metal extracted) and select the correct answer using codes given below Columns.

Column I (Ores)	Column II (Metal extracted)
A. Bauxite	1. Lead
B. Haematite	2. Thorium
C. Galena	3. Aluminium
D. Monazite	4. Iron
	5. Gold

Codes

	A	B	C	D		A	B	C	D
(a)	5	4	1	2	(b)	3	4	5	1
(c)	3	4	1	2	(d)	4	3	2	5

Match Column I (Substances) with Column II (Use) and select the correct answer using the codes given below the Columns.

Column I	Column II
A. Zeolite	1. Purgative
B. Sodium thiosulphate	2. Safety matches
C. Magnesium sulphate	3. Dry cell
D. Graphite	4. Purification of water
	5. Photography

Codes

	A	B	C	D		A	B	C	D
(a)	3	5	2	4	(b)	3	2	1	5
(c)	4	1	2	3	(d)	4	5	1	3

Match the following Columns.

Column I	Column II
A. Aluminium	1. Monazite
B. Uranium	2. Pitch blende
C. Thorium	3. Bauxite
D. Lead	4. Galena
	5. Haematite

Codes

	A	B	C	D
(a)	3	2	1	4
(b)	4	3	2	1
(c)	1	2	3	4
(d)	4	1	3	2

Match the following.

Alloys	Uses
A. Brass	1. Gears and bearings.
B. Bronze	2. Caps of cartidges.
C. Gun metal	3. Spring and suspension filament in electrical instruments.
D. Phosphor bronze	4. Resistance wire.
	5. Control valves.

Codes

	A	B	C	D		A	B	C	D
(a)	5	1	3	2	(b)	2	5	3	1
(c)	2	5	1	3	(d)	5	1	2	3

Match the following.

Alloy	Composition
A. Bronze	1. Lead, antimony, tin
B. Brass	2. Copper, zinc, nickel
C. German silver	3. Copper, zinc
D. Type metal	4. Copper, tin
	5. Copper, zinc nickle aluminium

Codes

	A	B	C	D		A	B	C	D
(a)	4	3	2	5	(b)	4	3	2	1
(c)	5	3	2	1	(d)	4	3	5	1

Answers

1. (a)	2. (c)	3. (b)	4. (a)	5. (d)	6. (a)	7. (c)	8. (c)	9. (d)	10. (a)
11. (c)	12. (a)	13. (d)	14. (d)	15. (a)	16. (d)	17. (d)	18. (b)	19. (c)	20. (c)
21. (c)	22. (a)	23. (c)	24. (d)	25. (b)	26. (c)	27. (a)	28. (a)	29. (b)	30. (b)
31. (c)	32. (a)	33. (c)	34. (b)	35. (d)	36. (d)	37. (c)	38. (c)	39. (a)	40. (a)
41. (d)	42. (b)	43. (c)	44. (d)	45. (c)	46. (a)	47. (a)	48. (c)	49. (a)	50. (c)
51. (c)	52. (c)	53. (a)	54. (b)	55. (d)	56. (d)	57. (d)	58. (a)	59. (a)	60. (b)
61. (a)	62. (c)	63. (a)	64. (c)	65. (c)	66. (a)	67. (b)	68. (a)	69. (d)	70. (c)
71. (a)	72. (c)	73. (a)	74. (b)	75. (b)	76. (b)	77. (b)	78. (b)	79. (a)	80. (a)
81. (c)	82. (c)	83. (b)	84. (a)	85. (c)	86. (d)	87. (d)	88. (d)	89. (d)	90. (a)
91. (d)	92. (d)	93. (c)	94. (d)	95. (c)	96. (d)	97. (a)	98. (c)	99. (b)	

Hints and Solutions

1. Gypsum ($CaSO_4 \cdot 2H_2O$) is added to clinker during cement manufacturing to decrease the rate of setting of cement so that it gets sufficiently hardens.

4. On mixing with water, plaster of Paris hardens because it takes up the water of crystallisation again and thus converts back into the dihydrate *i.e.*, gypsum and sets to a hard mass with slight expansion.

$$\underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2}H_2O} + 1\frac{1}{2}H_2O \longrightarrow \underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O}$$

5. Pearl consists of approximately 85% calcium carbonate hence the main constituent of a pearl is calcium carbonate.

8. Sodium thiosulphate ($Na_2S_2O_3$) solution is used in photography as a fixer since, it removes undecomposed AgBr as a soluble silver thiosulphate complex.

$$AgBr + 2Na_2S_2O_3 \longrightarrow \underset{\text{Sodium argento thiosulphate}}{Na[Ag(S_2O_3)_2]} + NaBr$$

12. Oxides of sulphur and nitrogen present in high concentration in air dissolve in rain drops and form oxyacids of sulphur and nitrogen. These oxyacids are highly acidic in nature and therefore, they make rain water acidic.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

$$2SO_2 + 2H_2O + O_2 \longrightarrow 2H_2SO_4$$

The pH of acid rain is 4-5.

16. When calcium oxide or quicklime (CaO) is dissolved in water, calcium hydroxide or limewater is obtained and there is a release of heat.

$$\underset{\text{Quicklime}}{CaO} + H_2O \longrightarrow \underset{\text{Limewater}}{Ca(OH)_2} + \text{Heat}$$

17. Titanium (Ti) metal is used for making boats because it does not corrode by the sea water.

21. Heavy water or deuterium oxide (D_2O) is an oxide of deuterium which is an isotope of hydrogen. It is a colourless, odourless and tasteless liquid. It contains 0.014% normal water (H_2O). It is used as moderator in nuclear reactor to slow down the neutrons.

22. Water is a good coolant and is used to cool the engines of cars buses, trucks, etc. It is because water has a high specific heat.

26. Radioactivity is not a periodic property. It is a nuclear property. Atomic size, valency and electronegativity are periodic properties because they show a trend on moving from one side to the other in the Periodic Table.

31. Helium-III is abundant on the lunar surface and holds the potential to put an end to the energy crisis of the earth.

32. The coil in a heater is made up of nichrome because its melting point and resistivity are high. It can be easily drawn into thin wires and also cannot be oxidised by the oxygen of air when heated.

34.

Alloy	Constituent
Solder	Lead and tin
Brass	Copper and zinc
Bronze	Copper and tin
Steel	Iron and carbon

35. When limestone piece is dipped in water, the bubbles are evolved due to evolution of carbon dioxide.

$$CaCO_3 + H_2O \longrightarrow Ca(OH)_2 + CO_2$$

36. Magnesium sulphate ($MgSO_4$) is used as a mordant in dyeing and tanning industry. In medicine, it is used as a purgative.

40. Alkali metals such as lithium, sodium and potassium are soft metals. These can be easily cut with a knife.

41. Fluorescent coating on the glass is the secondary source of light in a fluorescent lamp.