CONCEPT MAP
CLASS XI

Trends and Anomalies in *s*- and *p*-Block Elements

Generally in a group, elements show a regular trend in their physical and chemical properties with increase in their atomic numbers. But some of the elements show exceptional behaviour and anomalies.

General Trends in Properties of *s*- and *p*-Block Compounds

Carbonates and Bicarbonates Stability
- $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
- $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$
- $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

Basic Strength, Solubility and Stability of Hydroxides
- $LiOH < NaOH < KOH < RbOH < CsOH$
- $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
- $B(OH)_3 < Al(OH)_3 < Ga(OH)_3 < In(OH)_3 < Tl(OH)_3$ (Acidic; Amphoteric; Basic)

Solubility and Basic Strength of Oxides
- $Li_2O < Na_2O < K_2O < Rb_2O < Cs_2O$
- $BeO < MgO < CaO < SrO < BaO$ (Amphoteric; Weakly basic; Strongly basic)
- $B_2O_3 < Al_2O_3 < Ga_2O_3 < In_2O_3 < Tl_2O_3$ (Weakly acidic; Amphoteric; Basic)

Stability of Peroxides and Superoxides
- $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$
- $NaO_2 < KO_2 < RbO_2 < CsO_2$
- $MgO_2 < CaO_2 < SrO_2 < BaO_2$

Solubility in Water
- $LiF < NaF < KF < RbF < CsF$
- $LiCl < NaCl < KCl < RbCl < CsCl$
- $NaF < NaCl < NaBr < NaI$
- $BeCl_2 > MgCl_2 > CaCl_2 > SrCl_2 > BaCl_2$
- $BF_3 > BCl_3 > BBr_3$

Stability of Halides
- $CX_4 > SiX_4 > GeX_4 > SnX_4 > PbX_4$
- $CF_4 > CCl_4 > CBr_4 > CI_4$
- $PbX_2 > SnX_2 > GeX_2 > SiX_2$

Solubility of Sulphates
- $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

Stability of Sulphate
- $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4$

Anomalous Behaviour of First Element of Group

Due to:
- Small size
- High electronegativity
- High ionization enthalpy
- Absence of *d*-orbitals in valence shell

Anomalous Behaviour of Lithium
- Melting and boiling points are comparatively high.
- Lithium forms nitride while other alkali metals do not.
  $6Li + N_2 \rightarrow 2Li_3N$
- Lithium hydroxide and carbonate decompose on heating, while other alkali metal hydroxides and carbonates do not.
  $2LiOH \xrightarrow{\Delta} Li_2O + H_2O$ $Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$

Anomalous Behaviour of Beryllium
- Beryllium is harder than other group members.
- Beryllium does not react with water even at high temperature.
- Beryllium forms covalent compounds. Because of covalent character salts of beryllium are easily hydrolysed.
  $BeCO_3 + 4H_2O \rightarrow [Be(H_2O)_4]^{2+} + CO_3^{2-}$

Anomalous Behaviour of Boron
- Boron is hard and has high melting and boiling points.
- Boron forms only covalent compounds while others form both ionic and covalent compounds.
- The oxide and hydroxide of boron are weakly acidic.
  $B_2O_3 + 2NaOH \rightarrow 2NaBO_2 + H_2O$
  $B(OH)_3 + NaOH \rightarrow NaBO_2 + 2H_2O$

Anomalous Behaviour of Carbon
- Due to small size and high electronegativity, carbon has a strong tendency to form $p\pi$-$p\pi$ multiple bonds.
- Carbon has high tendency of catenation. Tendency for catenation: $C > Si > Ge \approx Sn > Pb$

Stability of Hydrides
- $LiH > NaH > KH > RbH > CsH$
- $CH_4 > SiH_4 > GeH_4 > SnH_4 > PbH_4$

Lewis Acid Character
- $BI_3 > BBr_3 > BCl_3 > BF_3$

Stability of Nitrates
- $Be(NO_3)_2 < Mg(NO_3)_2 < Ca(NO_3)_2 < Sr(NO_3)_2 < Ba(NO_3)_2$

CONCEPT MAP
Class XI

SOME IMPORTANT COMPOUNDS OF GROUP 13 & GROUP 14

Boron and silicon compounds find applications in industry and technology. Agriculture, fire retardants, soaps and detergents rely on boron compounds. Silicon compounds are useful in glass making and electronic devices. Carbon dioxide being heavy and non-supporter of combustion, is used as fire-extinguisher.

Group 13

Borax ($Na_2B_4O_7.10H_2O$)

Preparation

$Ca_2B_6O_{11} + 2Na_2CO_3 \xrightarrow{\Delta} Na_2B_4O_7 + 2NaBO_2 + 2CaCO_3$ (Colemanite)

$4NaBO_2 + CO_2 \rightarrow Na_2B_4O_7 + Na_2CO_3$

Properties

$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$ (Transparent glassy bead)

$Na_2B_4O_7 + 2NaOH \rightarrow 4NaBO_2 + H_2O$

$Na_2B_4O_7 + H_2SO_4 \rightarrow Na_2SO_4 + H_2B_4O_7$

Uses
- As water softener and cleansing agent.
- In the laboratory for borax bead test.

Diborane (B_2H_6)

Preparation

$2NaBH_4 + I_2 \xrightarrow{\text{Diglyme}} B_2H_6 + 2NaI + H_2$

$2BF_3 + 6NaH \xrightarrow{450\ K} B_2H_6 + 6NaF$

Properties

$B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$; $\Delta_cH^\circ = -1976\ kJ\ mol^{-1}$

$3B_2H_6 + 6NH_3 \rightarrow 3[BH_2(NH_3)_2]^+[BH_4]^- \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$ (Borazine)

Uses
- For preparing a number of borohydrides such as $LiBH_4$, $NaBH_4$, etc.
- As a reducing agent in organic reactions.

Borazine or Borazole ($B_3N_3H_6$)

Preparation

$3B_2H_6 + 6NH_3 \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$

Properties

The π bond in borazine is formed by back bonding involving filled *p*-orbital of N and vacant *p*-orbital of B. However, borazine is more reactive than benzene.

$B_3N_3H_6 + 3HCl \rightarrow B_3N_3H_9Cl_3$

$B_3N_3H_6 + 9H_2O \rightarrow 3NH_3 + 3H_3BO_3 + 3H_2$

Orthoboric acid (H_3BO_3)

Preparation

$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 4H_3BO_3 + 2NaCl$

$Ca_2B_6O_{11} + 4SO_2 + 11H_2O \rightarrow 2Ca(HSO_3)_2 + 6H_3BO_3$

Properties

$H_3BO_3 \xrightarrow{370\ K} HBO_2 + H_2O$; $4HBO_2 \xrightarrow[-H_2O]{410\ K} H_2B_4O_7 \xrightarrow{\text{red hot}} 2B_2O_3 + H_2O$

Uses
- It is used in the manufacture of heat resistant borosilicate glass.
- The aqueous solution of boric acid is used as eye wash under the name *boric lotion*.

Group 14

Carbon dioxide (CO_2)

Preparation

$C_{(s)} + O_{2(g)} \xrightarrow{\Delta} CO_{2(g)}$

$CH_{4(g)} + 2O_{2(g)} \xrightarrow{\Delta} CO_{2(g)} + 2H_2O_{(g)}$

Properties

$CO_2 + 4Na \rightarrow 2Na_2O + C$

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$ (Insoluble)

$CO_2 + Zn \rightarrow ZnO + CO$

$CO_2 + C \rightarrow 2CO$

Uses
- In the manufacture of soda.
- As carbogen [mixture of O_2 + CO_2 (5-10%)] in artificial respiration especially for pneumonia patients and victims of CO poisoning.

Silicates

Types of silicates
- Orthosilicates contain discrete SiO_4^{4-} tetrahedra.
- Pyrosilicates contain $Si_2O_7^{6-}$ anions.
- Cyclic or ring silicates contain $(SiO_3)_n^{2n-}$ anions.
- Chain silicates contain $(SiO_3^{2-})_n$ anions.
- Sheet silicates contain $(Si_2O_5)_n^{2n-}$ anions.
- Three dimensional silicates contain three dimensional network structure.

Silicon dioxide (SiO_2)

Properties

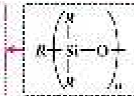
Almost non-reactive due to high Si—O bond enthalpy. However, it is attacked by HF and NaOH.

$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$

$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O$

Uses
- Quartz is extensively used as a piezoelectric material.
- Silica gel is used as a drying agent and as a support for chromatographic materials and catalysts.

Silicones



where R = alkyl or phenyl group

Preparation

$2CH_3Cl + Si \xrightarrow[570\ K]{\text{Cu powder}} (CH_3)_2SiCl_2 \xrightarrow[-2HCl]{+2H_2O} (CH_3)_2Si(OH)_2$

$n(CH_3)_2Si(OH)_2 \xrightarrow[\text{Polymerisation}]{-nH_2O}$ Silicones

Uses
- They are used as sealant, greases, electrical insulators and for water proofing of fabrics.