The p Block Elements

DESIGNED

By

Edustudy point

P block elements: P block is present at extreme right of periodic table.

- It has general electronic configuration ns^2np^{1-6}.
- It includes solids, liquids and gases.
- The elements of this group are metal, non- metal and metalloids.

Group-13 Elements: the BORON family

- This group includes following elements:Boron(B), Aluminum(Al), Gallium(Ga), Indium(In), Thallium(Tl).

  General electronic configuration of this group: ns^2np^1

Physical properties:

1. **Atomic size and Ionic radii**: Down the group, size increases because nuclear charge decreases (due to addition of new shell).
   - Expected order: B < Al < Ga < In < Tl
   - But actual the order is: B < Ga < Al < In < Tl
   - Gallium is smaller than Aluminum because Gallium has d-electrons and Aluminum doesn't have.
2. **Ionization enthalpy**: Down the group ionization energy decreases, as the size increase and nuclear charge decrease. So, the expected order is : B > Al > Ga > In > Tl
   - But actually it is: B > Al > In > Tl due to poor shielding effect by d electrons in gallium.
3. **Electronegativity**: first it decreases from B to Al, then it increases slightly from Al to Tl.
4. **Oxidation state**: It depends on electronic configuration. As their electronic configuration is ns^2 np. So, oxidation states shown by them are +3, +1.

Chemical properties:

- Out of all elements of this group, Boron is non-reactive. This is because of its small size as it has high ionization energy. So reactivity increases down the group.

  B < Al < Ga < In < Tl

1. **Reactivity towards oxygen:**
   - Boron does not react with oxygen at ordinary temperature due to small size and high ionization energy.
   - If we react Al with oxygen, it reacts at normal temperature. With time it forms a protective layer of oxide on its surface. This layer makes it non reactive.

     $Al + 3O_2 \rightarrow 2Al_2O_3$
   - They react with nitrogen gas also, to form compound with formula EN.

     $6Al + 3N_2 \rightarrow 6\ AlN$

2. Reaction with water:

- Boron does not react with water.
- Aluminum reacts with cold water that is: $Al + H_2O \rightarrow Al(OH)_3 + H_2$
- Gallium and indium neither react with cold water nor with hot water.
- Thallium reacts with water but form protective layer which make it passive.

3. Reactivity towards acids and bases:

- Boron doesn't react with acids and bases at normal temperature, but reacts with strong acids.
- Aluminum reacts with acid and base because it is amphoteric in nature.

$$Al + HCl \rightarrow AlCl_3 + H_2$$

$$Al + NaOH \rightarrow Na[Al(OH)_4]$$

4. Reaction with Halogens:

$$B + F_2 \rightarrow BF_3$$

$$Al + Cl_2 \rightarrow AlCl_3$$

Some important compounds of Boron

1. **Borax**: $Na_2B_4O_7.10H_2O$

Preparation : It is prepared from Colemanite ore (calcium ore).

$$Ca_2B_6O_{11} + Na_2CO_3 \rightarrow CaCO_3 + Na_2B_4O_7 + NaBO_2$$

properties of borax:

- It is white crystalline solid.
- On heating, it loses water of crystallization and form Na_2B_4O
- On further heating, it gives white transparent liquid which further on cooling gives white transparent bead.

Uses of Borax: It is used in candle making.

- It is used in optical glass.

2. **Ortho boric acid:** H_3BO_3 or $B(OH)_3$

Preparation: It is prepared from Borax.

$$Na_2B_4O_7.10H_2O + HCl + H_2O \rightarrow H_3BO_3 + NaCl$$

Properties: It is white crystalline solid with soapy touch.

- It is sparingly soluble in cold water but soluble in hot water.

Uses: It is used as food preservative.

- It is used in medicines for eye wash.

3. **Diborane**:(B_2H_6)

Preparation: It is prepared by reacting Sodium boron hydride with Iodine:

$$NaBH_4 + I_2 \rightarrow B_2H_6 + NaI + H_2$$

Properties: It is colorless and toxic gas.

- It catches fire spontaneously.

Uses of Boron: Boron is used as semi-conductor for making electrical appliances.

- It is used in steel industry for hardening.
- Its compounds like borax and boric acid are used in glass industry.

Uses of Aluminum: It is soft and light metal, non toxic and is used for wrapping food items.

- It is used in making electric power cables.
- It is used as packaging of food items.

Group-14 Elements: the CARBON family

- This group includes the following elements: Carbon(C), Silicon(Si), Germanium(Ge), Tin(Sn), Lead(Sb)
- General electronic configuration of this group: ns^2np^2

Physical properties:

1. **Atomic size**: Along group, As we move down size increases, as each time a new shell is being added.
2. **Ionization energy**: It is amount of energy required to remove electron from last shell of an atom.

   Along group: Ionization energy decreases because size increases. If we look at the trend of ionization energy we see certain abnormality:

   C > Si > Ge > Sn > Pb

3. **Melting point and Boiling point**: As we move down the group melting and boiling point decreases due to increase in size, bonds formed are not so strong.

   C > Si > Ge > Sn > Pb

4. **Metallic character**: less is the ionization energy, more is the metallic character.

- Down the group metallic character increases as size increase and ionization energy decreases. Therefore, the order is :

  C < Si < Ge < Sn < Pb

5. **Oxidation states**: This group can show +4 and +2 oxidation states.

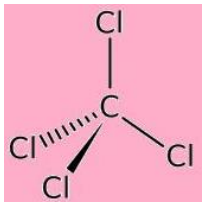
Chemical properties:

1. **Reactivity towards oxygen** : They form two types of oxides
   a. Monoxides : CO,SiO,GeO,SnO,PbO
   b. Dioxides: CO_2,SiO_2,GeO_2,SnO_2,PbO

   Out of them Co is Neutral, SiO is not so stable, GeO is Weakly acidic, SnO and PbO are Amphoteric, CO2 and SiO2 are Acidic, GeO_2 is Amphoteric, SnO_2 and PbO_2 are weakly basic

2. **Reaction with water**: They form hydroxides.
   - In this group, Carbon does not react with water.
   - Tin reacts with steam forming SnO_2 + H
   - Ge,Sn Pb –do not react with water due to formation of protective layer of oxide on it .

3. **Reaction with halogens**: Halides are formed (EX_4).
   - The halides formed are: CCl_4, $SiCl_4$, $GeCl_4$, $SnCl_4$, $PbCl_4$
   - All are tetrahedral in nature.
   - Out of all, $SnCl_2$ and $PbCl_2$ both are stable.
   - CCl_4 can't be hydrolyzed easily whereas $SiCl_4$ can be easily hydrolyzed: The reason being, that carbon has no d orbital.

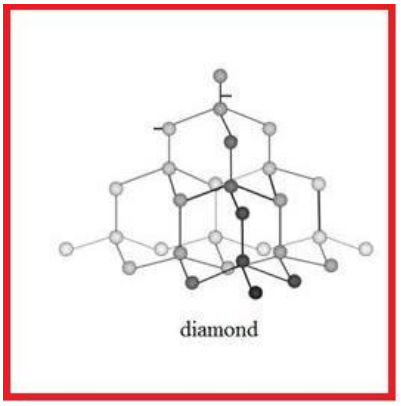


4. **Reaction with hydrogen**: hydrides are formed (EH_4)
   - They form respective hydrides:CH_4, SiH_4, GeH_4
   - Sn and Pb do not form as they are less reactive towards hydrogen.
   - Carbon has maximum tendency to form hydrides in its own family. these hydrides have covalent bonding in them and a tetrahedral geometry.

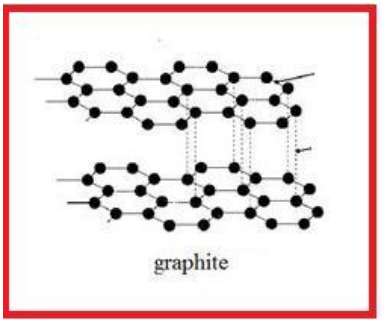
Allotropes of carbon: Allotropes Are the different forms of elements having same physical properties but different chemical properties.

- Crystalline form: Diamond, Graphite and Fullerene
- Amorphous forms: Coke, Charcoal, lamp black

1) **Diamond**: In this carbon is sp^3 hybridized. Each carbon attached to four carbon atom giving rise to compact three-dimensional structures.
   - It is hardest substance.
   - It is bad conductor of electricity because it has no free electrons.
   - It is used as cutting tool.
   - It is used in making jewellery.

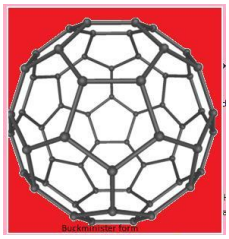

diamond

2) **Graphite**: in this carbon is sp^2 hybridized and each carbon is covalently attached to two other carbon ,such that it gives hexagonal rings (sheet like structure).



- It has soft structure because of Vander wall forces in it. Therefore, used as Lubricant.
- It is used to make pencil leads, as it marks the paper black.
- It is good conductor of electricity as it has free electrons.

3) **Fullerenes**: It is having many Carbon atoms. The carbon atoms are in a shape of football.



Uses of Carbon: It is used in the form of fuel.

- It is used in manufacturing of coal gas, water gas etc.

Uses of Silicon: It is used to form n-type or p-type semiconductor.

- Pure Si is used to make computer chips.

Uses of germanium: It is used in transistors.

- It is making for lenses and prism.

Uses of lead: It is used for making lead sheets and pipes.

- It is used for telephone wires.

Uses of Tin: It is used for electroplating.

- It is used in making alloys: Pb, Cu and Sn.

Some important compounds of carbon and silicon

1. Carbon monoxide (CO)

Preparation: It is prepared from incomplete combustion of carbon.

$$C + \tfrac{1}{2} O_2 \rightarrow CO$$

- Commercial preparation: Heating Coke with water at high temperature.

$$C + H_2O \rightarrow CO + H_2$$

Properties: It is colourless and odourless.

- It is insoluble in water.
- It burns in air to form carbon dioxide.

Uses: It acts as reducing agent in extraction of metals.

- It reacts with certain metals to form Metal carbonyls.

2. Carbon dioxide (CO_2)

Preparation: From complete combustion of Carbon and Carbon containing fuels in excess of air:

$$C + O_2 \rightarrow CO_2$$

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

Properties: It is colourless and odourless.

- It is soluble in water.

Uses: Gaseous carbon dioxide is used in carbonated soft drinks.

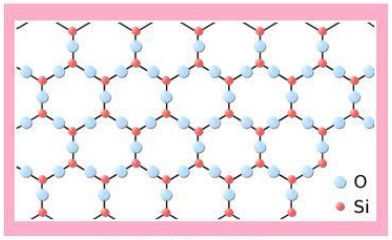
- Carbon dioxide is used in fire extinguisher as it is non supporter of combustion.

3. **Silicon dioxide (SiO_2):** About 95% of earth crust is made up of silica and silicates .Silicon dioxide is commonly called as silica and it occurs in different forms :

Crystalline form of silica

- Quartz
- Cristobalite
- Tridymite

These forms are inter-convertible at suitable temperature.



Structure of Silicon dioxide

Structure of Silicon dioxide: Silicon dioxide is covalent in nature with three dimensional network of solid.

Properties: Silica in normal form is almost non reactive because of high bond enthalpy of Si-O bond.

- Silica is inert.
- Silica has high melting point.

Uses: Silicon dioxide is used as catalyst in petroleum industry.

4. **Silicones:** They are synthetic organo-silicon compounds containing repeated R_2SiO units held by Si-O-Si linkages.

Preparation: The methyl chloride reacts with Silicon in presence of Copper at temperature 573k.

$$CH_3Cl + Si \rightarrow (CH_3)_2SiCl_2$$

Properties: They are chemically inert, resistant to oxidation and thermal decomposition.

- They are heat resistant and possess high dielectric constant.

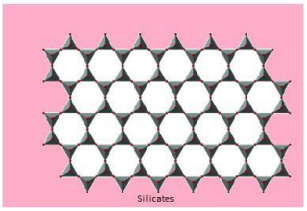
Uses: They are used in making water proof papers, wool ,textile, wood etc by coating them with thin film of silicones.

- They are used as electric insulators.
- They are used in surgical implants.

5. **Silicates**: Their basic structural units are SiO_4^{4-}.The important man made silicates are :

- Glass
- Cement

If we look at its structure



6. **Zeolites**: They are widely used as catalyst in petrochemical industries for cracking of hydrocarbons.

- In them basically the Silicon atoms in three dimensional structures is replaced by Aluminum ions.
- As a result, the overall structure carries the negative charge.
- To balance this negative charge some cations like sodium ion etc are added in the structure.

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