

QUICK LOOK

The elements in the long form of the periodic table has been divided into four blocks, namely s, p, d & f blocks. The elements of group I & II receive their last electron in s-orbital. So they are called as s – block elements. The first element of a group differs considerably from the rest of the elements of the same group. This anomalous behaviour is due to

- Smaller size of their atoms
- Their higher ionization energies
- Their higher electronegativities
- Absence of vacant d-orbitals in their valence shell
- High polarizing power of its cation.

Thus Li differs from the rest of alkali metals (Na, K, Rb & Cs) and Be differs from rest of the alkaline earth metals (Mg, Ca, Sr & Ba)

Diagonal Relationships: On moving diagonally some members show similar properties with the members of next higher group which is particularly seen in the elements of second and third periods of the periodic table. However the similarities shown are far less pronounced than the similarities within a group.

Table 26.1: Diagonal Relationships

| | Group 1 | Group 2 | Group 13 | Group 14 |
|----------|---------|---------|----------|----------|
| Period-2 | Li | Be | B | |
| Period-3 | | Mg | Al | Si |

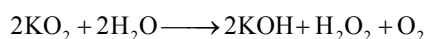
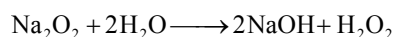
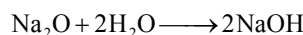
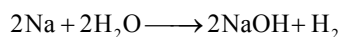
The main reasons for the diagonal relationship are

- Similarity in electropositive character:
- Similarity in polarizing power
- Similarity in atomic or ionic radii

Alkali Metals: The group I comprising Li, Na, K, Rb, Cs & Fr are commonly called alkali metals. Francium is radioactive and has a very short life (half life of 21 minutes), therefore very little is known about it.

General Characteristic of the Compounds of the Alkali Metals

- **Oxides and Hydroxides:** All the alkali metals, their oxides, peroxides and superoxides readily dissolve in water to produce corresponding hydroxides which are strong alkalies eg



Thus peroxides and superoxides also act as oxidizing agents since they react with H_2O forming H_2O_2 and O_2 respectively. The hydroxides of all the alkali metals are white crystalline solids. They are strongest of all base and readily dissolve in water with the evolution of much heat.

- **Basic strength:** The basic strength of these hydroxides increases as we move down the group Li to Cs. The hydroxides of alkali metals behave as strong bases due to their low ionization energies which decrease down the group. The decrease in ionization energies leads to weakening of the bond between metal and hydroxide ion and $\text{M}-\text{O}$ bond in $\text{M}-\text{O}-\text{H}$ can easily break giving M^+ and OH^- . This results in the increased concentration of hydroxyl ions in the solution i.e increased basic characters.
- **Solubility and stability:** All these hydroxides are highly soluble in water and thermally stable except lithium hydroxide. $2\text{LiOH} \xrightarrow{\Delta} \text{Li}_2\text{O} + \text{H}_2\text{O}$
- **Formation of salts with acids:** Alkali metals hydroxides being strongly basic react with all acids forming salts.

$$\text{NaOH} + \text{HCl} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$$

$$2\text{NaOH} + \text{H}_2\text{SO}_4 \longrightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$$
- **Halides:** The alkali metals combine directly with halogens under appropriate conditions forming halides of general formula MX . These halides can also be prepared by the action of aqueous halogen acids (HX) on metals oxides, hydroxides or carbonate.

$$\text{M}_2\text{O} + 2\text{HX} \longrightarrow 2\text{MX} + \text{H}_2\text{O}$$

$$\text{MOH} + \text{HX} \longrightarrow \text{MX} + \text{H}_2\text{O}$$

$$\text{M}_2\text{CO}_3 + 2\text{HX} \longrightarrow 2\text{MX} + \text{CO}_2 + \text{H}_2\text{O} \quad (\text{M} = \text{Li, Na, K, Rb or Cs})$$

$$(\text{X} = \text{F, Cl, Br or I})$$

Polarization Effects: Comparison of ionic and covalent character of alkali metal halides.

When a cation approaches an anion, the electron cloud of the anion is attracted towards the cation and hence gets distorted. This effect is called polarization. The power of the cation to polarize the anion is called its polarizing power and the tendency of the anion to get polarized is called its polarizability. The greater the polarization produced more is the concentration of the electrons between the two atoms thereby decreasing the ionic character or increasing the covalent character.

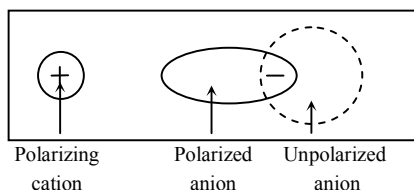


Figure: 26.1

Anomalous Behaviour of Lithium and its Diagonal Relationship with Magnesium

The properties of lithium are quite different from the properties of other alkali metals. On the other hand, it shows greater resemblance with magnesium, which is diagonally opposite element of it. The main reasons for the anomalous behaviour of lithium as compared to other alkali metals are

- The extremely small size of lithium atom and its ion.
- Greater polarizing power of lithium ion (Li^+), due to its small size which result in the covalent character in its compounds.
- Least electropositive character and highest ionization energy as compared to other alkali metals.
- Non availability of vacant d-orbitals in the valence shell.

Alkaline Earth Metals

The group 2 of the periodic table consists of six metallic elements. They are Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). The name alkaline earth metals was given to magnesium, calcium, barium & strontium since their oxides were alkaline in nature and these oxide remained unaffected by heat or fire and existed in earth.

Occurrence: Like alkali metals, alkaline earth metals are also highly reactive and hence do not occur in the free state but are likely distributed in nature in the combined state as silicates, carbonates, sulphates and phosphates.

Minerals

Be – Beryl ($\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$) & Phenacite (Be_2SiO_4)

Mg – Magnesite MgCO_3 , Dolomite $\text{CaMg}(\text{CO}_3)_2$, Epsomite MgSO_4 & H_2O

Ca–Limestone (CaCO_3), fluorapatite [$3(\text{Ca}_3(\text{PO}_4)_3 \cdot \text{CaF}_2)$]

Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), Anhydrite (CaSO_4)

Sr – Celestite (SrSO_4), Strontianite (SrCO_3)

Br – Barytes (BaSO_4)

Electronic Configuration: The general electronic onfiguration of alkaline earth metals is ns^2 .

Be – $1s^2 2s^2$

Mg – $1s^2 2s^2 2p^6 3s^2$

Ca – $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Sr – $[\text{Kr}]5s^2$

Ba – $[\text{Xe}]6s^2$

Ra – $[\text{Rn}]7s^2$

- **Nature of metallic bonding in alkaline earth metals:** The alkali metal two electrons are involved in the metallic bonding. Moreover, sizes of alkaline earth metal ions are smaller than those of alkali metal ions. Consequently, stronger metallic bonds are formed which result in the close packing of the atoms. Due to the presence of stronger metallic bonds, alkaline earth metals have

- (1) Higher melting points
- (2) Higher boiling points
- (3) higher densities
- (4) Harder than the corresponding alkali metals.

- **Density:** The alkaline earth metals are denser and harder than the corresponding alkali metals. The atoms of alkaline earth metals have smaller size and are hence held by stronger metallic bonds, as compared to alkali metals. Therefore, they are more closely packed in their crystal lattice which accounts for high density and increased hardness of these elements.

- **Characteristic flame colouration:** Expect Be & Mg (due to high ionization energy), the alkaline earth metals impart characteristic colour when introduced into flame of a burner. This property is due to the ease of excitation of their valence electrons. When elements or their compounds are introduced to flame, the electron absorbs energy from the flame and gets excited to higher energy levels. When these electrons return to their ground state, they emit absorbed energy in form of visible light having characteristic wavelengths. Depending upon the wavelength of light emitted, different colours are impart to the flame. Salts (generally chlorides) impart characteristic colours to the Bunsen flame.

Table 26.2: Ion and Colour

| Ion | Colour |
|------------------|----------------|
| Ca^{2+} | Brick-red |
| Sr^{2+} | Crimson |
| Ba^{2+} | Apple green |
| Ra^{2+} | Carmines – red |

Electropositive or Metallic Character: The alkaline earth metals are highly electropositive and hence metallic and their electropositive or metallic character increases down the group. However they are less electropositive or metallic than the alkali metals. It is due to smaller size and higher ionization energies as compared to alkali metals, hence have less tendency to lose electron than those of alkali metals (group I)

Like the alkali metals they also form predominantly ionic compounds but tendency of covalency is greater, particularly with Be and Mg because of their smaller atomic and ionic radii. Be forms compounds which are essentially covalent.

Melting and Boiling Points: The alkaline earth metals have higher melting and boiling points as compared to those of alkali metals which is attributed to their small size and more closely packed crystal lattice as compared to alkali metals and presence of two valence electrons.

Heat of Hydration

- The heats of hydration of M^{2+} decrease with an increase in their ionic size and their values are greater than that of alkali metal ions.
- Alkaline earth metal ions, because of their larger charge to size ratio, exert a much stronger electrostatic attraction on the oxygen of water molecule surrounding them.
- Since the alkaline earth metals (except Be) tend to lose their valence electrons readily, they act as strong reducing agents as indicated by E^0 red values. The particularly less negative value for Be arises from the large hydration energy associated with the small size of Be^{2+} and the relatively large value of heat of sublimation.

Table 26.3: Occurrence and Uses of Alkaline Earth Metals

| Elements | Abundance | Main Minerals | Uses |
|-----------|--|--|--|
| Beryllium | $2.8 \times 10^{-3}\%$ | First detected in 1798 in the gemstone beryl and emerald ($Be_2Al_2Si_6O_{18}$) | Used in corrosion resistant alloys. |
| Magnesium | 2.33%, 7 th most abundant element in earth's crust | Pure Mg first prepared in 1800, named after the magnesia district in Thessaly Greece where large deposits of the mineral are found | When alloyed with Al, Mg is widely used as structural materials because of its high strength, low density and ease in machining. |
| Calcium | 4.15%, 5 th most abundant element in earth's crust. | $CaCO_3 \cdot 2H_2O$ obtained in pure form in 1808, calcium is derived from latin word calx, meaning "lime" | As an alloying agent for hardness in aluminium compounds. Calcium is the primary constituent of teeth and bones. |

| | | | |
|-----------|--------|---|--|
| Strontium | 0.038% | Discovered in 1787 and named after the small town of strontion (Scotland) | $SrCO_3$ is used for the manufacture of glass for colour TV picture tubes. |
| Barium | 0.042% | Found in minerals witherite ($BaCO_3$) and barite ($BaSO_4$) after which it is named. | $BaSO_4$ is used in medicine as a contrast medium for stomach and intestine X-rays |
| Radium | Traces | Isolated as chloride in 1898 from the mineral pitchblende | Used in cancer radiotherapy |

Group IIA (Alkaline earth metals) and groups IIB (Zn, Cd, Hg) Mg acts as a bridge element between IIA and IIB.

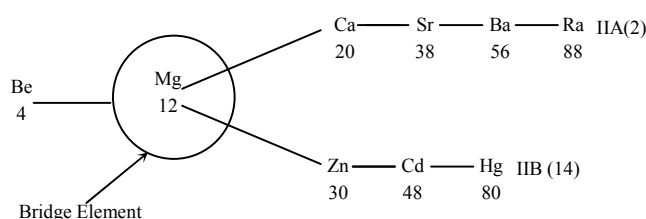


Figure: 26.2

Table 26.4: Properties of IIA and IIB Groups

| S. No. | Properties | IIA (Be, Mg, Ca, Sr, Ba, Ra) | IIB (Zn, Cd, Hg) |
|--------|--------------------------|--|--|
| 1 | Electronic configuration | [Inert gas] ns^2 | [Inert gas] $(n-1)d^{10}ns^2$ |
| 2. | Block | S-block | d-block |
| 3. | Oxidation state | +2 | +2, mercury also forms dimeric Hg_2^{2+} |
| 4. | Nature of oxide | BeO is amphoteric, other oxides are basic. | ZnO is amphoteric, CdO and MgO are basic |
| 5. | Nature of Halides | Electron-deficient BeX_2 , others (MX_2) are ionic: $MgCl_2 < CaCl_2 < SrCl_2 < BaCl_2$ | $ZnCl_2$, $CdCl_2$ are ionic but less than IIA, $HgCl_2$ is covalent. |
| 6. | Nature of sulphates | Less soluble in water and solubility decreases down the group $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$ | More soluble than IIA |
| 7. | Nature of hydroxides | Solubility of hydroxides increases as we move down the group. | Solubility of hydroxides decreases as we move down the group. |
| 8. | Nature of sulphides | Soluble | ZnS , CdS , HgS insoluble and precipitate in salt analysis. |
| 9. | Reactivity | Increases as we move down the group $Be < Mg < Ca < Sr < Ba$ | Decreases as we move down the group $Zn > Cd > Hg$ |

Difference between Alkaline Earth Metals and Alkali Metals: Both alkaline earth metals and alkali metals are s-block elements as the last electron enters the ns – orbital. They resemble with each other in some respects but still there are certain dissimilarities in their properties on account of different number of electrons in the valency shell, smaller atomic radii, high ionization potential, higher electro negativity etc.

Table 26.5: Properties of Alkaline Earth Metals and Alkali Metals

| | Properties | Alkaline earth metals | Alkali metals |
|-----|--------------------------|--|---|
| 1. | Electronic configuration | Two electrons are present in the valency shell. The configuration is ns^2 (bivalent) | One electron is present in the valency shell. The configuration is ns^1 (monovalent) more electropositive |
| 2. | Valency | Bivalent | Monovalent |
| 3. | Electropositive nature | Less electropositive | More electropositive |
| 4. | Hydroxides | Weak bases, less soluble and decompose on heating. | Strong bases, highly soluble and stable towards heat. |
| 5. | Bicarbonates | These are not known in free state. Exist only in solution. | These are known in solid state. |
| 6. | Carbonates | Insoluble in water. Decompose on heating. | Soluble in water. Do not decompose on heating ($LiCO_3$ is an exception) |
| 7. | Action of nitrogen | Directly combine with nitrogen and form nitrides | Do not directly combine with nitrogen except lithium |
| 8. | Action of carbon | Directly combine with carbon and form carbides | Do not directly combine with carbon |
| 9. | Nitrates | Decompose on heating evolving a mixture of NO_2 and oxygen | Decompose on heating evolving only oxygen |
| 10. | Solubility of salts | Sulphates, phosphates, fluorides, chromates, oxalates etc are insoluble in water | Sulphates, phosphates, fluorides, chromates, oxides etc are soluble in water. |
| 11. | Physical properties | Comparatively harder. High melting points. Diamagnetic. | Soft, low melting points paramagnetic. |
| 12. | Hydration of compounds | The compounds are extensively hydrated. $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$ are hydrated chlorides. | The compounds are less hydrated. $NaCl$, KCl , $RbCl$ form non – hydrated chlorides |
| 13. | Reducing power | Weaker as ionization potential values are high and oxidation potential values are low. | Stronger as ionization potential values are low and oxidation potential values are high. |

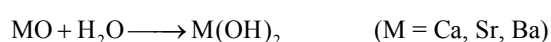
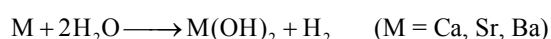
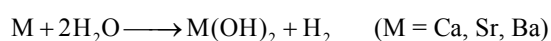
General Characteristics of Compounds of the Alkaline Earth Metals

- **Oxides:** The oxides MO are obtained either by heating the metals in oxygen or by thermal decomposition of their carbonates.

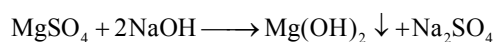
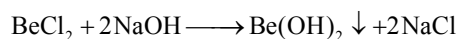


Expect BeO all other oxides are extremely stable ionic solids due to their high lattice energies. These have high melting point, have very low vapour pressure, are very good conductors of heat, are chemically inert and act as electrical insulators. Therefore, these oxides are used for lining furnaces and hence used as refractory materials. Due to small size of beryllium ion, BeO is covalent but still has high melting point because of its polymeric nature.

- **Hydroxides:** The hydroxides of Ca , Sr & Ba are obtained either by treating the metal with cold water or by reacting the corresponding oxides with water. The reaction of these oxides with H_2O is also sometimes called as slaking.



$Ba(OH)_2$ and $Mg(OH)_2$ being insoluble are obtained from suitable metal ion solutions by precipitation with OH^- ions.



Uses

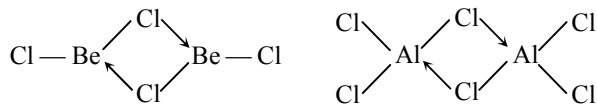
- Calcium fluoride or fluorospar (CaF_2) is by far the most important of all the fluorides of the alkaline earth metals since it is the only large scale source of fluorine.
- $CaCl_2$ is widely used for melting ice on roads, particularly in very cold countries because 30% eutectic mixture of $CaCl_2$ / ice freezes at 218 K as compared to $NaCl$ / ice at 255K.
- $CaCl_2$ is also used as a desiccant (drying agent) in the laboratory.
- Anhydrous $MgCl_2$ is used in the electrolytic extraction of magnesium.

Resemblance of Beryllium with Aluminium (Diagonal relationship)

The following points illustrate the anomalous behaviour of Be and its resemblance with Al .

- Unlike groups 2 elements but like aluminium, beryllium forms covalent compounds.
- the hydroxides of Be , $[Be(OH)_2]$ and aluminium $[Al(OH)_3]$ are amphoteric in nature, whereas those of other elements of group – 2 are basic in nature.

- The oxides of both Be and Al i.e. BeO and Al₂O₃ are high melting insoluble solids.
- BeCl₂ and AlCl₃ have bridged chloride polymeric structure.



- The salts of beryllium as well as aluminium are extensively hydrolysed.

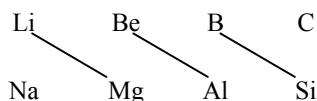
p-block Elements

The right side of the periodic table having group number 13, 14, 15, 16, 17 and 18 are known as p-block elements. These elements have 3, 4, 5, 6, 7 and 8 electrons in their outer most shell, respectively. The last electron of these groups' elements occupies the position in p-sub shell that is why these elements are called as p – block elements. Their general electronic configuration is ns^2np^{1-6} .

Some Important Properties of p-block

- **Electron affinity:** Electron affinity increases from left to right along the period amongst the p – block elements and it decreases from top to bottom. But group 15 is having exceptionally low values of electron affinity and is due to extra stability of exactly half filled orbitals in their valence shell. Similarly, elements of group 18 (noble gases) have zero affinities due to presence of complete octet which provides them stability.
- **Metallic Character:** The metallic character is governed by
 - Size of atoms and
 - Ionization energy

The elements having bigger size and low ionization energy has a greater metallic character. After combining both the above mentioned factors we observe that the elements with above two properties are located in left corner of p – block and strong non – metallic elements are located at right corner and a diagonal strip of elements separates thus two, having in between properties are called as metalloids.
- **Oxidation state:** The p-block elements show variety of oxidation states both positive and negative. Some of the p-block elements show different oxidation state due to inert – pair effect, where their lower oxidation state is more predominant.
- **Diagonal relationship:** On moving diagonally across the periodic table the element shows certain similarities



Note

Elements of 2nd period differ from their own group elements in some of the is due to the following reason:

Properties

- Small size
- Absence of vacant d-orbital
- High IP

Table 26.6: Some Important Characteristics of p – block in Tabular form

| S. No. | Property | Along period (left to right) | Along group (top to bottom) |
|--------|----------------------|------------------------------|-----------------------------|
| 1. | Atomic radii | Decreases | Increases |
| 2. | Ionization potential | Increases | Decreases |
| 3. | Electron affinity | Increases | Decreases |
| 4. | Electro negativity | Increases | Decreases |
| 5. | Metallic character | Decreases | Increases |
| 6. | Oxidizing property | Increases | Decreases |
| 7. | Reducing property | Decreases | Increases |

Boron Family: Group 13 elements are boron (B), aluminium (Al), Gallium (Ga), Indium (In) and thallium (Tl).

Boron is the only non-metal in this group others are metal. Non-metallic character of boron is due to its small size and high ionization energy.

The general valence shell electronic configuration of these elements is ns^2np^1 .

Boron: The name boron comes from the Arabic and Persian words for borax, its principal ore. It was first isolated in 1808 by Gay-Lussac and Thenard and independently by Sir Hymphry Davy. The pure element is shiny and black. It is very hard and in extremely pure form is nearly as hard as diamond, but too much brittle for practical use. At high temperatures it is a good conductor but at room temperature and below is an insulator.

Aluminium: Aluminium ranks third on the list of the ten most abundant elements in the earth's crust, while its oxide is fourth among the ten most common compounds in the crust. It is the most abundant metal on the planet. Its name is taken from the Latin *alumen* for alum. It is soft, light weight and silvery, its existence was proposed by Lavoisier in 1787, it was named by Davy in 1807 and finally isolated by Orsted in 1825. In its purest form the metal is bluish – white and very ductile. It is an excellent conductor of heat and electricity and finds use in some wiring. When pure it is too soft for construction purposes but addition of small amounts of silicon and iron hardened it significantly. Aluminium is the most abundant element in earth crust among this family

Gallium: Gallium is one of the elements originally predicted by Mendeleev in 1871 as aluminium, indicating that it should have the properties similar to aluminium. The actual metal was isolated and named by Paul-Emile Lecog de Boisbaudran in 1875.

At room temperature gallium is soft as lead and can be cut with a knife. Its melting point is abnormally low and it will begin to melt in the palm of a warm hand. Gallium is from one of the small numbers of metals that expands on freezing.

Indium: The element indium (Latin indicum, for the colour indigo) was discovered in 1863 by Reich and Ritcher. It is a rare metal, with an abundance similar to that of silver. It is generally found in deposits with zinc and refineries which produce this more common metal often sell indium as well. The pure metal is so soft that you can “wipe” it onto other material in much the same way as lead. It is corrosion resistant.

Thallium: Sir William Crookes discovered thallium in 1861, positively identifying it by a green line in its spectrum (hence the name, which is from the Greek, *thallos* for “green twig”) Thallium compounds are quite toxic and some have been used as rat poisons. A few compounds are used in glasses for special infra – red lenses.

Table 26.7: General Trends in Physical Properties

| S. No. | Property | Boron | Aluminium | Gallium | Indium | Thallium |
|--------|--|---|---|---|---|---|
| 1. | Configur- ation | [He] 2s ² 2p ² | [Ne] 3s ² 3p ² | [Ar] 4s ² 4p ² | [Kr] 5s ² 5p ² | [Xe] 6s ² 6p ² |
| 2. | Common oxidatio n state | +3 | +3 | +3 | +3 | +3, +1 |
| 3. | Atomic radius (pm) | 83 | 143 | 135 | 167 | 170 |
| 4. | First ionizatio n energy (KJ/mol) | 801 | 578 | 579 | 558 | 589 |
| 5. | Electro negativity | 2.0 | 1.5 | 1.6 | 1.7 | 1.8 |

- **Density:** Generally increases down the group but aluminium has an exceptionally low density.
- **Melting point and Boiling point:** B to Ga decrease then Ga to Tl increases Ga has lowest M.P (29.8°C) and therefore liquid at room temperature.
- **Atomic radii and Ionic radii:** On moving from B to Tl the size increases due to addition of new energy shells at each step down the group but Ga is smaller than Al.

- **Ionization Energy:** Generally IE decreases down the group but Ga has higher IE than Al exceptionally due to smaller in size as compared to Al.
- **Metallic character:** Electropositive character increases down the group hence metallic character also increase down the group but aluminium is having high metallic character than Gallium due to low IE than Ga.
- **Oxidation state:** The elements of B group have three valence electron *i.e.*, two in s – subshell. The most oxidation state should be +3 but due to small size of boron it cannot lose its valence electrons to B³⁺ ion, and combines with other atoms through covalent bonds. Except boron, other elements also exhibit +1 oxidation state and down the group +1 state becomes more stable.
- **Reducing property:** Down the group the reducing property decreases.
Al > Ga > In > Tl

Group Trends in Chemical Properties

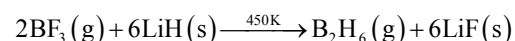
- **Hydrides:** None of the element from 13 groups reacts directly to hydrogen. However a number of hydrides of these elements have been prepared by indirect methods.
- Boron hydrides are called boranes.

Two types of boranes:

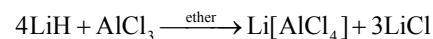
B_nH_{n+4}, called nido-boranes

B_nH_{n+6}, called arachno-boranes

The simplest borane is diborane B₂H₆

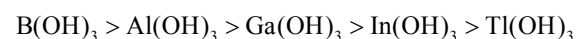
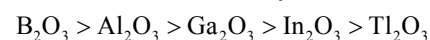


Other elements of this group forms only a few stable hydrides of NH₃ types. AlH₃ is colour less polymeric solid of formula (AlH₃)_x and contains Al — H — Al bridges. A complex hydride of aluminium is a very good reducing agent and used as a reagent in lab is Li[AlH₄], Lithium aluminium hydrides. It is a white crystalline solid.



Gallium also form Li[GaH₄]

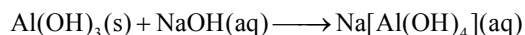
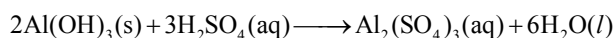
- **Oxides and hydroxides:** The 13 group elements forms oxides and hydroxides of composition M₂O₃ and M(OH)₃ respectively. As we move down the group the acidic character in oxides and hydroxides decreases and basic character increases due to decrease in strength of M — O bond due to which basicity increases.



Trend in acidity

Basic Character increases

Oxides and hydroxide of Al and Ga shows amphoteric nature.



Carbon Family: The carbon family or group 14 consists of carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn) and Lead (Pb). Carbon and silicon are non metals; germanium is a semi-metal or metalloid whereas tin and lead are metals. All the elements of group 14 have four electrons in their valence shells. Their general electronic configuration is ns^2np^2 . Carbon and silicon are the most abundant elements in the group in earth crust.

Carbon: Carbon is the sixth most abundant element in the known universe but not nearly as common on the earth, despite the fact the living organisms contain significant amounts of the elements. Carbon commonly occurs in environment as methane (CH_4) and carbon dioxide (CO_2). Carbon exists in several forms called allotropes. Diamond is one of very strong crystal lattice, known as a precious gem. Graphite is another allotrope in which carbon atoms are arranged in planes which are loosely attracted to one another (hence used as lubricant). The recently discovered fullerenes are yet other form of carbon. Carbon has a very high melting and boiling point and rapidly combines with oxygen at elevated temperature. An important (but rare) radioactive isotope of carbons, C-14 is used to date ancient objects of organic origin.

Silicon: The silicon name is taken from Latin silver which means “*flint*”. The element is on second position in abundance in the earth’s crust after oxygen, was discovered by Berzelius in 1824.

The most common compound of silicon, SiO_2 is the most abundant chemical compound in the earth’s crust.

Silicon is a crystalline semi – metal or metalloid. One of its forms is shiny, grey and very brittle. In another allotropic form silicon is a brown amorphous powder most familiar in “dirty” beach sand.

Germanium (Ge): Like silicon, germanium is used in the manufacture of semi – conductor devices. But unlike silicon, it is rather rare. It was also predicted by Mendeleev in 1871 (ekasilicon) to fill out his periodic table and was discovered in 1886 by Winkler. It is generally extracted from the by products of zinc – refining.

Tin (Sn): It is one of the major elements along with copper used in bronze. It was named after the Etruscan god Tinia, the

chemical symbols for it is taken from Latin *Stannum*. The metal is silvery white and very soft when pure. It has the look of freshly cut aluminium but the feel of lead. Polished tin is slightly bluish. It has been used for many years in the coating of steel cans for food because it is more resistant to corrosion than iron. It is chiefly used in solders. SnF_2 is found in fluoride toothpastes.

Lead (Pb): Its symbol came from ‘plumber’ word because since old plumbing was done with lead pipes. Although lead is not very common in earth’s crust, what is there is readily available and easy to refine. Its chief use today is in lead – acid storage batteries such as those used in automobiles.

In pure form it is too soft to be used for much else. Lead has a blue – white colour when first cut but quickly dulls on exposure to air forming Pb_2O . Various isotopes of lead come at the end of the natural decay series of elements like uranium, thorium and actinium. These are Pb – 206, Pb – 207 and Pb – 208.

Table: 26.8 Physical Properties

| Sr. No. | Property | Carbon | Silicon | Germanium | Tin | Lead |
|---------|----------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 1. | Configuration | [He] $2s^2 2p^2$ | [Ne] $3s^2 3p^2$ | [Ar] $4s^2 4p^2$ | [Kr] $5s^2 5p^2$ | [Xe] $6s^2 6p^2$ |
| 2. | Common oxidation state | +4 | +4 | +4 | +4, +2 | +4, +2 |
| 3. | Atomic radius (pm) | 77 | 117 | 122 | 140 | 175 |
| 4. | First ionization energy (KJ/mol) | 1086 | 786 | 762 | 709 | 716 |
| 5. | Electronegativity | 2.5 | 1.8 | 1.8 | 1.8 | 1.9 |

Catenation: A remarkable property of carbon is its ability to form compounds in which carbon atoms are linked to one another in chains or rings. This property of forming chains and rings is known as catenation. On going down the group, tendency of catenation decreases. $\text{C} \gg \text{Si} > \text{Ge} \approx \text{Sn} \gg \text{Pb}$

Due to high tendency of catenation carbon forms bonds with other carbon atoms and forms so many compounds which are studied in organic chemistry.

Allotropy: A characteristic property of the elements of carbon family is that these show allotropy. Example: carbon has two important allotropic forms i.e. diamond and graphite. Allotropy is the existence of an element in two or more forms, which are significantly different in physical properties but have similar chemical properties. In diamond carbon is sp^3 hybridised and

has four tetrahedral bonds with adjacent carbon atoms. In graphite carbon is sp^2 hybridised. The three covalent bonds form hexagonal layers and fourth unhybridised p-electron of each carbon forms an extended delocalized π -bonding with carbon atoms of adjacent layers. Due to this free electron graphite is electric conductor while diamond is not. Also due to sliding property of graphite it has been using as a lubricant.

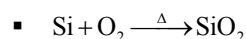
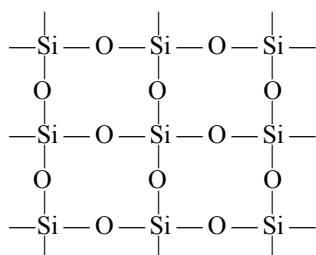
Silica (SiO_2)

Silicon is unable to form $p\pi - p\pi$ bond with oxygen atom due to its relatively large size. Thus it satisfies its all four valency with four oxygen atoms and constitutes three - dimensional network. In this structure each oxygen atom is shared by two silicon atoms. Three crystalline modification of SiO_2 are quartz, cristobalite and tridymite of which quartz and cristobalite are important.

Quartz (rock crystal) is the purest form of silica. It is used in preparation of costly glasses and lenses. It is also used as piezoelectric material (crystal oscillators and transducers).

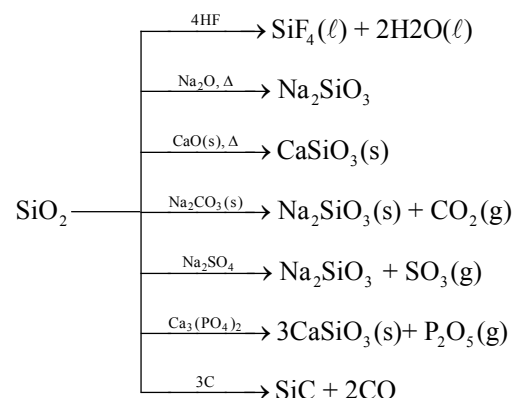
Several amorphous forms of silica such as silica gel and fumed silica are known.

Structure of Silica: Artificially silica can be obtained by following methods.



Properties of Silica

Pure silica is colourless but sand is brownish or yellowish due to presence of impurities of iron oxide.

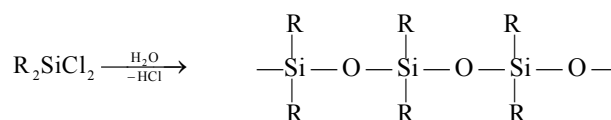


Silicates: This is the general term applied for the solids with silicon – oxygen bonds. Some of the silicate minerals are quartz, asbestos ($CaMgSi_2O_6$), feldspar ($KAlSi_3O_8$), mica [$KAl_2(Si_3AlO_{10})(OH)_2$] and zeolites ($Na_2Al_2SiO_8 \cdot xH_2O$).

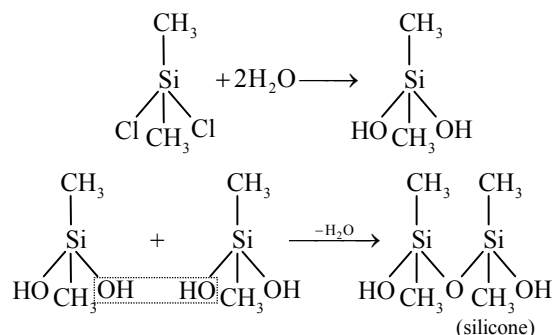
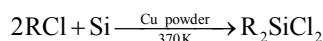
The solids contain silicate ion $(SiO_4)^{4-}$ as the basic structural unit. The silicate ion is tetrahedral in structure and when the one or more oxygen atoms between such tetrahedrons, a complex structure arise. The silicates may be classified in to chain silicates, ring silicates, cyclic silicates, sheet silicates, three-dimensional silicates depends on the way in which the $(SiO_4)^{4-}$ tetrahedral units are linked together.

Silicones: Silicones are polymeric compounds containing repeated R_2SiO units. The name is given silicone because their empirical formula is analogous to that of ketones (R_2CO). Silicones are chemically inert, water repelling nature, heat resistance and having good electrical insulating properties. They are used as sealants, greases, electrical insulators and for water proofing of fabrics.

Commercial silicon polymers are usually methyl derivatives and to a lesser extent phenyl derivatives. They are prepared by the hydrolysis of R_2SiCl_2 ($R = Me$ or Ph).



The starting alkyl substituted chlorosilanes are obtained by direct reaction of RCl with silicon in the presence of metallic copper as a catalyst.



It is interesting to note that hydrolysis of alkyl trichlorosilanes, $RSiCl_3$ gives cross linked polymers instead of chain polymers.

MULTIPLE CHOICE QUESTIONS

Alkali metals

- Which of the following statement is correct regarding alkali metals?
 - Cation is less stable than the atom
 - Cation is smaller than the atom
 - Size of cation and atom is the same
 - Cation is greater in size than the atom
- In certain matters lithium differs from other alkali metals, the main reason for this is:
 - Small size of Li atom and Li^+ ion
 - Extremely high electropositivity of Li
 - Greater hardness of Li
 - Hydration of Li^+ ion
- Based on lattice energy and other considerations which one of the following alkali metal chlorides is expected to have the highest melting point:
 - LiCl
 - NaCl
 - KCl
 - RbCl
- Potassium is kept in:
 - Alcohol
 - Water
 - Kerosene
 - Liquid ammonia
- Which of the following metal has stable carbonates?
 - Na
 - Mg
 - Al
 - Si
- Photoelectric effect is maximum in:
 - Cs
 - Na
 - K
 - Li
- Amongst LiCl , RbCl , BeCl_2 and MgCl_2 the compounds with the greatest and least ionic character respectively are
 - LiCl and RbCl
 - MgCl_2 and BeCl_2
 - RbCl and BeCl_2
 - RbCl and MgCl_2
- Causticization process is used for the preparation of:
 - Caustic soda
 - Caustic potash
 - Baryta
 - Slaked lime

Alkaline earth metals

- Setting of plaster of paris is
 - Oxidation with atmospheric oxygen
 - Combination with atmospheric CO_2
 - Dehydration
 - Hydration to yield another hydrate

- The right order of the solubility of sulphates of alkaline earth metals in water is:
 - $\text{Be} > \text{Ca} > \text{Mg} > \text{Ba} > \text{Sr}$
 - $\text{Mg} > \text{Be} > \text{Ba} > \text{Ca} > \text{Sr}$
 - $\text{Be} > \text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$
 - $\text{Mg} > \text{Ca} > \text{Ba} > \text{Be} > \text{Sr}$
- Setting of cement is an:
 - Exothermic reaction
 - Endothermic reaction
 - Neither exothermic nor endothermic
 - None of these
- Which of the following alkaline-earth metal hydroxides is the strongest base?
 - $\text{Be}(\text{OH})_2$
 - $\text{Mg}(\text{OH})_2$
 - $\text{Ca}(\text{OH})_2$
 - $\text{Ba}(\text{OH})_2$
- Among K, Ca, Fe, and Zn, the element which can form more than one binary compound with chlorine is:
 - K
 - Ca
 - Fe
 - Zn
- Plaster of paris is used
 - In surgery and dentistry
 - As a white wash
 - As a constituent of tooth paste
 - For the preparation of RCC
- Sparingly soluble salt is:
 - KCl
 - NaCl
 - NH_4Cl
 - BaSO_4
- Slow acting nitrogenous fertilizer among the following is
 - NH_2CONH_2
 - NH_4NO_3
 - CaNCN
 - KNO_3

Boron family

- In the reaction $\text{B}_2\text{O}_3 + \text{C} + \text{Cl}_2 \longrightarrow \text{A} + \text{CO}$. The A is
 - BCl_3
 - BCl_2
 - B_2Cl_2
 - CCl_2
- Which of the following is only acidic in nature:
 - $\text{Be}(\text{OH})_2$
 - $\text{Mg}(\text{OH})_2$
 - $\text{B}(\text{OH})_3$
 - $\text{Al}(\text{OH})_3$
- In the purification of bauxite by Hall's process
 - Bauxite ore is heated with NaOH solution at 50°C
 - Bauxite ore is fused with Na_2CO_3
 - Bauxite ore is fused with coke and heated at 1800°C in a current of nitrogen
 - Bauxite ore is heated with NaHCO_3

- b.** It is converted into stannic nitrate
- c.** It is converted into metastannic acid
- d.** It becomes passive

- a. HCl b. HF
c. HI d. HBr

Nitrogen family

29. Phosphine is prepared by the reaction of
- a. P and H_2SO_4 b. P and NaOH
- c. P and H_2S d. P and HNO_3
30. In Birkeland-Eyde process, the raw material used is
- a. Air b. NH_3
- c. NO_2 d. HNO_3
31. HNO_2 acts as
- a. Oxidising agent b. Reducing agent
- c. Both a and b d. Its solution is stable

- 32.** Which nitrogen trihalides is least basic?
- a. NF_3 b. NCl_3
- c. NBr_3 d. NI_3
- 33.** V-A group precipitate was dissolved in HNO_3 and treated with excess of NH_4OH . It gives a white ppt. because of
- a. $\text{Cu}(\text{OH})_2$ b. $\text{Cd}(\text{OH})_2$
- c. $\text{Bi}(\text{OH})_3$ d. $\text{Hg}(\text{OH})_2$
- 34.** Which has the lowest boiling point?
- a. NH_3 b. PH_3
- c. AsH_3 d. SbH_3
- 35.** Which of the following oxy acids of phosphorus is a reducing agent and monobasic
- a. H_3PO_2 b. H_3PO_3
- c. H_3PO_4 d. $\text{H}_4\text{P}_2\text{O}_6$

36. Bond angle is minimum for

37. Which compound acts as an oxidising as well as reducing agent
- | | |
|----------------------------|--------------------------|
| a. H_2O | b. H_2S |
| c. H_2Se | d. H_2Te |
| a. SO_2 | b. MnO_2 |
| c. Al_2O_3 | d. CrO_3 |

38. Which of the following is formed by the action of water on sodium peroxide?
- H_2
 - N_2
 - O_2
 - CO_2
39. The most efficient agent for the absorption of SO_3 is
- 80% H_2SO_4
 - 98% H_2SO_4
 - 50% H_2SO_4
 - 20% $\text{H}_2\text{S}_2\text{O}_7$
40. Bleaching action of SO_2 is due to its
- Oxidising property
 - Acidic property
 - Basic property
 - Reducing property
41. When PbO_2 reacts with conc. HNO_3 the gas evolved is
- NO_2
 - O_2
 - N_2
 - N_2O

Halogen family

42. The solubility of iodine in water increases in the presence of
- Alcohol
 - Chloroform
 - Sodium hydroxide
 - Potassium iodide
43. Which has the highest molar heat of vaporisation
- HF
 - HCl
 - HBr
 - HI
44. Which of the following is used in the preparation of chlorine?
- Only MnO_2
 - Only KMnO_4
 - Both MnO_2 and KMnO_4
 - Either MnO_2 or KMnO_4
45. With cold and dilute sodium hydroxide fluorine reacts to give
- NaF and OF_2
 - $\text{NaF} + \text{O}_3$
 - O_2 and O_3
 - $\text{NaF} + \text{O}_2$

Noble gases

46. The inert gases are
- Polyatomic
 - Triatomic
 - Diatomic
 - Monoatomic
47. Which of the following inert gas liquifies easily?
- Kr
 - He
 - Ne
 - Ar
48. Deep sea divers used to respire is a mixture of
- Oxygen and argon
 - Oxygen and helium
 - Oxygen and nitrogen
 - Oxygen and hydrogen

49. Which one of the following statements regarding helium is incorrect?
- It is used to produce and sustain powerful superconducting magnets
 - It is used as a cryogenic agent for carrying out experiments at low temperatures
 - It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable
 - It is used in gas-cooled nuclear reactors
50. Which of the following is planar?
- XeF_2
 - XeO_3F
 - XeO_2F_2
 - XeF_4

NCERT EXEMPLAR PROBLEMS

More than One Answer

51. The temporary hardness of water is caused by which of the following compound(s):
- CaCl_2
 - $\text{Mg}(\text{HCO}_3)_2$
 - $\text{Ca}(\text{HCO}_3)_2$
 - MgSO_4
52. Electrolysis of KH produces H_2 :
- at the cathode
 - at the anode
 - either at the cathode or at the anode
 - Cannot be predicted
53. In which of the following cases, does N_2 evolve as a gaseous product?
- KNO_3 reacts with K on heating
 - Na_2O_2 reacts with NH_3
 - NH_3 reacts with bleaching powder
 - None of these
54. Which of the following statements are correct regarding the diagonal relationship between Al and Be?
- BeO and Al_2O_3 are amphoteric in nature
 - Carbides of both produce the same gas on hydrolysis
 - Both can form complexes.
 - Hydrides of both the elements are covalent in nature
55. Which of the following processes cannot give Cl_2 gas as a product?
- Electrolysis of aq. NaCl
 - Oxidation of conc. HCl by K_2CrO_4
 - Electrolysis of very dilute aq. NaCl
 - Oxidation of conc. HCl by MnO_2
56. Which of the following statements are correct?
- NO is a diamagnetic liquid
 - B_2 and C_2 are diamagnetic
 - N_2O_4 is diamagnetic
 - BH_3 loses its planarity on dimerization

57. Which of the following properties of red P and white P are related to their structure?
- Large difference in m.p.
 - Difference in hardness
 - Ignition behavior
 - None of these
58. When NaOH is prepared, the gas released is:
- Cl₂
 - H₂
 - O₂
 - H₂O
59. Phosphine is obtained from the following ore
- Calcium superphosphate
 - Calcium phosphide
 - Potassium phosphide
 - Calcium hypophosphite
60. Which of the following form dimeric halides
- Al
 - Mg
 - In
 - Ga
61. White phosphorus (P₄) has
- Six P - P single bonds
 - Four P - P single bonds
 - Four lone pairs of electrons
 - PPP angle of 60°
62. Among the members of V A group (N, P, As, Sb and Bi), which of the following properties shows an increase as we go down from nitrogen to bismuth:
- Stability of +3 oxidation state
 - Reducing character of hydrides
 - Electronegativity
 - Acidic nature of the pentoxide
63. Ammonia on reaction with hypochlorite anion, can form:
- NO
 - NH₄Cl
 - N₂H₄
 - HNO₂
64. SO₂ is obtained when
- Oxygen reacts with dilute sulphuric acid
 - Hydrolysis of dilute H₂SO₄
 - Concentrated H₂SO₄ reacts with Na₂SO₃
 - All of these
65. Which statement is false
- Electronegativity of fluorine is maximum
 - Electron affinity of fluorine is maximum
 - Melting point of fluorine is minimum
 - Boiling point of fluorine is maximum
- Assertion and Reason**
- Note:** Read the Assertion (A) and Reason (R) carefully to mark the correct option out of the options given below:
- If both assertion and reason are true and the reason is the correct explanation of the assertion.
 - If both assertion and reason are true but reason is not the correct explanation of the assertion.
 - If assertion is true but reason is false.
 - If the assertion and reason both are false.
 - If assertion is false but reason is true.
66. **Assertion:** HF, NH₃ and H₂O form intermolecular hydrogen bonding.
Reason: HF, NH₃ and H₂O molecules are bonded in same manner.
67. **Assertion:** Hard water does not lather with soap.
Reason: In hard water, the sodium stearate of soap changes to the corresponding calcium magnesium salt which precipitates out.
68. **Assertion:** H₂O₂ is stored in wax-lined glass.
Reason: Presence of metal surfaces, traces of alkali (present in glass) etc. increases its decomposition.
69. **Assertion:** A nearly tetrahedral arrangement of the orbitals about the oxygen atom allows each water molecule to form hydrogen bonds with as many as four neighbouring water molecules.
Reason: In ice each water molecule form four hydrogen bond as each molecule is fixed in the space.
70. **Assertion:** Calgon is used for removing Ca²⁺ and Mg²⁺ ions from hard water.
Reason: Calgon forms precipitate with Ca²⁺ and Mg²⁺ ions.
71. **Assertion:** Reaction of SO₂ and H₂S in the presence of Fe₂O₃ catalyst gives elemental sulphur.
Reason: SO₂ is a reducing agent.
72. **Assertion:** SiF₆²⁻ is known but SiCl₆²⁻ is not.
Reason: Size of fluorine is small and its lone pair of electrons interacts with d-orbitals of Si strongly.
73. **Assertion:** Borax bead test is not suitable for Al(III).
Reason: Al₂O₃ is insoluble in water.
74. **Assertion:** SeCl₄ does not have a tetrahedral structure.
Reason: Se in SeCl₄ has two lone pairs.
75. **Assertion:** Ozone is a powerful oxidizing agent in comparison to O₂.
Reason: Ozone is diamagnetic but O₂ is paramagnetic.
76. **Assertion:** Potassium and caesium are used in photo-electric cells.
Reason: Potassium and caesium emit electrons on exposure to light.
77. **Assertion:** The fluorine has lower reactivity.
Reason: F - F bond has low bond dissociation energy.

78. **Assertion:** Halogens do not occur in free-state.

Reason: Halogens are highly reactive.

79. **Assertion:** Lithium forms Lithium oxide (Li_2O).

Reason: N_2 molecule have unpaired electrons.

80. **Assertion:** Liquid NH_3 is used for refrigeration.

Reason: Liquid NH_3 quickly vaporises.

Comprehension Based

Paragraph –I

s-block elements having ns^{-1} (alkali metals) or ns^2 (alkaline earth metals) include Li, Na, K, Rb, Cs, Fr and Be, Mg, Ca, Sr, Ba, Ra respectively. These metals are soluble in NH_3 and their ammonia solution is strongly conducting, paramagnetic as well as show colour. All of these are reactive metals due to low values of ionization energy. The physical properties of alkali metals almost describe a regular trend from Li to Cs whereas no such trend is noticed in alkaline earth metals. Also the properties such as density m.pt, b.pt for alkaline earth metals are more than alkali metals. Li in alkali metals and Be in alkaline earth metals differ markedly in many of their properties with their respective group elements.

81. The conductivity of alkali metals in liq. NH_3 at -33°C :

- a. Increases with increase in temperature
- b. Decrease with increase in temperature
- c. Remains same with increase or decrease in temperature
- d. Due to ions furnished by metals

82. Which set of statements are correct?

- (I) ΔH_{hyd} for $\text{Sr}^{2+} > \Delta H_{\text{hyd}}$ for Ag^+
 - (II) $\text{Ca}(\text{OH})_2$ is less soluble in water than $\text{Ba}(\text{OH})_2$
 - (III) Ba^{2+} is more powerful reducing agent than Ca^{2+} in acidic solution
 - (IV) Ca^{2+} is more powerful reducing agent in alkaline medium
- a. I, II, III, IV b. I, II
c. I, III, IV d. II, IV

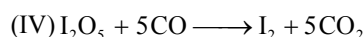
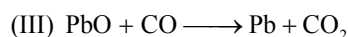
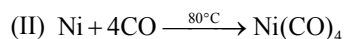
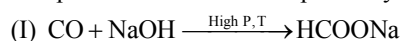
83. Select the wrong statement:

- a. Hydration energy: $\text{Mg}^{2+} > \text{Mg}^+ > \text{Na}^+$
- b. λ released during flame colour: $\text{Li} > \text{Na} > \text{K} > \text{Rb} > \text{Cs}$
- c. Conducting power in solution: $\text{Cs}^+ > \text{Rb}^+ > \text{K}^+ > \text{Na}^+ > \text{Li}^+$
- d. Density: $\text{Be} > \text{Mg} > \text{Ca} > \text{Sr} > \text{Ba} > \text{Ra}$

Paragraph –II

Group 14 of periodic table includes C, Si, Se Te and Po. Carbon forms two oxides CO (neutral) and CO_2 (acidic) whereas other members of group 14 forms amphoteric oxides. Both CO and CO_2 are covalent compounds. Si does not form monoxide.

84. CO although neutral acts as acid as well as π -electron acceptor in the reactions respectively:



- a. I, II b. II, III
c. III, II c. I, IV

85. Which statement is not correct?

- a. The CO_2 molecule possesses sp -hybridization and also shows resonating structure
- b. The structure of CO is $[:C \equiv C:]$
- c. Ammoniacal CuCl absorbs CO forms adduct product
- c. Asphyxia is low level poisoning produced in a atmosphere of CO_2

86. Which statement is not correct?

- a. CO is isoelectronic with N_2 but less reactive than N_2
- b. CO is isoelectronic with N_2 and possesses more bond energy
- c. CO is isoelectronic with N_2 and more reactive than N_2
- c. CO is isoelectronic with N_2 and required for respiration

Paragraph –III

Group 15 includes pnictogens *i.e.*, N, P, As, Sb and Bi elements with ns^2np^3 configuration. N_2 is gas. All these elements except Bi show allotropy. Phosphorus exists in three allotropic forms, white phosphorus, red phosphorus and black phosphorus. The later being most stable (thermodynamically) form of P. Each member of this forms hydrides of the molecular formula MH_3 . Nitrogen however forms three hydrides NH_3 , N_3H and N_2H_4 . The thermal stability, basic nature and solubility in water of hydrides (MH_3) however decreases from N to Bi.

87. The correct order for acidic nature is:

- a. $\text{NH}_4^+ < \text{PH}_4^+ < \text{AsH}_4^+$ b. $\text{NH}_4^+ > \text{PH}_4^+ > \text{AsH}_4^+$
c. $\text{AsH}_4^+ > \text{NH}_4^+ > \text{PH}_4^+$ d. $\text{AsH}_4^+ < \text{NH}_4^+ < \text{PH}_4^+$

88. Which hydride of group 15 is most powerful reducing agent?

- a. NH_3 b. PH_3
c. AsH_3 d. SbH_3

89. The correct order of bond angles is:

- a. $\text{NH}_3 > \text{PN}_3 > \text{AsH}_3 > \text{SbH}_3$
- b. $\text{SbH}_3 > \text{AsH}_3 > \text{PN}_3 > \text{NH}_3$
- c. $\text{SbH}_3 > \text{PN}_3 > \text{AsH}_3 > \text{NH}_3$
- d. $\text{PN}_3 > \text{NH}_3 > \text{SbH}_3 > \text{BiH}_3$

Paragraph –IV

There are some deposits of nitrates and phosphates in earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under the laboratory conditions but microbes do it easily. Ammonia forms larger number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3 and PH_3 . Phosphine is a flammable gas and is prepared from white phosphorus.

90. Among the following, the correct statement is:

- a. Phosphates have no biological significance in humans
- b. between nitrates and phosphates, phosphates are less abundant in earth's crust
- c. Between nitrates and phosphates, nitrates are less abundant in earth's crust
- d. Oxidation of nitrates is possible in soil

91. Among the following, the correct statement is:

- a. Between NH_3 and PH_3 , NH_3 is a better electron donor because the lone pair of electrons occupies spherical 's' orbital and is less directional
- b. Between NH_3 and PH_3 , NH_3 is a better electron donor because the lone pair of electrons occupies sp^3 -orbital and is more directional
- c. Between NH_3 and PH_3 , NH_3 is a better electron donor because the lone pair of electrons occupies sp^3 -orbital and is more directional
- d. Between NH_3 and PH_3 , NH_3 is a better electron donor because the lone pair of electrons occupies spherical 's' orbital and is less directional

92. White phosphorus on reaction with NaOH gives PH_3 as one of the products. This is a:

- a. dimerization reaction
- b. disproportionation reaction
- c. condensation reaction
- d. precipitation reaction

Match the Column

93. Match the chemical properties with the compounds:

| Column I | Column II |
|--------------------|--|
| (A) Ca | 1. Produces H_2 on reaction with H_2O . |
| (B) CaH_2 | 2. Produce Ca(OH)_2 on reaction with H_2O . |
| (C) CaO | 3. The compound is ionic. |
| (D) CaC_2 | 4. Can absorb N_2 under hot conditions. |

- a. $\text{A} \rightarrow 1,4$; $\text{B} \rightarrow 1,2,3$; $\text{C} \rightarrow 2,3$; $\text{D} \rightarrow 2,3$,
- b. $\text{A} \rightarrow 1,3,4$; $\text{B} \rightarrow 1,2,4$; $\text{C} \rightarrow 2,3$; $\text{D} \rightarrow 2,3,4$
- c. $\text{A} \rightarrow 1,2,4$; $\text{B} \rightarrow 1,3$; $\text{C} \rightarrow 2,3$; $\text{D} \rightarrow 2,3,4$
- d. $\text{A} \rightarrow 1,2,4$; $\text{B} \rightarrow 1,2,3$; $\text{C} \rightarrow 2,3$; $\text{D} \rightarrow 2,3,4$

94. Match the compounds with their uses / properties:

| Column I | Column II |
|--|---|
| (A) $\text{NaCO}_3 \cdot 10\text{H}_2\text{O}$ | 1. Desiccating agent. |
| (B) CaCl_2 (anhydride) | 2. Used for preparing freezing mixture. |
| (C) CaSO_4 (anhydride) | 3. Washing soda. |
| (D) NaCl | 4. Dead burnt. |
| | 5. Soluble in water. |

- a. $\text{A} \rightarrow 1,5$; $\text{B} \rightarrow 1,4$; $\text{C} \rightarrow 4$; $\text{D} \rightarrow 2,5$
- b. $\text{A} \rightarrow 3,5$; $\text{B} \rightarrow 1,5$; $\text{C} \rightarrow 4$; $\text{D} \rightarrow 2,3$
- c. $\text{A} \rightarrow 3,5$; $\text{B} \rightarrow 1,5$; $\text{C} \rightarrow 4$; $\text{D} \rightarrow 2,5$
- d. $\text{A} \rightarrow 3,5$; $\text{B} \rightarrow 3,5$; $\text{C} \rightarrow 4$; $\text{D} \rightarrow 1,5$

95. Match the xenon compounds with their properties.

| Column I | Column II |
|------------------------------|--|
| (A) XeO_6^{4-} | 1. Central atom in sp^3d^2 hybridized. |
| (B) XeF_4 | 2. On treatment with conc. H_2SO_4 produces XeO_4 . |
| (C) XeO_3 | 3. Only one lone pair is present on the central atom |
| (D) XeO_2F_4 | 4. Central atom of the molecule has four surrounding atoms |

- a. $\text{A} \rightarrow 1,3$; $\text{B} \rightarrow 1,2$; $\text{C} \rightarrow 3$; $\text{D} \rightarrow 3,4$
- b. $\text{A} \rightarrow 1,3$; $\text{B} \rightarrow 2,4$; $\text{C} \rightarrow 3$; $\text{D} \rightarrow 3,4$
- c. $\text{A} \rightarrow 1,2$; $\text{B} \rightarrow 1,4$; $\text{C} \rightarrow 3$; $\text{D} \rightarrow 3,4$
- d. $\text{A} \rightarrow 1,2$; $\text{B} \rightarrow 1,4$; $\text{C} \rightarrow 1$; $\text{D} \rightarrow 1,4$

Integer

96. The Among the following compounds, the number of compounds which do not produce acidic or basic solutions which do not produce acidic or basic solutions when dissolved in water is

NaCl , BeCl_2 , Li_2O , MgO , CaH_2 , CaSO_4

97. The ratio of the number of water of crystallization in gypsum and that in plaster of Paris is

98. Among the following elements, the number of elements that release H_2 on reaction with NaOH is

Be , Al , B , Mg , Ca , Zn , Sn

99. The number of bicarbonates that do not exist in solid form among the following is

LiHCO_3 , NaHCO_3 , $\text{Ca(HCO}_3)_2$, KHCO_3 , NH_4HCO_3 , $\text{Ba(HCO}_3)_2$, $\text{Mg(HCO}_3)_2$

100. The number of planes of symmetry in $[\text{BeH}_4]^{2-}$ is

ANSWER

| | | | | | | | | | |
|-----|-----|-------|-------|-------|-----|-------|-----|-----|-------|
| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. |
| b | a | b | c | a | a | c | a | d | c |
| 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. | 19. | 20. |
| a | d | c | a | d | c | a | c | c | b |
| 21. | 22. | 23. | 24. | 25. | 26. | 27. | 28. | 29. | 30. |
| c | a | b | b | b | c | c | b | b | a |
| 31. | 32. | 33. | 34. | 35. | 36. | 37. | 38. | 39. | 40. |
| c | a | c | d | a | d | a | c | b | d |
| 41. | 42. | 43. | 44. | 45. | 46. | 47. | 48. | 49. | 50. |
| b | d | d | c | a | d | a | b | c | d |
| 51. | 52. | 53. | 54. | 55. | 56. | 57. | 58. | 59. | 60. |
| b,c | a,b | a,b,c | a,b,c | a,b,c | a,c | a,b,c | a,b | b,c | a,c,d |
| 61. | 62. | 63. | 64. | 65. | 66. | 67. | 68. | 69. | 70. |
| a,d | a,b | b,c | b,c | b,d | c | a | a | a | d |
| 71. | 72. | 73. | 74. | 75. | 76. | 77. | 78. | 79. | 80. |
| b | a | b | c | b | a | e | a | a | a |
| 81. | 82. | 83. | 84. | 85. | 86. | 87. | 88. | 89. | 90. |
| b | c | d | a | d | a | a | d | a | c |
| 91. | 92. | 93. | 94. | 95. | 96. | 97. | 98. | 99. | 100. |
| c | b | d | c | c | 3 | 4 | 5 | 4 | 6 |

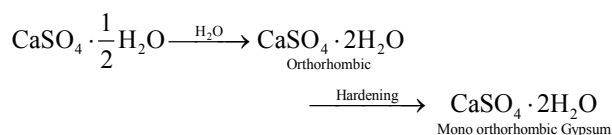
SOLUTION

Multiple Choice Questions

- (b) After removal of an electron the effective nuclear charge per electron increases hence the size decreases.
- (a) Small atomic and ionic size leads to high electronegativity and hydration energy. Small atomic and ionic size leads to high electronegativity and hydration energy.
- (b) Although lattice energy of LiCl higher than NaCl but LiCl is covalent in nature and NaCl ionic there after, the melting point decreases as we move NaCl because the lattice energy decreases as a size of alkali metal atom increases (lattice energy \propto melting point of alkali metal halide)
- (c) Alkali metals are highly reactive metals. They react with
 Alcohol $2C_2H_5OH + 2K \longrightarrow 2C_2H_5OK + H_2$
 Water $2K + 2H_2O \longrightarrow 2KOH + H_2$
 Ammonia
 $K + (x + y)NH_3 \longrightarrow [K(NH_3)_x]^+ + [e(NH_3)_y]^-$
Ammoniated cation Ammoniated electron
- (a) When carbonate are heated they decompose to form the oxide. Sodium carbonate and potassium carbonate do

not decompose. The carbonate become more difficult to decompose as we go down the group.

- (a) Group I element are so highly electropositive that they emit electrons even when exposed to light (Photoelectric effect) and this character increase on moving down the group from lithium towards cesium.
- (c) According to Fajan's rule RbCl has greatest ionic character due to large ionic size of Rb^+ ion. $BeCl_2$ has least ionic (Maximum covalent) due to small size of Be^{+2} ion which has highly polarising.
- (a) Causticizing process (Gossage process) it is an old process and involves heating of 10% solution of Na_2CO_3 with a little excess of milk of lime $Ca(OH)_2$
 $Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 \downarrow + 2NaOH$
- (d) Setting of plaster of paris is exothermic process



- (c) $Be > Mg > Ca > Sr > Ba$

On moving down the group lattice energy remains almost constant as the sulphate is so big that small increase in the size of the cations from Be to Ba does not make any difference.

However the hydration energy decreases from Be^{+2} to Ba^{+2} .

This causes decrease in the solubility of the sulphates as the ionic size increases.

- (a) When water is added to cement an exothermic reaction occurs. During this process, the cement reacts with water to form a gelatinous mass which slowly sets into a hard mass having three dimensional network structure involving $-Si-O-Si-$ and $-Si-O-Al-$ chains.
- (d) $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2$
 $< Sr(OH)_2 < Ba(OH)_2$

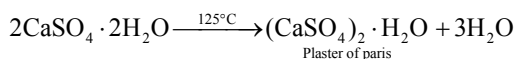
On moving down the group basic character increases.

- (c) A binary compound is one made of two different elements. These can be one of each element such as CuCl or FeO. These can also be several of each element such as Fe_2O_3 or $SnBr_4$. Metal which have variable oxidation number can form more than one type of binary compound

like Fe shows the oxidation state +2 and +3.

Hence it forms two type of binary compound e.g., $\text{FeCl}_2, \text{FeCl}_3$.

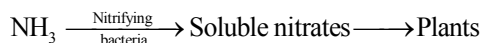
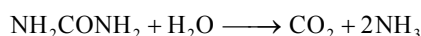
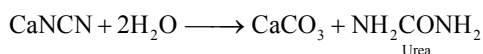
14. (a) Plaster of paris $[(\text{CaSO}_4)_2 \cdot \text{H}_2\text{O}]$ is used in surgery for setting of bones, dentistry and manufacturing of statues. It is prepared as follows,



15. (d) BaSO_4 is sparingly soluble in water because the solubility of second group sulphates decreases with increasing atomic size.

Because of hydration energy decreases.

16. (c) Calcium cyanamide is the slow acting nitrogenous fertilizer as it decompose very slowly.



17. (a) $\text{B}_2\text{O}_3 + 3\text{C} + 3\text{Cl}_2 \longrightarrow 2\text{BCl}_3 + 3\text{CO}$

BCl_3 is obtained by passing chlorine over the heated mixture of B_2O_3 and powdered charcoal.

18. (c) Except $\text{B}(\text{OH})_3$ all other hydroxide are of metallic hydroxide having the basic nature $\text{B}(\text{OH})_3$ are the hydroxide of nonmetal showing the acidic nature.

19. (c) For the purification of red bauxite which contains iron oxide as impurity \longrightarrow Baeyer's process. For the purification of white bauxite which contains silica as the main impurity Serpeck's process.

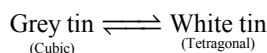
20. (b) Pure alumina is a bad conductor of electricity and the fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried of fused mass the metal formed vapoureses as the boiling point of Al is 1800°C .

To overcome this difficulty, Na_3AlF_6 and CaF_2 are mixed with alumina.

21. (c) In electrolytic method of obtaining aluminium from purified bauxite, cryolite is added to charge because it reduces the melting point of Bauxite (from 1200°C to $800^\circ - 900^\circ\text{C}$) and also it increases electrical conductivity of mixture.

22. (a) Among alkali metal carbonates only Li_2CO_3 decomposes. $\text{Li}_2\text{CO}_3 \xrightarrow{\Delta} \text{Li}_2\text{O} + \text{CO}_2 \uparrow$

23. (b) Grey tin is very brittle and easily crumbles down to a powder in very cold climates.



The change of white tin to grey tin is accompanied by increase in volume. This is called tin disease or tin plague.

24. (b) Zeolite have SiO_4 and AlO_4 tetrahedrons linked together in a three dimensional open structure in which four or six membered ring predominate. Due to open chain structure they have cavities and can take up water and other small molecules.

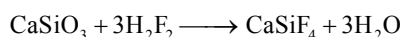
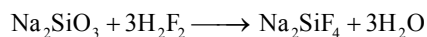
25. (b) Noble gases are found in very minute amount in atmosphere. These are separated from each other by using coconut charcoal. Which adsorb different gas at different temperature.

26. (c) Lapis Lazuli is a rock composed mainly of the following mineral, lazurite, hauynite sodalite, nosean, calcite, pyrite, lapis lazuli is actually sulphur containing, sodium aluminium silicate having chemical composition $3\text{Na}_2\text{O} \cdot 3\text{Al}_2 \cdot 6\text{SiO}_2 \cdot 2\text{Na}_2\text{S}$.

27. (c) Tin is oxidised to meta stannic acid when it is treated with nitric acid.



28. (b) Glass being a mixture of sodium and calcium silicates reacts with hydrofluoric acid forming sodium and calcium fluorosilicates respectively.



The etching of glass is based on these reactions.

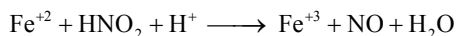
29. (b) $\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} \longrightarrow \text{PH}_3 + 3\text{NaH}_2\text{PO}_2$
- (White) Phosphine Sod. hypophosphite

30. (a) Birkeland – Eyde process

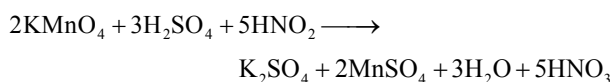
Dinitrogen is prepared commercially from air by liquification and fractional distillation. When liquid air is allowed to distil, dinitrogen having lower b.pt (77K) distils over first leaving behind liquid oxygen (bpt 90K). World wide production of dinitrogen from liquid air is more than 50 million tonnes per year.

31. (c) Nitrous acid behaves as reducing as well as an oxidising agent. It reduces potassium permanganate, potassium dichromate, H_2O_2 and other strong oxidising agents. It oxidises strong reducing agents such as hydroiodic acid, sulphurous acid etc.

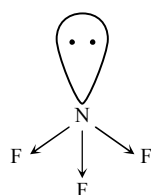
It oxidises Fe^{+2} into Fe^{+3} in acidic medium;



It reduces acidified KMnO_4 .



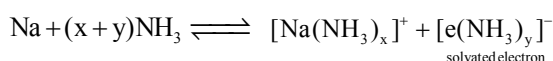
32. (a) NF_3



It is least basic because of the high electronegativity of 3F atoms. The lone pair present on nitrogen atom is not easily available for donation.

33. (c) When the black ppt. of Bi_2S_3 is dissolved in 50% HNO_3 and a solution of NH_4OH is added. A white ppt. of $\text{Bi}(\text{OH})_3$ is obtained.

34. (d) Sodium metal in liq. NH_3 solution shows strong reducing power due to solvated electron.



35. (a) Hypophosphorus acid (H_3PO_2) is a monobasic acid which act as reducing agent. In this molecule two P–H bonds are responsible for its reducing character and one O–H bond is responsible for its monobasic acid character.

36. (d) H_2O H_2S H_2Se H_2Te
 104.5° 92.1° 91° 90°

As we go down the group electronegativity decreases due to which repulsion between bonded pairs of electron also decreases.

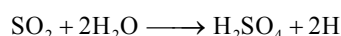
Hence, bond angle decreases.

37. (a) The minimum and maximum oxidation number of S are –2 and +6 respectively. Since the oxidation number of S in SO_2 is +4, therefore it can be either increased or decreased. Therefore SO_2 behaves both as an oxidising as well as reducing agent.

38. (c) $2\text{Na}_2\text{O}_2 + 2\text{H}_2\text{O} \longrightarrow 4\text{NaOH} + \text{O}_2$
 In this reaction oxygen (O_2) is formed.

39. (b) 98% H_2SO_4 is used for absorbing dense fog of acid which is formed by dissolving SO_3 in water. Hence 98% H_2SO_4 is the most efficient agent for the absorption of SO_3 .

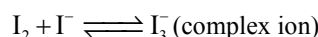
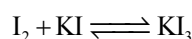
40. (d) SO_2 act as bleaching agent due to its reducing property.



Coloured matter + H \longrightarrow Colourless matter

41. (b) PbO_2 is a powerful oxidizing agent and liberate O_2 when treated with acids SO , O_2 gas will be evolved.

42. (d) Iodine has the least affinity for water and is only slightly soluble in it. However, it dissolves in 10% aq. solution of KI due to the formation of a complex ion i.e. I_3^- .

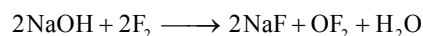


43. (d) In case of HI due to large size of iodine strong Vander Waal forces are present. Hence, it has highest molar heat of vaporisation.

44. (c) $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$
 $2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 + 10\text{HCl} \longrightarrow$



45. (a) Fluorine is the most electronegative element. It does not form oxyfluorides like other halogens. If reacts with NaOH to form sodium fluoride and oxygen fluoride.



46. (d) All the noble gases are monoatomic, colourless and odourless gases. Their monoatomic nature is due to the stable outer configuration ns^2np^6 of their atoms. As a result, they do not enter into chemical combination even amongst themselves.

47. (a) The maximum temperature at which gas can be liquified is called its critical temperature. The gas which have high boiling point will change into liquid first and so critical temperature of the gas will be more.

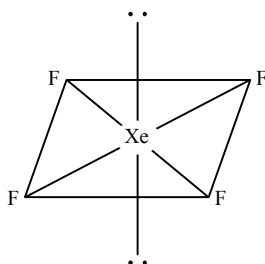
$$T_c \propto \text{B.P. and B.P.} \propto \text{Molecular weight}$$

So, Kr liquifies first.

48. (b) An oxygen-helium mixture is used artificial respiration in deep sea diving instead of air because nitrogen present in air dissolves in blood under high pressure when sea diver goes into deep sea. When he comes to the surface, nitrogen bubbles out of the blood due to decrease in pressure, causing pains. This disease is called “bends”.

49. (c) Helium is twice as heavy as hydrogen, its lifting power is 92% of that of hydrogen. Helium has the lowest melting and boiling point of any element which makes liquid helium an ideal coolant for many extremely low temperature application such as super conducting magnet and cryogenic research where temperature close to absolute zero are needed.

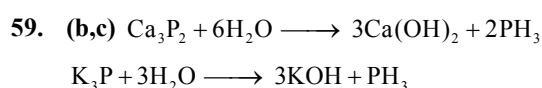
50. (d) In the formation of XeF_4 , sp^3d^2 hybridisation occurs which gives the molecule an octahedral structure. The xenon and four fluorine atoms are coplanar while the two equatorial positions are occupied by the two lone pairs of electrons.



NCERT Exemplar Problems

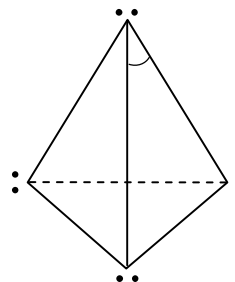
More than One Answer

51. (b, c) $\text{Mg}(\text{HCO}_3)_2$, $\text{Ca}(\text{HCO}_3)_2$
52. (a, b) at the cathode, either at the cathode or at the anode
53. (a, b, c) KNO_3 reacts with K on heating, Na_2O_2 reacts with NH_3 , NH_3 reacts with bleaching powder
54. (a, b, c) BeO and Al_2O_3 are amphoteric in nature, Carbides of both produce the same gas on hydrolysis, Both can form complexes.
55. (a, b, d) Electrolysis of aq. NaCl , Oxidation of conc. HCl by K_2CrO_4 , Oxidation of conc. HCl by MnO_2
56. (a, c) NO is a diamagnetic liquid, N_2O_4 is diamagnetic
57. (a, b, c) Large difference in m.p., Difference in hardness, Ignition behavior
58. (a,b) $2\text{NaCl} + 2\text{H}_2\text{O} \longrightarrow 2\text{NaOH} + \underset{\text{Anode}}{\text{Cl}_2} + \underset{\text{Cathode}}{\text{H}_2}$



60. (a,c,d) Al_2Cl_6 , In_2Cl_6 , Ga_2Cl_6

61. (a,d) P_4 molecule



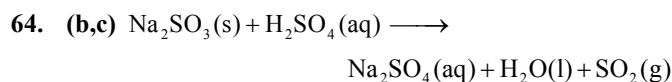
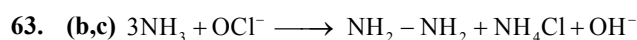
Bond angle = 60°

Six P–P = Single bonds

Lone pairs = 4

62. (a,b) Stability of +3 oxidation states increases on account of inert pair effect.

Reducing character of hydrides increases down the group because bond dissociation energy decreases down the group.



65. (b,d) Electron affinity of Cl_2 is maximum

| Element | F | Cl | Br | I |
|---------------------------------|--------|-------|-------|-------|
| E.A. kJ/mole | 332.6 | 348.5 | 324.7 | 295.5 |
| Boiling pt ($^\circ\text{C}$) | -188.1 | -34.6 | 59.5 | 185.2 |

Assertion and Reason

66. (c) Assertion is true but reason is false.

The water molecules are joined together in an extensive three dimensional network in which each oxygen atom is bonded to four hydrogen atoms two by hydrogen bonds and two by normal covalent bonds in a near tetrahedral configuration. This situation does not exist for molecules like NH_3 and HF .

67. (a) Both assertion and reason are true and reason is the correct explanation of assertion. Hard water contain soluble calcium and magnesium salt like bicarbonates, chlorides and sulphates.

68. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

To stop decomposition H_2O_2 is stored in wax-lined glass or plastic vessels in the presence of stabilizers like urea.

69. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

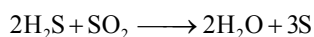
At any given instant in liquid water at room temperature, each water molecule forms hydrogen bonds with an average 3.4 other water molecules. The H_2O molecules are in continuous motion so hydrogen bonds are constantly and rapidly broken and formed. In ice H_2O molecules are, however fixed in the space lattice.

70. (d) Both assertion and reason are false.

Calgon is used for making Ca^{2+} and Mg^{2+} ions present in hard water ineffective. It forms soluble complex with Ca^{2+} and Mg^{2+} ions.

71. (b) SO_2 shows both oxidising as well as reducing nature.

The reaction given in assertion is due to oxidising nature of SO_2 .



72. (a) (i) Due to smaller size of F; steric repulsions will be less in SiF_6^{2-} .

(ii) Interaction of F lone pair electrons with Si is stronger than that of chlorine lone pairs.

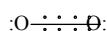
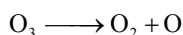
73. (b) Borax bead test is not suitable for Al(III) because its oxidising as well as reducing flame is colourless in both hot as well as cold.

Alumina is insoluble in water as they exist in hydrated form like $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$, $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ etc.

74. (c) SeCl_4 possess see saw geometry, which can be regarded as a distorted trigonal bipyramidal structure having one lone pair (lp) of electrons in the basal position of the trigonal bipyramidal.

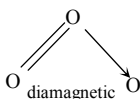
See-saw geometry of SeCl_4 molecules arises due to the sp^3d hybridisation of the central atom. The distortion in shape is due to the presence of one lone pair of electrons.

75. (b) Due to the ease with which it can liberate nascent oxygen, O_3 acts as a powerful oxidising agent.



paramagnetic

(due to presence of two unpaired electrons)



76. (a) K and Cs emit electrons on exposure of light due to low ionisation potential.

77. (e) The lower value of bond dissociation energy of F-F bond due to longer inter electronic (electron-electron) repulsion between the non-bonding electrons in the 2p orbitals of fluorine atom.

78. (a) It is fact that halogens are highly reactive as they have seven electrons in their outermost orbit and they want to stabilize by acquiring an electron.

Therefore, they do not occur in free-state. Here both assertion and reason are true and the reason is the correct explanation of assertion.

79. (a) Lithium forms lithium oxide. This is due to the fact that Li^+ ion has smallest size and it has a strong positive field around it. Therefore, it stabilize O^{2-} ion with strong negative field around it. Thus, both assertion as well as reason are true.

80. (a) Liquid NH_3 is used for refrigeration is true and it is due to the fact that it vaporises quickly and for vaporisation it takes up heat and cool the refrigerator. Hence assertion and reason both are true.

Comprehension Based

81. (b) The passage of current in the system is due to electronic conduction.

82. (c) Sr^{2+} has more charge, $\text{Ca}(\text{OH})_2$ is more soluble than $\text{Ba}(\text{OH})_2$ in water. The reducing nature depends upon E°_{Op} values in acidic and alkaline solution.

83. (d) Density order

| | | | | | | |
|------|------|------|------|------|------|-----------------|
| Be | Mg | Ca | Sr | Ba | Ra | |
| 1.84 | 1.74 | 1.55 | 2.54 | 3.75 | 6.00 | g/cm^3 |

84. (a) CO reacts with alkali to form salt CO is π -electron pair acceptor in $\text{Ni}(\text{CO})_4$.

85. (d) Asphyxia is due to CO which combines with haemoglobin to form cherry coloured carbon haemoglobin complex and reduces the capacity of O_2 to be absorbed.

86. (a) CO and N_2 are isoelectronic. No doubt bond energy of $\text{CO} >$ bond energy of N_2 but because of lower nuclear charge on carbon (compared to N or O), the lone pair on carbon is loosely held in CO.

87. (a) The basic character of hydrides decrease from N to Bi because of increasing size of central atom and thus electron density of lone pair is diffused over larger region. Stronger is base, weaker is its conjugate acid.

88. (d) The reducing character of hydrides increases from N to Bi because of decrease in M–H bond strength with decrease in electro-negativity from N to Bi.

89. (a) The decrease in bond angle down the group is due to increasing size of central atom having lone pair which reduces repulsion between bond pair-lone pair.

| | | | |
|-----------------|-----------------|------------------|------------------|
| NH ₃ | PH ₃ | AsH ₃ | SbH ₃ |
| 106.5° | 93.5° | 91.5° | 90.5° |

90. (c) Between nitrates and phosphates, nitrates are less abundant in earth's crust because all nitrates are soluble in water.

91. (c) NH₃ is a better electron donor than PH₃ because the lone pair of electrons occupies sp³-orbital formed from the more compact 2s and 2p-orbitals as compared to 3s and 3p-orbitals of phosphorus in PH₃

92. (b) The reaction of $P_4 + 3OH^- + 3H_2O \longrightarrow PH_3 + 3H_2PO_2^-$
The oxidation state of phosphorus in P₄, PH₃ and H₂PO₂⁻ are 0, -3 and +1, respectively, thus, the reaction is disproportionation reaction.

Match the Column

93. (d) A→1,2,4; B→1,2,3; C→2,3; D→2,3,4

94. (c) A→3,5; B→1,5; C→4; D→2,5

95. (c) A→1,2; B→1,4; C→3; D→3,4

Integer

96. (3)

97. (4)

98. (5)

99. (4)

100. (6)

* * *