The *s*-Block Elements

GROUP 1 - ALKALI METALS

Property	Li	Na	K	Rb	Cs
Atomic number (Z)	3	11	19	37	55
Electronic configuration	[He] $2s^1$	[Ne] $3s^1$	[Ar] $4s^1$	[Kr] $5s^1$	[Xe] $6s^1$
Ion	Li^+	Na^+	K^+	Rb^+	Cs^+
Atomic radius (Å)	1.34	1.54	1.96	2.11	2.25
Flame colouration	Crimson red	Golden yellow	Violet	Violet	Violet

- The group 1 elements are called 'alkali metals' because they form water soluble hydroxides.

Common Properties

- Lower densities than other metals.
- Low ionization energies results in their metallic properties and high reactivities.
- They react readily with non-metals, particularly halogens.

Chemical Properties

- **Reaction with oxygen :** The alkali metals tarnish in air due to the formation of oxide (M_2O) or hydroxide on the surface.
  $4M + O_2 \rightarrow 2M_2O$ (where, M = Li, Na, K, Rb, Cs)
  When heated with excess of air:
  $4Li + O_2 \rightarrow 2Li_2O$ (Lithium oxide)
  $2Na + O_2 \xrightarrow{575\,K} Na_2O_2$ (Sodium peroxide)
  Potassium, rubidium and caesium form superoxides having general formula (MO_2).
- **Reaction with hydrogen :**
  $2M + H_2 \xrightarrow{\Delta} 2MH$ (M = Li, Na, K, Rb, Cs)
- Reaction with water and other compounds containing acidic hydrogen atoms like HX, C_2H_2, etc.
  $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- **Reaction with halogens :** Form metal halides of MX type, which are ionic crystalline solids.
  $2M + X_2 \rightarrow 2MX$
  where, M = Li, Na, K, Rb, Cs and X = F, Cl, Br, I.
- Reactivity of alkali metals with particular halogens increases from Li to Cs. On the other hand, reactivity of halogens decreases from F_2 to I_2.
- The alkali metals are soluble in liquid NH_3 giving a solution which is paramagnetic, highly conducting, reducing and deep blue in colour (due to the presence of ammoniated or solvated electrons).
  $M^+ + (x+y)NH_3 \rightarrow \underbrace{[M(NH_3)_x]^+}_{\text{Ammoniated cation causes conductivity}} + \underbrace{[e(NH_3)_y]^-}_{\text{Ammoniated electron responsible for blue colour and paramagnetism}}$

Exceptional Behaviour of Lithium

	All alkali Metals	Except
1.	do not react directly with N or C	Li_3N
2.	nitrates are thermally stable	$LiNO_3$
3.	carbonates are thermally stable	Li_2CO_3
4.	form double salts (alums) from their sulphates	Li_2SO_4

Diagonal Relationship

- Certain elements of 2nd period show similarity with their diagonal elements in the 3rd period as shown below :

	Group 1	Group 2	Group 13	Group 14
2nd period	**Li**	**Be**	**B**	C
3rd period	Na	**Mg**	**Al**	**Si**

- This is due to the reason that these pairs of elements have almost identical ionic radii and polarizing power (*i.e.* charge/size ratio). Elements of second period are known as bridge elements.

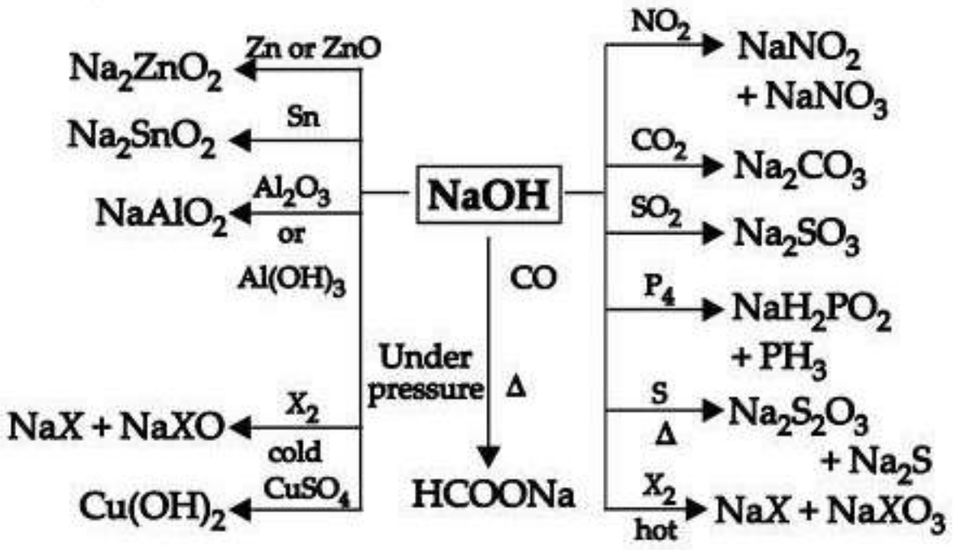
Anomalous Behaviour of the First Element of a Group

- This is due to (i) small size (ii) high electronegativity and (iii) non-availability of *d*-orbitals for bonding. Anomalous behaviour is observed among the second row elements (*i.e.* Li to F).

Some Important Compounds of Sodium

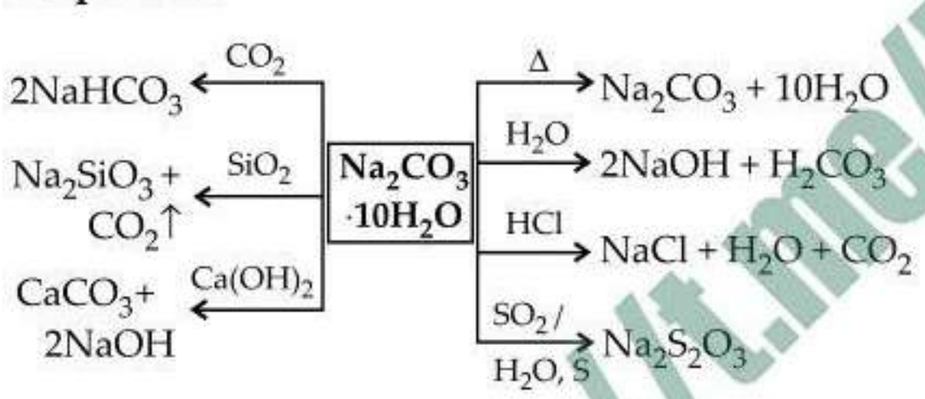
1. Sodium hydroxide (NaOH) or Caustic soda

- **Preparation :** By electrolysis of NaCl solution (brine).
  $2NaCl_{(aq)} + 2H_2O_{(l)} \longrightarrow H_{2(g)} + Cl_{2(g)} + 2NaOH_{(aq)}$
- **Properties :**



2. Sodium carbonate ($Na_2CO_3 \cdot 10H_2O$) or Washing soda

- **Preparation :** By Solvay process,
  $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$
  $(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$
  $NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3\downarrow$
  $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$
- **Properties :**



3. Sodium bicarbonate ($NaHCO_3$) or Baking soda

- **Preparation :** Obtained as an intermediate product in the solvay process.
  $NaCl + NH_3 + CO_2 + H_2 \longrightarrow NaHCO_3 + NH_4Cl$
- **Properties :**
  $2NaHCO_3 \xrightarrow[\text{decomposes}]{\Delta} Na_2CO_3 + CO_2\uparrow + H_2O$
- **Uses :**

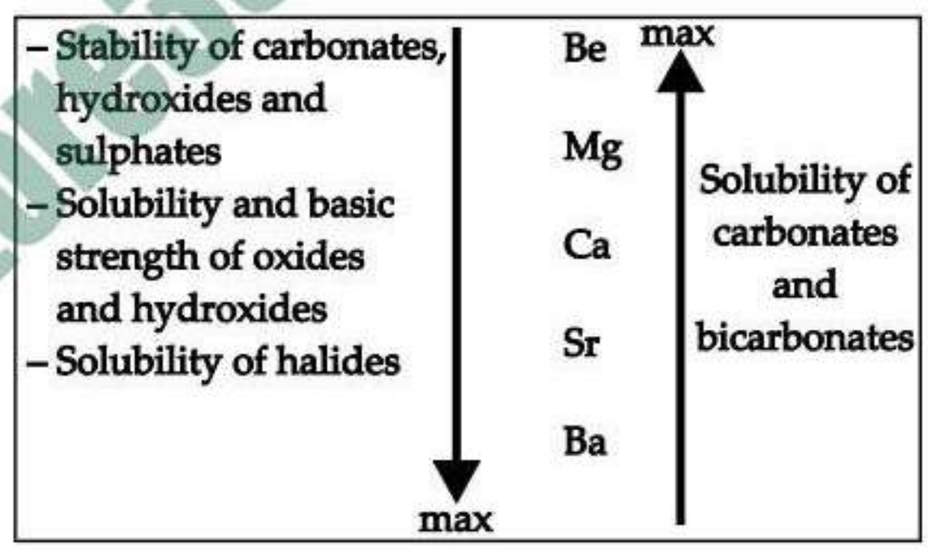
Sodium hydroxide	Sodium carbonate	Sodium bicarbonate
❍ In the manufacture of sodium metal, soap, rayon, paper, dyes, drugs, etc. ❍ As a laboratory reagent.	❍ In laundries and in softening of water as washing soda. ❍ In the manufacture of glass, caustic soda, etc. ❍ In textile industry and petroleum refining.	❍ In the preparation of baking powder, effervescent drinks, etc. ❍ In medicines to remove acidity of the stomach. ❍ In fire extinguishers.

GROUP 2 - ALKALINE EARTH METALS

- The group 2 elements are called "alkaline earth metals" because
  - their hydroxides form alkaline aqueous solutions.
  - their oxides are earthen *i.e.*, soil like, means having very high melting points.

Property	Be	Mg	Ca	Sr	Ba	Ra
Atomic number (Z)	4	12	20	38	56	88
Electronic configuration	[He] $2s^2$	[Ne] $3s^2$	[Ar] $4s^2$	[Kr] $5s^2$	[Xe] $6s^2$	[Rn] $7s^2$
Atomic radius (Å)	0.90	1.36	1.74	1.92	1.98	–
Flame colouration	None	None	Brick red	Crimson red	Grassy green	Crimson red
Ions	Be^{2+}	Mg^{2+}	Ca^{2+}	Sr^{2+}	Ba^{2+}	Ra^{2+}

- **Gradation in properties of alkaline earth metals**



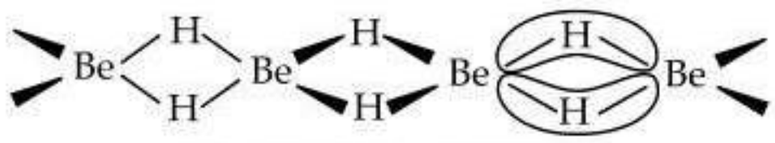
- **Properties :**

Property	Group-2
Electronic configuration	[Inert gas] ns^2
Block	s-block
Oxidation state	+2
Nature of oxides	BeO is an amphoteric oxide while other *M*O oxides are basic in nature.
Nature of halides	Electron - deficient BeX_2 are covalent while others (MX_2) are ionic. $MgCl_2 < CaCl_2 < SrCl_2 < BaCl_2$
Nature of sulphates	Less soluble in water and solubility decreases down the group. $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$
Nature of hydroxides	Solubility of hydroxide increases down the group. $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
Nature of carbonates	Solubility of carbonates decreases down the group. $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
Reactivity	Increases down the group. Be < Mg < Ca < Sr < Ba

- **Reaction with hydrogen (formation of hydrides) :**

$$M + H_2 \xrightarrow{\Delta} MH_2 \text{ (except Be)}$$

  - The hydride of beryllium can be obtained by the reduction of $BeCl_2$ with $LiAlH_4$.
    $2BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$
  - Both BeH_2 and MgH_2 are covalent compounds having polymeric structures in which H-atoms between beryllium atoms are held together by three centre-two electron ($3c$-$2e$) bonds as shown below :



Beryllium hydride polymer

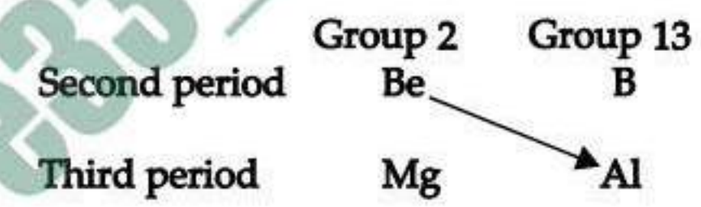
  - The hydrides of other elements of this group *i.e.*, CaH_2, SrH_2 and BaH_2 are ionic and contain H^- ions.
  - All the hydrides of alkaline earth metals react with water liberating H_2 gas and thus act as reducing agents.
    $MH_2 + 2H_2O \rightarrow M(OH)_2 + 2H_2$
  - CaH_2 is called hydrolith and is used for production of H_2 by action of water on it.

- **Reaction with halogens :** Form MX_2 type halides.
- **Action of acids :** They readily react with acids liberating hydrogen.
  $M + 2HCl \rightarrow MCl_2 + H_2$ (M = Be, Mg, Ca, Sr, Ba)
- **Reaction with ammonia :** Like alkali metals, the alkaline earth metals dissolve in liquid ammonia to give deep blue-black solutions from which ammoniates $[M(NH_3)_6]^{2+}$ can be recovered.
- **Exceptional behaviour of beryllium :**

All alkaline earth metals	Beryllium
Less hard and low m.pt. and b.pt.	Hardest and high m.pt. and b.pt.
React with water	Not even on boiling
Ionic compounds	Covalent compounds
Non-volatile nitrides	Volatile nitrides
Stable carbonates	Unstable*

* $Be_2CO_3 \longrightarrow BeO + CO_2$
So, usually placed in atmosphere of CO_2.

Diagonal Relationship between Beryllium and Aluminium



- Both metals have a tendency to form covalent compounds, *e.g.* the chlorides of both (*i.e.* $BeCl_2$ and $AlCl_3$) being covalent are soluble in organic solvents.
- Both the metals dissolve in strong alkalies to form soluble complexes : beryllates $[Be(OH)_4]^{2-}$ and aluminates $[Al(OH)_4]$.

Industrial Uses

Quick lime (CaO)	Limestone ($CaCO_3$)	Plaster of Paris ($CaSO_4 \cdot {}^1/_2H_2O$)
○ In steel industry to remove phosphates and silicates as slag. ○ In making cement by mixing it with silica, alumina or clay. ○ In making glass. ○ In lime soda process for the conversion of Na_2CO_3 to NaOH. ○ For softening of water, for making slaked lime, $[Ca(OH)_2]$ by treatment with water or calcium carbide (CaC_2).	○ As building material in the form of marble. ○ In manufacture of quick lime (CaO). ○ As a raw material for the manufacture of Na_2CO_3 in solvay ammonia process. ○ As a fertilizer.	○ For producing moulds for pottery and ceramics and casts of statues and busts. ○ In surgical bandages used for plastering broken or fractured bones. ○ In dentistry.

Biological Significance of Na, K, Mg and Ca

- Na^+ and K^+ are essential for proper functioning of human body.
  - Different ratio of Na^+ to K^+ inside and outside cells produces an electrical potential across the cell membrane which is essential for functioning of nerve and muscle cells.
  - These ions activate many enzymes.
  - These ions primarily help in transmission of nerve signals, in regulating the flow of water across cell membranes, transport of sugars and amino acids into the cells, etc.
- Mg^{2+} ions are concentrated in animal cells, and Ca^{2+} are concentrated in the body fluids outside the cell. Mg^{2+} ions form a complex with ATP. They are also essential for the transmission of impulse along nerve fibres. Mg^{2+} is an important constituent of chlorophyll, in the green parts of plants. Ca^{2+} is present in bones and teeth as apatite $Ca_3(PO_4)_2$, and the enamel on teeth as fluoroapatite $[3(Ca_3(PO_4)_2) \cdot CaF_2]$, Ca^{2+} ions are important in blood clotting, and are required to trigger the contraction of muscles and to maintain the regular beating of the heart.

EXAM DRILL

1. Magnesium burns in air to give
(a) MgO (b) Mg_3N_2
(c) $MgCO_3$ (d) MgO and Mg_3N_2

2. The correct arrangement of increasing order of atomic radii among Na, K, Mg, Rb is
(a) Mg < K < Na < Rb
(b) Mg < Na < K < Rb
(c) Mg < Na < Rb < K
(d) Na < K < Rb < Mg

3. Which of the following salts does not impart colour to the flame?
(a) $MgCl_2$ (b) $SrCl_2$ (c) $BaCl_2$ (d) LiCl

4. Which among the following has the tendency to form covalent compounds?
(a) Calcium (b) Beryllium
(c) Strontium (d) Magnesium

5. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?
(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2 \cdot MgSO_4$ (d) $MgSO_4$

9. In all oxides, peroxides and superoxides, the oxidation state of alkali metals is
(a) +1 and –1 (b) +1 and +2
(c) +1 only (d) +1, –1 and +2

7. The first ionisation potential of Na, Mg, Al and Si are in the order
(a) Na < Mg > Al < Si
(b) Na > Mg > Al > Si
(c) Na < Mg < Al < Si
(d) Na > Mg > Al < Si

8. Which of the following metal carbonate is decomposed on heating?
(a) Na_2CO_3 (b) $MgCO_3$
(c) K_2CO_3 (d) Rb_2CO_3

9. Which of the following sulphates have the highest solubility?
(a) $BeSO_4$ (b) $MgSO_4$
(c) $BaSO_4$ (d) $CaSO_4$

10. Which of the following can be extracted from sea water?
(a) Li (b) K (c) Mg (d) Ca

11. Several blocks of magnesium are fixed to the bottom of a ship to
(a) prevent puncturing by under sea rocks
(b) keep away the sharks
(c) prevent action of water and salt
(d) make the ship lighter

12. $Be + 2NH_3 + 4HF \longrightarrow A \xrightarrow{\Delta} BeF_2 + 2NH_4F$
The compound (*A*) in the reaction is
(a) NF_3 (b) $NH_3 - BeF_2$
(c) $(NH_4)_2[BeF_4]$ (d) NF_3NH_3

13. The decomposition temperature is maximum for
(a) $MgCO_3$ (b) $SrCO_3$
(c) $CaCO_3$ (d) $BaCO_3$

14. For two ionic solids CaO and KI, identify the wrong statement among the following:
(a) Lattice energy of CaO is much higher than that of KI.
(b) KI is soluble in benzene.
(c) CaO is sparingly soluble in water.
(d) KI has high melting point.

15. Which one of the following pairs do not impart colour to the flame?
(a) $BeCl_2$ and $SrCl_2$ (b) $BeCl_2$ and $MgCl_2$
(c) $CaCl_2$ and $BaCl_2$ (d) $BaCl_2$ and $SrCl_2$

16. Sodium on heating with moist air produces
(a) NaO (b) NaO_2
(c) Na_2O (d) Na_2CO_3

17. Which is used in the treatment of manic depression disorders?
(a) Na_2CO_3 (b) Li_2CO_3
(c) K_2CO_3 (d) $MgCO_3$

18. A compound *X* on heating gives a colourless gas which is not supporter of combustion. The residue is dissolved in water and excess of CO_2 is passed through it. Compound *Y* is formed, which is recovered in the solid form. *Y* on gentle heating gives back *X*. The compound *X* can be
(a) $CaCO_3$ (b) $NaNO_3$
(c) $CaSO_4 \cdot 2H_2O$ (d) K_2CO_3

19. Which oxide is formed when potassium is heated in excess of oxygen?
(a) K_2O (b) KO (c) K_2O_2 (d) KO_2

20. Oxone is
(a) KO_2 (b) Na_2O_2 (c) Li_2O (d) CaO

21. Na_2O_2 has light yellow colour. This is due to
(a) presence of unpaired electron in the molecule
(b) presence of trace of NaO_2
(c) presence of KO_2 as an impurity
(d) none of these.

22. When a substance *A* reacts with water it produces a combustible gas *B* and a solution of a substance *C* in water. When another substance *D* reacts with this solution of *C*, it also produces the same gas *B* on warming, but *D* can produce *B* on reaction with dilute sulphuric acid at room temperature. *A* imparts a deep golden yellow colour to a smokeless flame of Bunsen burner. *A*, *B*, *C* and *D* are respectively
(a) Na, H_2, NaOH and Zn
(b) K, H_2, KOH and Al
(c) Ca, H_2, $Ca(OH)_2$ and Sn
(d) CaC_2, C_2H_2, $Ca(OH)_2$ and Sn.

23. Match (*X*) with (*Y*) and select the correct alternative.

	X		*Y*
P.	Sorel cement	1.	CaH_2
Q.	Anhydrone	2.	$BaSO_4 + ZnS$
R.	Hydrolith	3.	$MgCl_2 \cdot 5MgO \cdot xH_2O$
S.	Lithopone	4.	$Mg(ClO_4)_2$

	P	**Q**	**R**	**S**
(a)	1	2	3	4
(b)	2	3	4	1
(c)	3	4	1	2
(d)	4	1	2	3.

24. Among KO_2, AlO_2^-, BaO_2 and NO_2^+, unpaired electron is present in
(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-
(c) KO_2 only (d) BaO_2 only.

25. The name and formula of the compound of magnesium, chlorine and oxygen used as a drying agent is
(a) magnesium oxychlorite, $Mg(OCl)_2$
(b) magnesium chlorate, $Mg(ClO_3)_2$
(c) magnesium perchlorate, $Mg(ClO_4)_2$
(d) none of the above.

26. $Be_2C + H_2O \longrightarrow BeO + X$
$CaC_2 + H_2O \longrightarrow Ca(OH)_2 + Y$
$Mg_2C_3 + H_2O \longrightarrow Mg(OH)_2 + Z$
X, *Y* and *Z* are respectively
(a) CH_4, C_2H_2, C_3H_8
(b) CH_4, C_2H_6, C_3H_8
(c) CH_4, C_2H_2, C_3H_4
(d) C_2H_2, C_2H_6, C_3H_4.

27. What is the heat of solution of sodium chloride from following data?
Hydration energy of $Na^+ = -389.4$ kJ mol^{-1}
Hydration energy of $Cl^- = -382.3$ kJ mol^{-1}
Lattice energy of NaCl = – 776 kJ mol^{-1}
(a) + 8.6 kJ mol^{-1} (b) + 4.3 kJ mol^{-1}
(c) – 4.3 kJ mol^{-1} (d) – 8.6 kJ mol^{-1}.

28. The carbide of which of the following metals on hydrolysis gives allylene or propyne?
(a) Be (b) Ca (c) Al (d) Mg

29. Property of all the alkaline earth metals that increases with their atomic number is
(a) ionisation energy
(b) solubility of their hydroxides
(c) solubility of their sulphates
(d) electronegativity.

30. Carnallite is the mineral of
(a) Mg (b) Na (c) Zn (d) Ca

31. The radius of which ion (hydrated) is lowest?
(a) $[Li_{(aq)}]^+$ (b) $[Na_{(aq)}]^+$
(c) $[K_{(aq)}]^+$ (d) $[Cs_{(aq)}]^+$

32. An ingredient of baking powder is
(a) $NaHCO_3$ (b) Na_2CO_3
(c) Na_2SO_4 (d) NaCl

33. Which of the bicarbonates does not exist in solid state?
(a) $NaHCO_3$ (b) $KHCO_3$
(c) $Ca(HCO_3)_2$ (d) $RbHCO_3$

34. Strongest reducing agent amongst alkali metals in solutions is
(a) Li (b) Na (c) K (d) Cs

35. Sodium carbonate can be manufactured by Solvay's process but potassium carbonate cannot be prepared because
(a) K_2CO_3 is more soluble
(b) K_2CO_3 is less soluble
(c) $KHCO_3$ is more soluble than $NaHCO_3$
(d) $KHCO_3$ is less soluble than $NaHCO_3$.

36. Which of the following statements is/are true for IIA group elements?
(a) Except beryllium halides, all other halides are ionic in nature.
(b) All form nitrides in air.
(c) The solubility of the hydroxides increases from Be to Ba.
(d) All are correct.

37. The correct sequence of increasing covalent character is represented by
(a) $BeCl_2 < NaCl < LiCl$
(b) $NaCl < LiCl < BeCl_2$
(c) $BeCl_2 < LiCl < NaCl$
(d) $LiCl < NaCl < BeCl_2$

38. Which is least thermally stable?
(a) Li_2CO_3 (b) $MgCO_3$
(c) $BaCO_3$ (d) $BeCO_3$

39. The element which does not directly combine with carbon on strong heating is
(a) Li (b) Be (c) K (d) Ca

40. Sodium metal reacts with Al_2O_3 at high temperature to give a sodium compound *X*. *X* reacts with carbon dioxide in water to form *Y*. *Y* is .....

(a) Na_2O_2 (b) Na_2O
(c) Na_2CO_3 (d) $NaAlO_2$.

41. On heating quick lime with coke in an electric furnace, we get
(a) Ca and CO_2 (b) $CaCO_3$
(c) CaO (d) CaC_2

42. What are the products formed when Li_2CO_3 undergoes decomposition?
(a) $Li_2O_2 + CO$ (b) $Li_2O + CO$
(c) $Li_2O + CO_2$ (d) $LiO_2 + CO$

43. In Solvay ammonia process, sodium bicarbonate is precipitated due to
(a) presence of NH_3
(b) reaction with CO_2
(c) reaction with brine solution
(d) reaction with NaOH.

44. Select the correct statement
(a) Solubility of alkali hydroxides is in order LiOH > NaOH > KOH > RbOH
(b) Solubility of alkali carbonates is in order $Li_2CO_3 > Na_2CO_3 > K_2CO_3 > Rb_2CO_3$
(c) Both are correct (d) None is correct.

45. The pair of compounds which cannot exist together in solution is
(a) $NaHCO_3$ and NaOH
(b) Na_2CO_3 and $NaHCO_3$
(c) Na_2CO_3 and NaOH
(d) $NaHCO_3$ and NaCl

DAY 10 OMR SHEET

Time : 45 min

INSTRUCTIONS

- Use HB pencil only and darken each circle completely.
- If you wish to change your answer, erase the already darkened circle completely and then darken the appropriate circle.
- Mark only one choice for each question as indicated.

Correct marking ● ⓑ ⓒ ⓓ
Wrong marking ⊗ ✓ ◑ ⊙

1. ⓐ ⓑ ⓒ ⓓ	10. ⓐ ⓑ ⓒ ⓓ	19. ⓐ ⓑ ⓒ ⓓ	28. ⓐ ⓑ ⓒ ⓓ	37. ⓐ ⓑ ⓒ ⓓ
2. ⓐ ⓑ ⓒ ⓓ	11. ⓐ ⓑ ⓒ ⓓ	20. ⓐ ⓑ ⓒ ⓓ	29. ⓐ ⓑ ⓒ ⓓ	38. ⓐ ⓑ ⓒ ⓓ
3. ⓐ ⓑ ⓒ ⓓ	12. ⓐ ⓑ ⓒ ⓓ	21. ⓐ ⓑ ⓒ ⓓ	30. ⓐ ⓑ ⓒ ⓓ	39. ⓐ ⓑ ⓒ ⓓ
4. ⓐ ⓑ ⓒ ⓓ	13. ⓐ ⓑ ⓒ ⓓ	22. ⓐ ⓑ ⓒ ⓓ	31. ⓐ ⓑ ⓒ ⓓ	40. ⓐ ⓑ ⓒ ⓓ
5. ⓐ ⓑ ⓒ ⓓ	14. ⓐ ⓑ ⓒ ⓓ	23. ⓐ ⓑ ⓒ ⓓ	32. ⓐ ⓑ ⓒ ⓓ	41. ⓐ ⓑ ⓒ ⓓ
6. ⓐ ⓑ ⓒ ⓓ	15. ⓐ ⓑ ⓒ ⓓ	24. ⓐ ⓑ ⓒ ⓓ	33. ⓐ ⓑ ⓒ ⓓ	42. ⓐ ⓑ ⓒ ⓓ
7. ⓐ ⓑ ⓒ ⓓ	16. ⓐ ⓑ ⓒ ⓓ	25. ⓐ ⓑ ⓒ ⓓ	34. ⓐ ⓑ ⓒ ⓓ	43. ⓐ ⓑ ⓒ ⓓ
8. ⓐ ⓑ ⓒ ⓓ	17. ⓐ ⓑ ⓒ ⓓ	26. ⓐ ⓑ ⓒ ⓓ	35. ⓐ ⓑ ⓒ ⓓ	44. ⓐ ⓑ ⓒ ⓓ
9. ⓐ ⓑ ⓒ ⓓ	18. ⓐ ⓑ ⓒ ⓓ	27. ⓐ ⓑ ⓒ ⓓ	36. ⓐ ⓑ ⓒ ⓓ	45. ⓐ ⓑ ⓒ ⓓ

(1) Number of questions attempted : _____ (3) Marks scored : _____
(2) Number of questions correct : _____

For every correct answer award yourself 4 marks. For every incorrect answer deduct 1 mark.

HINTS & SOLUTIONS

1. (d): Magnesium burns in air to form both MgO and Mg_3N_2.

$$2Mg + O_2 \xrightarrow{\Delta} 2MgO; \quad 3Mg + N_2 \xrightarrow{\Delta} Mg_3N_2$$

2. (b): Atomic radius increases on moving down the group and decreases from left to right in a period. Thus, the correct order of increasing atomic radii is Mg < Na < K < Rb.

3. (a): Because of high *IE* of Mg, Mg^{2+} ions are easily reduced by the electrons provided by the flame. As a result, a large amount of energy is released. The light corresponding to this large energy falls in the ultraviolet region of the electromagnetic spectrum. Consequently, $MgCl_2$ does not impart any colour to the flame.

4. (b): Beryllium has a tendency to form covalent salts due to its smaller size and higher ionization enthalpy.

5. (a): $\underset{\text{disodium hydrogen phosphate}}{Mg^{2+} + Na_2HPO_4} + NH_4OH \longrightarrow$

$$Mg(NH_4)PO_4 + 2Na^+ + H_2O$$
magnesium ammonium phosphate

6. (c)

7. (a): First ionisation energy of Mg (Z = 12) is higher than that of Na (Z = 11) because of increased nuclear charge on Mg. The first ionisation energy of Mg is higher than that of Al because in case of Mg ($1s^2\ 2s^2\ 2p^6\ 3s^2$) the electron has to be removed from 3*s*-orbital while in Al ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$) it has to be removed from 3*p*-orbital.
The *I.E.* of Si (Z = 14) is higher than those of Mg and Al because of increase in nuclear charge on Si. The correct order is Na < Mg > Al < Si.

8. (b): $MgCO_3 \xrightarrow{\text{heat}} MgO + CO_2$
That metal carbonate will be unstable whose oxide is stable.

9. (a): $BeSO_4$ is most soluble because hydration energy is more than lattice energy.

$$\underset{\text{Hydration energy decreases hence, solubility decreases}}{BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4 \longrightarrow}$$

10. (c): Sea water contains about 0.13% Mg^{2+} ions. Mg is extracted from sea water as follows:

$$Ca(OH)_2 + MgCl_2 \longrightarrow Mg(OH)_2 + CaCl_2$$
$$Mg(OH)_2 + HCl \longrightarrow MgCl_2 \xrightarrow{\text{Electrolysis}} Mg$$

11. (c): Mg does not react with cold water but it decomposes with hot water.

$$Mg + H_2O \longrightarrow MgO + H_2$$

Mg forms a protective layer of oxide.

12. (c): $Be + 2NH_3 + 4HF \longrightarrow \underset{(A)}{(NH_4)_2[BeF_4]} \xrightarrow{\Delta}$

$$BeF_2 + 2NH_4F$$

13. (d): Thermal stability of carbonates increases down the group.

14. (d): Due to lower lattice energy of KI as compared to that of CaO, the melting point of KI is much lower than that of CaO.

15. (b): $BeCl_2$ and $MgCl_2$ do not impart colour to the flame due to high ionization enthalpies of Be and Mg.

16. (d) **17. (b)**

18. (a): $\underset{X}{CaCO_{3(s)}} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$
$$Ca(OH)_{2(aq)} + \underset{\text{excess}}{2CO_{2(g)}} \longrightarrow \underset{Y}{Ca(HCO_3)_{2(aq)}}$$
$$\underset{Y}{Ca(HCO_3)_{2(aq)}} \xrightarrow{\Delta} \underset{X}{CaCO_{3(s)}} + CO_{2(g)} + H_2O_{(l)}$$

19. (d) **20. (b)** **21. (b)**

22. (a): $\underset{(A)}{Na} + H_2O \longrightarrow \underset{(C)}{NaOH} + \underset{(B)}{H_2}$;

$$\xrightarrow[(D)]{+Zn} (B)$$

$$Zn + H_2SO_{4(dil.)} \longrightarrow ZnSO_4 + H_2$$
(D)

23. (c): Sorel cement is a mixture of magnesium oxide and magnesium chloride.
Anhydrone is magnesium perchlorate.
Hydrolith is calcium hydride.
Lithopone is a mixture of barium sulphate and zinc sulphide.

24. (c): NO_2 contains three electron bond and in NO_2^+ odd (unpaired) electron is removed. Peroxides (O_2^{2-}) do not possess unpaired electrons as the antibonding π M.O.'s acquired one more electron each for pairing. AlO_2^- is obtained by the interaction of Al^{3+} ($2s^2p^6$ configuration) and 2 oxide (O^{2-}) ions each of which does not contain unpaired electron. Superoxide O_2^- has one unpaired electron in π antibonding M.O. and is therefore paramagnetic.

25. (c): Magnesium perchlorate (anhydrone) has strong affinity for water giving $Mg(ClO_4)_2 \cdot 6H_2O$. It loses whole of water when heated at 250°C and drying property is regenerated.

26. (c): $Be_2C + 2H_2O \longrightarrow 2BeO + CH_4$
$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$
$Mg_2C_3 + 4H_2O \longrightarrow 2Mg(OH)_2 + C_3H_4$

27. (b): Hydration energy of NaCl = – 389.4 – 382.3
= –771.7 kJ mol^{-1}

$\Delta H_{sol.}$ = Hydration energy – Lattice energy
= – 771.7 – (–776) = + 4.3 kJ mol^{-1}

28. (d): Be_2C and Al_4C_3 on reaction with water liberate methane gas while CaC_2 gives acetylene gas. Mg forms

MgC_2 either when heated directly with carbon in an electric furnace or when MgO is heated with carbon.
When MgC_2 is heated, it changes into Mg_2C_3. The carbide, Mg_2C_3 reacts with H_2O to form propyne.

$$Mg_2C_3 + 4H_2O \rightarrow 2Mg(OH)_2 + \underset{\text{Propyne}}{CH_3C \equiv CH}$$

29. (b)

30. (a) : Carnallite is $KCl \cdot MgCl_2 \cdot 6H_2O$.

31. (d): Larger the cation, smaller is its degree of hydration.

32. (a) : $NaHCO_3$ is baking powder.

33. (c) : Bicarbonates of alkaline earth metals do not exist in solid state but are known in solutions only.

34. (a) : Due to smallest size, hydration of Li^+ is maximum hence large amount of hydration energy is released.

35. (c) : $KHCO_3$ cannot be precipitated out due to higher solubility.

36. (d): Beryllium halides are essentially covalent and soluble in organic solvents.
All the alkaline earth metals burn in dinitrogen to form nitrides of the type, M_3N_2.
Down the group, decrease in lattice enthalpy is more than decrease in hydration energy therefore solubility of hydroxides increases down the group.

37. (b): According to Fajan's rule, smaller the cation and greater the charge on the cation, greater is the polarizing power and larger is the covalent character.
Be^{2+} is smaller than Li^+ which in turn is smaller than Na^+.

38. (d): $BeCO_3$ is least stable.
Thermal stability of alkaline earth metal carbonates increases down the group as the electropositive character of metal increases. Group 1 compounds are more stable to heat than group 2.

39. (c) : Li forms dilithium acetylide when heated directly with carbon while other alkali metals do not react with carbon directly.

$$2Li + 2C \xrightarrow{\Delta} \underset{\text{Dilithium acetylide}}{Li^+C^- \equiv C^-Li^+}$$

All alkaline earth metals or their oxides on heating with carbon form carbides.
Be_2C is prepared by heating a mixture of beryllium powder and carbon under hot pressing conditions.

$$2BeO + 3C \xrightarrow{2175\text{–}2275\ K} Be_2C + 2CO$$

$$\underset{\text{Powder}}{Ca} + 2C \xrightarrow{1373\ K} CaC_2$$

$$CaO + 3C \xrightarrow{2273\ K} CaC_2 + CO$$

40. (c) : $6Na + Al_2O_3 \longrightarrow \underset{(X)}{3Na_2O} + 2Al$

$$Na_2O + CO_2 \longrightarrow \underset{(Y)}{Na_2CO_3}$$

41. (d): $CaO + 3C \xrightarrow{\Delta/\text{electric furnace}} CaC_2 + CO\uparrow$

42. (c) : $Li_2CO_3 \longrightarrow Li_2O + CO_2$

43. (c) : In Solvay ammonia process, sodium bicarbonate is precipitated due to common ion(Na^+) effect provided by brine (concentrated NaCl Solution).

44. (b): Solubility of alkali carbonates is in the order.
$Li_2CO_3 > Na_2CO_3 > K_2CO_3 > Rb_2CO_3$.

45. (a) : $NaHCO_3$ is an acidic salt and will heat with strong base NaOH. Hence, they cannot exist togethe is solution.